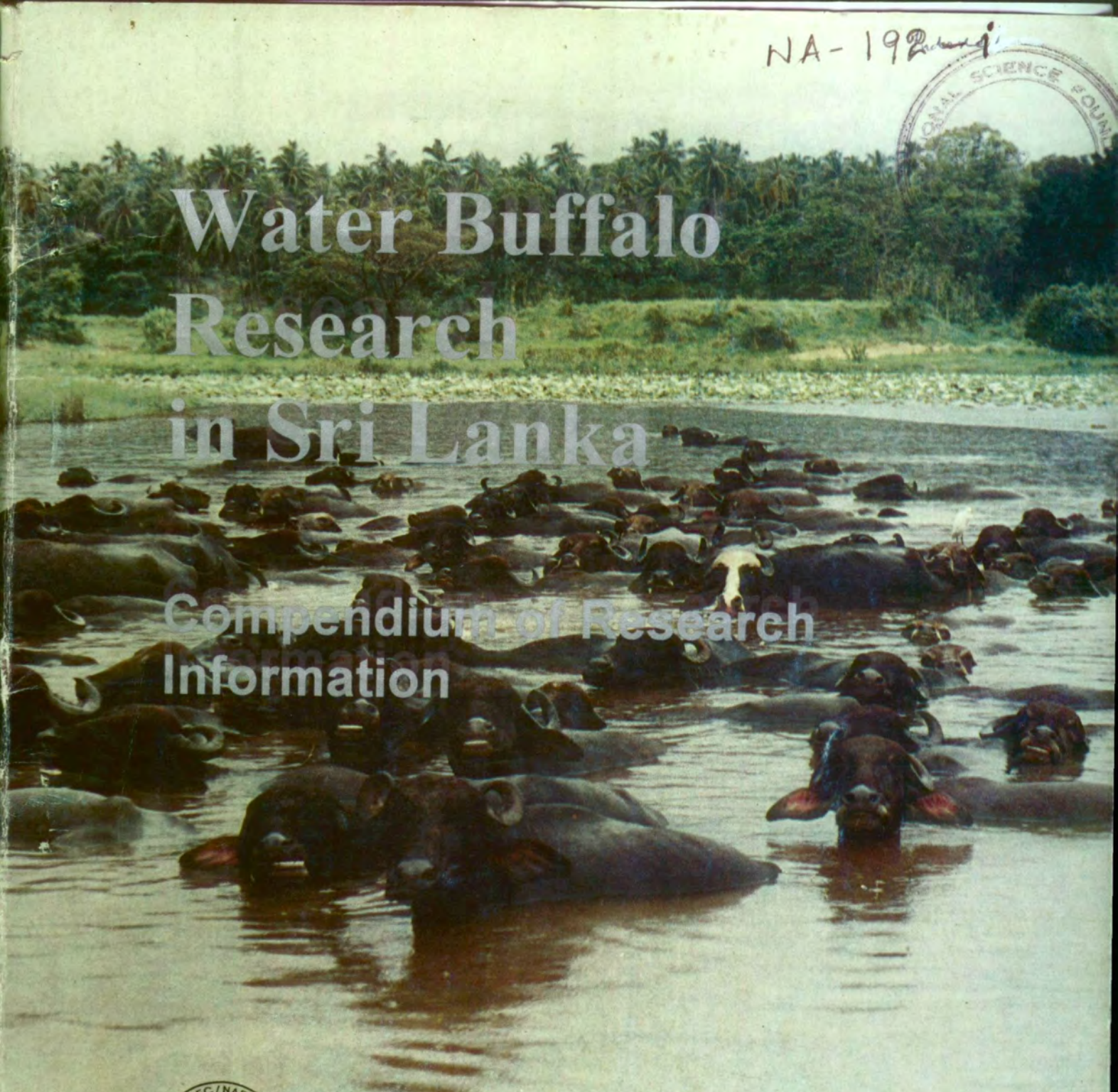


Water Buffalo Research in Sri Lanka

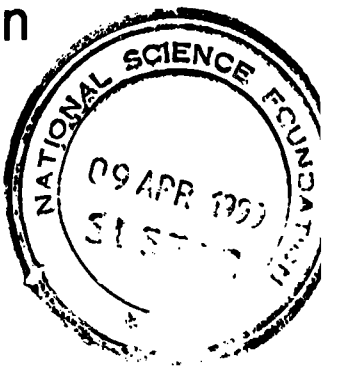
Compendium of Research Information

SAREC/NARESA Buffalo Research
and Development Programme
Peradeniya, Sri Lanka

Publication No. 17

Water Buffalo Research in Sri Lanka

Compendium of Research Information



Compiled and Edited by

J.A.de.S. Sriwardene
N.U. Horadagoda
H. Abeygunawardena
D.H.A. Subasinghe

SAREC/NSF(NARESA) Buffalo Research and Development Programme

National Science Foundation
1999

Printed and Published by

National Science Foundation,
47/5, Maitland Place,
Colombo 07, Sri Lanka

Tel: 696771-3
Fax: 691691
Internet homepage: *http://www.naresa.ac.lk*

ISBN 955-590-016-7

PREFACE

The buffalo has for centuries played a vital role in the rural economy of Sri Lanka, but until the 1970's very little scientific research had been done to improve the productivity of this animals. In 1980, a National Workshop sponsored by the Swedish Agency for Research Co-operation with Developing Countries (SAREC) reviewed the research conducted up to that point. This Workshop identified several priority areas for research and lead to the initiation of almost two decades of intense research which focused on different aspects of buffalo production. Consequently, there was an exponential increase in the research publications on the buffalo. The purpose of this compendium is to bring together references to literature on buffalo research published up to the present time, to serve researchers, students, planners and interested persons, both nationally and internationally, as a bibliography of the work done in Sri Lanka.

The articles cited in this compendium have been categorised under the headings, Health, Management and Utilisation, Nutrition and Physiology and Reproduction and Breeding depending on the content of the publication. However, a few papers have been included under more than one of the aforementioned headings, if it has relevance to two or more of the broad groupings.

The title of each abstract is cited by author(s) (small caps), title of article (bold), source (journal, presentation, report etc., in italics), volume (bold) and number (normal) followed by first and last pages. Further, the address of the author or in the case of multi-author papers, the senior author's address is included. The abstracts listed in the compendium are either those appearing in the publication or an edited version. In instances where no abstract appeared in the paper or presentation, an abstract prepared by the editors, which concisely reflect the objectives, results and conclusions of the work has be included.

Author and subject indexes have been included to help the users to conveniently locate abstracts of interest. The subject index included is based on the broad titles listed in the CAB thesaurus (1995 Edition). Each abstract is covered by at least one title in the subject index, but the user is requested to look under related subjects to locate abstracts of interest, as the editors have purposely selected a limited number of titles in order to keep the subject index short.

This compendium is an updated and a greatly expanded version of a previous bibliography on water buffalo research in Sri Lanka compiled by Dr. S.S.E. Ranawana for NARESA in 1994. One of the main differences between these publications is that this compendium contains abstracts of all the work cited. It is also worth noting that all papers cited could be accessed from the Buffalo Information Centre located in the library of the Department of Animal Production and Health at Peradeniya. Every attempt has been made to include all the publication on the buffalo in Sri Lanka, but it is still possible that some references have inadvertently been omitted. If such omissions do occur, it would be much appreciated if a copy of these papers are sent to Buffalo Information Centre, to update the database.

The editors wish to thank to Ms. Champika Fernando, who was responsible during the early stages to collect the papers cited herein, Ms. Farosa Azeez for typing the abstracts and the secretarial assistance provided during the compilation of this compendium, Ms. Ayesha Senerath Bandara and Mr. Janaka Herath for formatting and preparing the final document. Finally, we wish to express our gratitude to SAREC for funding the Buffalo Research and Development Programme in Sri Lanka and the National Science Foundation (formerly, Natural Resources, Energy & Science Authority of Sri Lanka; NARESA) for the excellent co-operation extended in administering the grant and undertaking the printing of this compendium.

JAdeSS
NUH
HA
DHAS

Contents

Part I - Health

H-01 ABEYGUNAWARDENA, I.S., WEILGAMA, D.J., HORADAGODA, N.U. and JAYAPADMA, H.M.H.L. **Studies on *Explanatum (Gigantocotyle) explanatum* infection: Prevalence in cattle and buffaloes in Sri Lanka and pathology in natural infection.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo. Sri Lanka, NARESA Press. 1996 pp. 473-486. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Explanatum (Gigantocotyle) explanatum is one of the common trematode parasites in the liver of cattle and buffaloes and reported cases show a chronic debility and unthriftiness. Examinations were conducted to determine the prevalence and pathophysiology of the trematode infection. A survey of livers from the Colombo and Kandy abattoirs was carried out over a one year, commencing in April 1993. Post-mortem material from several government farms and other field stations were also collected. Seventy percent of the carcasses examined were of cattle and the rest were of buffaloes. Livers and bile ducts of the cattle and buffaloes were examined for the presence of parasites. Out of 2297 carcasses of buffaloes examined, 784 (34.2%) were affected by the parasite, compared to 13 out of 6067 carcasses of cattle (0.21%); analysis of origin of animals or the carcasses examined revealed that the infection was found in all agro-climatic zones. However, the prevalence rate was slightly higher (26.9%) in the dry zone compared to the wet (19.2%) and intermediate (23.2%) zones. Animals over two years of age had a high prevalence rate (85.7%) whilst only a few animals in the younger group were affected. Affected livers were dissected and parasites were collected for further laboratory studies. Only one species of parasite, *Explanatum explanatum* was identified. The affected livers were firm in consistency. The capsule was thick and opaque compared to that of unaffected livers. The epithelial surface of affected bile ducts had polyp-like protuberances to which adult parasites were attached. Histological sections revealed a mononuclear cell infiltration around portal triads. The preliminary results of this study suggest that *Explanatum explanatum* is a widespread liver parasite, primarily affecting buffaloes in Sri Lanka. Further studies are needed to assess the clinical effects and the economic losses due to the infection.

H-02 AMARASINGHE, P.H. **Immunological response of buffalo cows to *Toxocara vitulorum* - antigenic analysis.** *PhD Thesis* (1987) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Parasitological, haematological and immunological responses of pregnant and non-pregnant indigenous buffaloes (n=12) to natural and experimental infections with *Toxocara vitulorum* were studied. Antigens responsible for eliciting an antibody response during natural infections were investigated. Immunogenicity of these antigens was studied in a mouse model. A strong gel diffusion precipitin (GPT) response to infective egg extracts of *T. vitulorum* was seen in the naturally infected buffalo cows. In these animals the GPT and Enzyme-linked Immunosorbent Assay (ELISA) titres rose prior to parturition and fell at the time of parturition. Also, the nature of the reactions in individual animals showed a direct relationship to the GPT titres. The anti-*T. vitulorum* antibodies were predominantly IgG isotopes class of immunoglobulins. A few eggs were seen in the faeces of three parturient animals. Haematological values were spread over a wide range in buffaloes, and there were no significant differences in the haematological values between naturally and the experimentally infected buffaloes. Antigenieity of excretory-secretory products of infective larvae, infective eggs and adult worm extracts and perienteric fluid of adult *T. vitulorum* were analysed. Oral secretory products were highly antigenic as seen in the circum-oral precipitin reactions. Of the extracts prepared, infective egg extracts gave the strongest precipitin reactions indicating a recurrent exposure to this antigen in nature. In comparison, the reactions with adult antigen preparations were weak. The antigenic sites in the adult parasite were located in the cuticle. The sera of calves born to infected cows were negative for *T.vitulorum* precipitins before feeding with colostrum but a precipitin reaction was evident from 24 hours of birth. Nevertheless, patent infections developed from 19-21 days after birth and one calf died with severe diarrhoea while the remainder revealed heavy faecal *Toxocara* egg counts. In six calves the

infection was spontaneously eliminated between 40 and 60 days after birth suggesting a self cure reaction. In a separate study involving 30 Murrah cows, sera precipitins were not observed during the first 4-6 months of pregnancy. In 14 calves born to these animals serum precipitins were never observed, but the animals had *T.vitulorum* egg counts comparable with those in indigenous buffalo calves. After an initial natural infection a strong resistance to re-infection was acquired by most calves of both breeds in that larvae did not generally develop beyond the second stage.

H-03 AMARASINGHE, P.H., RAJAPAKSE, R.P.V.J., LLOYD, S. and FERNANDO, S.T. **Antigen-induced protection against infection with *Toxocara vitulorum* larvae in mice.** *Parasitology Research* (1992) **78,** 643-647. Faculty of Science, University of Peradeniya, Peradeniya, SL.

Larvae of *Toxocara vitulorum* hatched and migrated in the tissues of normal mice. Larvae survived in reasonable numbers, particularly in the liver and, to a lesser extent, in the lungs and kidneys for at least 4-7 days and in muscles, albeit only in low numbers, for at least 3 weeks. Oral infection of mice on three or more occasions with *T. vitulorum* eggs induced protection against a challenge infection with eggs of *T. vitulorum.* Prior parental immunisation of mice with a variety of *T. vitulorum* soluble antigens (extracts, excretions/secretions, or perienteric fluid and their fractions) from adult parasites and/or infective larvae induced statistically significant protection against infection. The most effective protective immunogens were three or more injections with perienteric fluid from adults (100% protection) and excretions/secretions from infective larvae of *T. vitulorum* (>92% protection).

H-04 AMARASINGHE, P., MASOODI, M.A., SAMARASINGHE, B., SIVANATHAN, S., GUNAWARDENA, V.K. and FERNANDO, S.T. **Immunological responses of pregnant swamp and Murrah buffalo calves to *Toxocara (Neoascaris) vitulorum* infection** In: *The use of nuclear techniques to improve domestic buffalo production in Asia.* Vienna, Austria. IAEA. 1984 pp. 161-170. Faculty of Science, University of Peradeniya, Peradeniya, SL.

Swamp buffalo cows from an area where *T. vitulorum* infection was heavy, were examined for serum antibodies. Serum from all cows showed strongly positive precipitin reactions from the 4th to 6th months of pregnancy and after parturition using homologous larval, adult worm and adult excretory and secretory antigens. These precipitins continued to be being detected in the sera 4-6 months after calving. The sera of calves born to these cows were negative for *T. vitulorum* precipitins before feeding with colostrum but a precipitin reaction was evident from 24 hours of birth. Nevertheless, patent infections developed from 19-21 days after birth and one calf died with severe diarrhoea, the remainder revealed heavy faecal *Toxocara* egg counts. In six calves the infection was spontaneously eliminated between 40 and 60 days after birth suggesting a 'self cure' reaction. In a similar study involving 30 Murrah cows sera precipitins were not observed during the first 4-6 months of pregnancy. In 14 calves born to these animals serum precipitins were never observed, but the animals had *T. vitulorum* egg counts comparable with those in swamp buffalo calves. After an initial natural infection a strong resistance to re-infection was acquired by most calves of both breeds and the larvae generally did not develop beyond the second stage.

H-05 AMARASINGHE, P.H., VASANTHATHILAKE, V.W.S.M., LLOYD, S. and FERNANDO, S.T. **Periparturient reduction in buffalo of mitogen-induced lymphocyte proliferation and antibody to *Toxocara vitulorum.*** *Tropical Animal Health and Production* (1994) **26,** 109-116. Faculty of Science, University of Peradeniya, Peradeniya, SL.

Lymphocyte and antibody reactivity were examined during the periparturient period in buffalo cows naturally infected with *Toxocara vitulorum.* Titres of antibodies to an extract of *T. vitulorum* larvae increased about 3 months before parturition. Antibody titres declined at about the time of parturition and remained low for up to 3 months into lactation. Lowered titres were found in the IgG class and not the IgM class of immunoglobulins. Levels of lymphocyte transformation induced by the mitogens concanavalin A and pokeweed mitogen declined markedly from 1 to 2 weeks before and until one to 2 weeks after parturition. The relationship between this suppressed immunological reactivity and vertical transmission of *T. vitulorum* larvae is discussed.

H-06 ARIYARATNE, U.K.I. and MAHALINGAM, S. **Diarrhoea in buffalo calves.** In: *Proceedings of the Annual Research Sessions, Faculty of Veterinary Medicine and Animal Science University of Peradeniya, 19 December 1992. Peradeniya, Sri Lanka.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Attempts were made to identify coronavirus antigens in faeces of diarrhoeic buffalo calves by ELISA. The SDS-PAGE and ELISA were used also to identify the typical from the atypical rotaviruses and to compare buffalo rotaviruses with other animal rotavirus strains. Out of 139 diarrhoeic and 36 non-diarrhoeic faecal samples examined by ELISA, thirteen diarrhoeic and one non-diarrhoeic samples were positive for rotavirus group A antigen.

Out of these 14 samples, only 8 diarrhoeic and 1 non-diarrhoeic positive samples gave the electrophorogram similar to that of group A. Migratory patterns of three of these SDS-PAGE positive samples were compared with group A rotaviruses of the human, Simian (SAII), neat cattle and porcine group A and C mixture. The migratory patterns of the segments of group A rotaviruses of various species changed within the major classes, namely I, II, III and IV, whilst the electrophorogram of the mixture of porcine group A and C rotaviruses showed more than eleven segments. One hundred and five of 139 diarrhoeic and 35 of the 36 non-diarrhoeic faecal samples were also examined for the presence of coronavirus antigen. Fourteen of the 105 diarrhoeic samples were positive for coronavirus antigen by screening with ELISA. Ten of these positive samples, when subjected to the confirmatory blocking test, gave inconclusive results, because the pre-immune serum used also blocked the test antigen. However, the pre-immune serum did not block the control positive antigen. It is proposed to examine further faecal samples for coronavirus antigen in diarrhoeic buffalo calves, using a different set of biological reagents.

H-07 ARIYARATNE, U.K.I. and MAHALINGAM, S. **Virus diarrhoea in buffalo calves.** *Sri Lanka Veterinary Journal* **42,** (1) 26[Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, Sri Lanka.

Enteric coronaviruses are associated with diarrhoea in dairy cattle calves under five months of age. They are also associated with winter dysentery in adult cattle. The present study was to determine whether this virus was associated with diarrhoea in buffalo calves in Sri Lanka too. The method used to identify antigens and antibodies against bovine enteric coronavirus was ELISA. Faecal samples from 217 diarrhoeic and 74 non-diarrhoeic buffalo calves aged less than five months were examined. None of the samples were positive for antigens. None of the 204 buffalo calf sera examined were positive for anti-coronaviral antibodies. Sera and faecal samples from neat cattle calves, adult buffaloes and adult neat cattle from Polonnaruwa and Ambewela farms were also examined for bovine coronaviruses. None of the adult buffalo (>1 yr) serum samples from Polonnaruwa or Ambewela farms had antibodies to bovine coronavirus. In contrast, 50 out of 136 (36%) neat cattle calf sera, and 11 out of 25 (44%) adult neat cattle sera from these farms were positive for anti-bovine coronaviral antibodies. A feature to note is that, of the 84 samples of neat cattle calf sera from the Polonnaruwa farm, 37 (44%) had anti-coronaviral antibodies. But in the Ambewela farm, only 13 out of 52 (25%) samples of neat cattle calf sera were positive for the anti-coronaviral antibodies. None of the buffalo calves at Ambewela were positive (0/4). These findings suggest that although bovine enteric coronavirus (or a virus closely related to it) is circulating amongst the neat cattle calves at Polonnaruwa and Ambewela farms, buffalo calves in these farms are either refractory to infection by bovine coronavirus or the level of infection is very low.

H-08 ARIYARATNE, U. and MAHALINGAM, S. **Characterisation of strains of buffalo calf rotavirus by polyacrylamide gel electrophoresis.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 393-401. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The objective of the present study was to detect non-group A (atypical) rotaviruses as well as to study the genome profiles of strains of buffalo group A rotaviruses by polyacrylamide gel electrophoresis (PAGE). Faecal samples collected from 175 buffalo calves 1 to 150 days old, were examined by the Enzyme Linked Immunosorbent Assay (ELISA) test for group A rotaviruses antigen. These samples were also examined by PAGE. Of the 175 calves 139, (79.4%) were diarrhoeic at the time of sampling whilst the rest were non-diarrhoeic, but in contact with them. Fourteen of the 175 (8%) samples were positive for rotavirus by ELISA, and were of group A, sub-group 1 specificity. By PAGE only 9 of these samples showed banding pattern typical of group A rotavirus, although one of them was indistinct. None of the ELISA negative samples gave any banding pattern by PAGE similar to the atypical rotavirus. Six of these strains were different from each other. These strains were circulating in farms, 60-100 km distant from each other, but in the same region. Variations in the electrophorograms of rotaviruses detected in the same farm but at different times of sampling were also observed. The Sri Lankan strains of buffalo calf rotavirus differed from the bovine strain in the migratory pattern of segment 5, whereas the Indian strains differed in the migratory pattern of segment 10. PAGE is a useful technique to distinguish isolates and outbreaks of disease, and in detecting "atypical" rotaviruses where typing antisera are hard to come by. However, electrophorotyping of strains of rotaviruses may not indicate variation in antigenicity of these strains.

H-09 BANDARANAYAKE, A. and NAIR, V.K. **Listeriosis in buffaloes.** *Ceylon Veterinary Journal* (1962) **10,** (1) 43-45. Veterinary Research Laboratory, Peradeniya, SL.

Listeriosis is a sporadic disease caused by a small, motile, Gram-positive bacillus, *Listeria monocytogenes*. This paper describes an outbreak of listeriosis among buffaloes for the first time in Sri Lanka. The disease occurred in a dry zone government farm which carried a herd of around 1,000 buffaloes, of which about 750 were of the Murrah breed. The disease was confined to the milking herd. *L. monocytogenes* was isolated from the heart-blood of five animals between the ages of 3 1/2 months and 6 1/2 years, that died showing no symptoms of encephalitic origin. Cultural characteristics, laboratory and farm animal inoculations were used to confirm that the organism was *L. monocytogenes*. Antibiotic sensitivity test using the impregnated paper disc technique revealed that the organism was sensitive to chlortetracycline (aureomycin) and oxytetracycline (terramycin). It was found to be resistant to streptomycin, sulphathiazole, sulphadiazine, sulphamerazine, and partially resistant to penicillin. Listeriosis is a zoonotic disease which can spread to man by exposure to secretions and excretions of infected animals or through consumption of uncooked meat or unboiled milk, during the bacteraemic phase of the listeria within the host. In the farm under study, all the milk was disposed in the form of curd, where it is boiled for 20-30 minutes prior to dispensing into pots. Hence, the likelihood of dissemination of the infection through curd was eliminated.

H-10 BAHIRATHAN, M., WEILGAMA, D.J. and WIJESUNDARA, M.K.DE.S. **Coccidial infections in buffalo calves.** *Ceylon Veterinary Journal* (1988/89) **36,** 44-45 [Abstract]. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

Although coccidia are known to cause mortality among buffalo calves in Sri Lanka, few studies have been reported on coccidiosis in buffaloes. The present investigation was carried out to determine the species of coccidia and their prevalence in buffalo calves managed on a large farm in the North Western Province. Faecal samples were collected at 10 to 13 day intervals from birth. Samples were subjected to sugar floatation to detect and identify coccidial oocysts. Oocyst counts were made using the McMaster technique. Nine species of *Eimeria* hitherto unreported in Sri Lanka were detected from buffaloes. These include *E. subspherica, E. bareillyi, E. bovis, E. canadensis, E. cylindrica, E. ellipsoidalis, E. zuernii, E. auburnensis* and *E. ankarensis.* The earliest detection of coccidial oocyst excretion was made when calves were 15 days old. The maximum excretion of oocysts (2.07×10^6 oocysts/g of faeces) occurred between 20 to 30 days of age. During this period infection due to *E. bareillyi* and *E. subspherica* was 76% and 23%, respectively. After the second month of life, a low grade infection was observed in calves, involving all 9 species of coccidia. Thirty two of the 49 calves tested showed diarrhoea between 11 and 48 days of age. Nineteen diarrhoeic calves had oocyst counts of 1.25×10^5- 8.69×10^6/g of faeces but only two species of coccidia, namely *E. bareillyi* (90% - 100%) and *E. subspherica* (0.1%) were present in these calves. Eleven calves which had diarrhoea, died between 23 and 57 days of age. *Eimeria bareillyi* and *E. subspherica* appeared to be the most important species of coccidia among young buffalo calves and could be an important cause of diarrhoea in these animals.

H-11 DASSANAYAKE, L. **The haemorrhagic septicaemia outbreak of 1955-56.** *Ceylon Veterinary Journal* (1957) **5,** 56-58. Veterinary Research Laboratory, Peradeniya, SL.

It is generally accepted that haemorrhagic septicaemia is primarily a bovine disease caused exclusively by *Pasteurella multocida* (Type I); that cattle and buffaloes are the main carriers; that stress factors precipitate the disease and spread is through contaminated material. There appears to be a difference of opinion in this country as regards to the source of the infection for the major outbreak in the North Central Province (NCP) in 1955 as an outbreak of that dimension had not been recorded in the past, although there have been minor outbreaks of a sporadic nature. HS has occurred sporadically and at intervals of 2-3 years in almost all the provinces of the island, during the past 25 years. However, nearly 65% of these outbreaks have been in the Sabaragamuwa and Uva provinces. The most severe outbreak prior to 1955 was in 1937, particularly in the Eastern and Western Provinces resulting in 274 cases. The question then arises as to why those outbreaks were not as alarming or severe as the outbreak during the 1955-56 period. An examination of the stress factors to which the animals were exposed during 1955-56 allows speculation and a possible explanation for the massive outbreak. The stress factors to which animals in the NCP were particularly subjected to may be summarised as follows: (a) it had been a period of unprecedented drought, (b) the animals have been subjected to severe physical strain as it has been one of the best paddy seasons, (c) the adequate availability of water from the major and minor irrigation schemes and (d) there has been a very substantial shrinkage of the extent of grazing land available per animal due to an increase of the buffalo population, the ban on the slaughter of buffaloes and the opening up of the new land for growing paddy. These factors strongly suggests that

stress imposed by climatic factors as well as agricultural practises may have lead to the extensive outbreak of haemorrhagic sépticaemia in 1955.

H-12 DE ALWIS, M.C.L. **Haemorrhagic septicaemia (*Pasteurella multocida* serotype B:2 and E:2 infection) in cattle and buffaloes** In: *Haemophilus, Actinobacillus and Pasteurella.* [Edited by Donachie, W *et al.*] New York, USA Plenum Press. 1995 pp. 9-24. Veterinary Research Institute, Peradeniya, SL.

This paper reviews the literature of haemorrhagic septicaemia (HS), an acute septicaemic disease in cattle and buffaloes caused by specific serotypes of *Pasteurella multocida*. The review has a separate part on the disease which includes sections on pathogenesis, clinical syndrome, the occurrence and the economic losses cause by the disease. Included in the paper is also a comprehensive review of the epidemiology of HS, which deals with information related to the seasonal incidence, host susceptibility and factors affecting morbidity and mortality. In addition the paper reviews the diagnostic procedures, treatment and control of HS through vaccination.

H-13 DE ALWIS, M.C.L. **Haemorrhagic septicaemia - A general review.** *British Veterinary Journal* (1992) **148,** 99-112. Veterinary Research Institute, Peradeniya, SL.

This is a review of haemorrhagic septicaemia (HS). It critically reviews the current information on the aetiology, occurrence and distribution, economic losses, clinical syndrome, pathology, epidemiology, diagnosis, treatment and the control of HS. The section on epidemiology is extensive and deals with host animals, morbidity, mortality and case fatality, naturally acquired immunity, carrier status, the relationship between naturally acquired immunity and the carrier status and the epidemiological cycle. The section on diagnosis covers clinical diagnosis, laboratory diagnosis, serological typing, serotype designation and detection of antibodies. The paper concludes with sections on treatment and the control of HS through vaccination.

H-14 DE ALWIS, M.C.L. **Epidemiology of haemorrhagic septicaemia and the economics of control of the disease.** In: *Proceedings of the 5th Conference of the Institute of Tropical Veterinary Medicine, 1986. Kuala Lumpur, Malaysia.* pp. 133-136. Veterinary Research Institute, Peradeniya, SL.

Haemorrhagic septicaemia is an acute, highly fatal, septicaemic disease in cattle and buffaloes caused by the specific serotypes of *Pasteurella multocida,* (6:B and 6:E; Namioka-Carter). Recent studies seem to indicate that the disease occurs throughout the year, and that outbreaks are contained during the dry season. Outbreaks occurring during the rainy season spread, presumably due to the longer survival of the organism in the environment under moist conditions. Wide variations in morbidity, ranging from less than 5% to nearly 90% have been recorded. When clinical signs appear, it is often too late for treatment to be effective. The only opportunity for successful treatment is following the detection of the first case, regular monitoring of the rectal temperatures of all in contact animals and immediate treatment of any in the initial febrile stage. In most Asian countries losses due to HS are higher in buffaloes than in cattle and more common in young livestock under 2 years of age. In endemic areas, the mortality in each outbreak is low whereas in non-endemic areas high mortality is recorded irrespective of age. The lowest incidence is found to be in well managed, stall fed herds under stall fed conditions. In HS endemic areas, a high proportion of animals have naturally acquired immunity and in non-endemic areas animals remain susceptible. It has been shown that the level of naturally acquired immunity is of a higher magnitude than that induced by vaccination. Most of the animals exposed to HS were immune and were "latent carriers". But they become "active carriers" intermittently for short periods. It appeared that in the HS endemic areas in Sri Lanka, about two thirds of all buffalo deaths were caused by HS. In endemic areas, routine prophylactic vaccination appears to be economically worthwhile. With continued vaccination and a high coverage over several successive years, outbreaks of HS can be totally eliminated. But it is advisable to continue vaccination regularly despite the absence of disease, in order to keep up the immunity level as an insurance against the remote possibility of an outbreak.

H-15 DE ALWIS, M.C.L. **Haemorrhagic septicaemia in cattle and buffaloes.** *Revue Scientific et Technique Office International des epizootics* (1984) **3,** (4) 707-730. Veterinary Research Institute, Peradeniya, SL.

This is a review of haemorrhagic septicaemia (HS) in cattle and buffaloes. It critically reviews the literature on the aetiology, occurrence and distribution, economic losses, clinical syndrome, pathology, epidemiology, diagnosis, treatment and the control of HS.

H-16 DE ALWIS, M.C.L. **Immune status of buffalo calves exposed to natural infection with haemorrhagic septicaemia.** *Tropical Animal Health and Production* (1982) **14,** 29-30. Veterinary Research Institute, Peradeniya, SL.

Mortality patterns due to haemorrhagic septicaemia (HS) in the enzootic areas of Sri Lanka have indicated that those animals that survive an epizootic of HS are immune thereafter and that deaths are confined to calves born between epizootics. This paper describes the immune status of a group of buffalo calves following natural infection with HS. Twenty six buffalo calves were subjected to a natural infection of HS by housing them with calves clinically affected by the disease. The buffalo calves were closely observed and bled periodically. Serum antibodies against HS were assayed by the indirect haemagglutination (IHA) test followed by the passive mouse protection test (PMPT); an IHA titre of 1 in 10 and over was regarded as positive. Seven of the 26 calves died of HS within14 days. Of the surviving 19 calves, 13 had IHA titres ranging from 1/40 to 1/640 at 4 weeks post-exposure; 4 animals had no IHA antibodies, while in two the results were low or inconsistent. Six months after exposure the IHA titre had dropped to low levels ranging from 1 in 10 to 1 in 40. The results of the PMPT closely corresponded with the IHA titres during the first 6 months. Six calves with high IHA titres when reared in an HS-free area for 8 months still had mouse protective antibodies in serum dilutions ranging from 1 in 4 to 1 in 64. The results of this study suggests that when susceptible buffalo calves are exposed to natural infection with HS some calves died from HS, while others developed varying degrees of immunity which in most instances is considerably higher than that induced by vaccination.

H-17 DE ALWIS, M.C.L. **Mortality among cattle and buffaloes in Sri Lanka due to haemorrhagic septicaemia.** *Tropical Animal Health and Production* (1981) **13,** 195-202. Veterinary Research Institute, Peradeniya, SL.

Data on the mortality of cattle and buffaloes in 62 epizootics of haemorrhagic septicaemia (HS) in the HS enzootic and non-enzootic regions of Sri Lanka, were collected and subjected to statistical analysis. It was found that the overall mortality for buffaloes was higher than for cattle (45.2% and 15.8% respectively, P<0.001). For buffaloes in enzootic areas, the overall mortality was 29% whilst in non-enzootic areas it was 64.5% (P<0.05). In the enzootic areas deaths were mainly confined to young animals whereas in the non-enzootic areas where outbreaks of HS occurred the deaths were scattered over all age groups. The vaccines used, vaccination schedules adopted and the coverage of vaccination in these herds did not appear to influence the mortality among buffaloes in enzootic areas to a statistically significant degree.

H-18 DE ALWIS, M.C.L. **Epidemiology of haemorrhagic septicaemia in buffaloes and cattle in Sri Lanka.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November, 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982 pp. 135-139. Veterinary Research Institute, Peradeniya, SL.

There is a high incidence of haemorrhagic septicaemia (HS) in the dry zone (which constitutes about 60% of the land area) of Sri Lanka, where the disease is endemic. In the hill country (>1000m), the incidence is low or absent. Elsewhere, sporadic outbreaks occur. In the enzootic areas, epidemics begin during the end of the dry season (August to November). A preliminary epidemiological survey has shown that mortality due to HS is three times higher in the buffalo when compared with cattle (45.2% and 15.8% respectively; P<0.001). In the buffalo, mortality is higher and scattered among all age groups in sporadic epidemics in non-endemic areas, whereas it is lower and confined to young animals in the periodic outbreaks in endemic areas (64.5% and 29% respectively; P<0.05). The phenomenon of naturally acquired immunity (NAI) to HS was also investigated. The proportion of naturally immune animals in low, moderate and high HS incidence areas was 0.47%, 7.2% and 36.% respectively. The highest proportion of naturally immunised animals was found among clinically normal survivors after an epidemic. The level of NAI in some animals following exposure to infection was found to be far superior to that attainable by vaccination. It is believed that the pattern of morbidity is governed largely by the phenomenon of naturally acquired immunity. Studies on the HS status carrier showed that about 2.7% of carriers among cattle and buffaloes were detectable in endemic areas while none were present in the non-endemic areas. The highest detectable carrier rate was found immediately after an epidemic (22.7%) and dropped to 2 % at 6 weeks after the epidemic. Sites of long term carriage of HS in cattle and buffaloes, the status of the carrier organism and the role of other species as reservoirs are aspects that need further investigation.

H-19 DE ALWIS, M.C.L. **The status of haemorrhagic septicaemia in Asia.** *Animal Production and Health Bulletin* (1980) **13,** 1-4. Veterinary Research Institute, Peradeniya, SL.

Haemorrhagic septicaemia (HS) has been recognised as an economically important disease entity in most Asian countries. HS breaks out in times of maximum stress and is associated with the wet season. In Sri Lanka, morbidity due to HS in buffaloes is three times higher than that in cattle. In this region, most losses from HS occur in the age

group of 1-2 years. Most countries in Asia have recorded a lower incidence of HS among exotic breeds and their crosses because they are better managed than the indigenous ones. In Asian countries only serotype 6:B is reported to occur whereas 6:E is the dominant serotype in the African region. A few West Asian and Middle Eastern countries have recorded the incidence of both serotypes. HS causing pasteurellae have been isolated from pigs in most of the Asian countries. The presence of the organism in sheep, goat, horse and in elephant has also been recorded. In this region, vaccination is the accepted means of control of HS. All countries adopt prophylactic vaccination, at least in the enzootic areas. Broth bacterin, alum precipitated vaccine and oil adjuvant vaccine (OAV) are the most popular preparations. Vaccines used in different countries vary in the strain of the organisms used and the bacterial content. The duration of immunity conferred by the alum-precipitated vaccine is between 3-6 months whereas that by the OAV varies from 6-9 months to 28 months. Besides the strain and the bacterial content, the other factors which can lead to these variations are the method and the medium of growth, harvesting time and the method of evaluation of the immunity. OAV is the best of the available vaccines but only a few countries produce it on a large scale. At present, some degree of control of the disease has been achieved through vaccination. However, a more effective control of HS would require a better understanding of its epizootiology, better vaccines and indeed greater vaccination coverage.

H-20 DE ALWIS, M.C.L. **Preliminary field trails with a streptomycin-dependent vaccine against haemorrhagic septicaemia.** *Veterinary Record* (1980) **106,** 435-437. Veterinary Research Institute, Peradeniya, SL.

Studies using a streptomycin-dependent mutant of a type B *Pasteurella multocida* had been found to protect mice and rabbits challenged with a homologous virulent *P. multocida*. This papers describes two trials in which 68 cattle and buffalo calves, 4 to 10 months of age, were vaccinated with a live streptomycin-dependent mutant of *Pasteurella multocida* type B isolated in Sri Lanka. Immunity was assessed using a passive protection test in mice with cattle and buffalo sera, before and two or three weeks after vaccination. A single dose of vaccine conferred immunity in 66.6% to 83.3% of cattle and 100% of buffalo calves. A booster dose given three weeks later enhanced the immunity in cattle. There was no significant difference in the response, whether the vaccine was administered by the subcutaneous or intramuscular route. No adverse reactions were observed in any of the vaccinated animals.

H-21 DE ALWIS, M.C.L., CARTER, G.R. and CHENGAPPA, M.M. **Production and characterisation of streptomycin dependent mutants of *Pasteurella multocida* from bovine haemorrhagic septicaemia.** *Canadian Journal of Comparative Medicine* (1980) **44,** 418-422. Veterinary Research Institute, Peradeniya, SL.

A larger number of streptomycin dependent mutants were produced from bovine haemorrhagic septicaemia strains of *Pasteurella multocida*. The mutants required a minimum concentration of 20-50 µg/ml of streptomycin for growth and tolerated a concentration of 200 mg/ml. These mutants were avirulent to mice, when inoculated alone but some mutants killed mice when inoculated with streptomycin. Biochemically all mutants were uniform and similar to the wild type. Most mutants were stable, but a few produced streptomycin independent revertants. The rate of reversion varied with each mutant. Most revertants were highly virulent for mice, some totally avirulent and a few relatively avirulent.

H-22 DE ALWIS, M.C.L., GOMIS, A.I.U., VIPULASIRI, A.A. and RATHAKRISHNAN, S: **Evaluation of the efficacy of haemorrhagic septicaemia vaccines.** In: *Proceeding of the 4th International Workshop on Haemorrhagic Septicaemia, 11-15 February 1991. Kandy, Sri Lanka.* FAO/APHCA Publication: 1991/13 [Edited by De Alwis, M.C.L. and Wijewardana, T.G.] Bangkok, Thailand, FAO. 1991 pp. 121-123. Veterinary Research Institute, Peradeniya, SL.

Since the use of cattle and buffaloes for routine testing of vaccines was not feasible, an attempt was made to develop a simple laboratory animal model for testing of haemorrhagic septicaemia vaccines. The objective of the study was to establish a correlation between the results of the active mouse protection test (AMPT) and immunity in cattle conferred by the same vaccine. Oil adjuvant vaccines (OAV) were prepared using a standard bacterin containing 1.5 mg/ml bacteria (dry weight) and with dilutions of this bacterin. AMPT was carried out with each of these vaccines. Groups of cattle were given the OAV prepared from different dilutions of the bacterin. Passive mouse protection tests (PMPT) were performed using pre and post vaccination cattle sera to protect mice, and a field isolate for challenge. It was found that the AMPT gave undiminished protection with vaccines containing as low as 0.75 mg/bacteria per 3 ml cattle dose, whereas passive protection diminished when the bacterial content in the vaccine was reduced to 1.5 mg per 3 ml dose. It is concluded that the AMPT alone is not a reliable index of cattle imunity

and that a minimum bacterial content should also be ensured in the vaccine.

H-23 DE ALWIS, M.C.L., GUNATILLAKE, A.A.P. and WICKRAMASINGHE, W.A.T. **Duration of immunity to haemorrhagic septicaemia in cattle following immunisation with alum precipitated and oil adjuvant vaccines.** *Ceylon Veterinary Journal* (1978) **26,** 35-41. Veterinary Research Institute, Peradeniya, SL.

Under the conditions prevailing in most countries where HS is enzootic, vaccination of cattle and buffaloes more often than once a year is not feasible. A vaccine that gives a maximum of one year immunity with a single dose is thus required. A series of four experiments using a total of 269 animals were carried out in areas where haemorrhagic septicaemia is enzootic as well as non enzootic, to determine the level and duration of immunity in buffaloes and cattle following immunisation with alum precipitated and oil adjuvant vaccines. The immune response was evaluated by the indirect haemagglutination test, passive protection test in mice and by direct challenge with virulent cultures. It was found that calves under 3 1/2 months of age responded poorly to both vaccines, whilst in those 3 1/2 to 5 months of age, the alum precipitated vaccine gave protection for 3-4 months and the oil adjuvant vaccine for 6-9 months. Exposure of vaccinated animals to natural infection prolonged the duration of immunity. Unvaccinated controls similarly exposed, also developed immunity. The sensitivity of the indirect haemagglutination test was insufficient to detect immunity in vaccinated cattle, whilst the mouse protection test was satisfactory.

H-24 DE ALWIS, M.C.L., HORADAGODA, N.U., WIJEWARDANA, T.G., ABEYNAYAKE, P., VIPULASIRI, A.A. and THALAGODA, S.A. **Further studies on the epidemiology and immunology of haemorrhagic septicaemia in buffaloes.** In: *The role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 371-392. Veterinary Research Institute, Peradeniya, SL.

Three separate studies were conducted to investigate some aspects of the epidemiology and immunology of haemorrhagic septicaemia (HS) in buffaloes. The existence of 'latent' and 'active' carriers in HS, and the intermittent conversion of latent carriers into an active state have been demonstrated in previous studies. It is also known that the carrier state could not be cleared by treatment using antibiotics to which the organism was sensitive *in vitro*. This paper describes (a) immunohistochemical methods used to determine the exact site of localisation of the Pasteurellae within the tonsils of HS carriers, (b) the role of immunosuppression induced by corticosteriods in converting 'latent' carriers to 'active' carriers and (c) the immune response of buffaloes to the current oil adjuvant vaccine. The results indicated that the pasteurellae in HS carriers were localised exclusively in the crypts of the tonsils and that treatment of latent carriers with steroids and Neostigmin failed to trigger the conversion of "latent carrier" to an "active carrier". The protection produced by the oil adjuvant vaccine to direct challenge at 9 m and 12 m was 50% and 67%, respectively. There was however, no correlation between the response to direct challenge and antibody titres.

H-25 DE ALWIS, M.C.L., JAYASEKERA, M.U. and BALASUNDARAM, P. **Pneumonic pasteurellosis in buffalo calves associated with *Pasteurella multocida* serotype 6:B.** *Ceylon Veterinary Journal* (1975) **23,** 58-60. Veterinary Research Institute, Peradeniya, SL.

This paper describes an outbreak of pneumonia in a batch of 96 buffalo calves aged between 4 and 10 months. Thirty three calves were affected and thirty died. The course of the disease ranged from 2-10 days, from the onset of visible signs of the disease. Six of these calves were examined and *P. multocida* serotype 6:B was isolated from the lung tissue and heart blood of all. In a series of transmission experiments, it was found that this same isolate was capable of producing in healthy calves, a pneumonic syndrome similar to the naturally occurring condition, as well as the characteristic form of haemorrhagic septicaemia. It is postulated that in calves having low levels of immunity, insufficient to withstand infection altogether, type 6:B caused a protracted pneumonic syndrome instead of the characteristic clinical features of haemorrhagic septicaemia.

H-26 DE ALWIS, M.C.L., KODITUWAKKU, A.O. and KODITUWAKKU, S. **Haemorrhagic septicaemia - an analysis of two outbreaks of disease among buffaloes.** *Ceylon Veterinary Journal* (1976) **24,** 18-21. Veterinary Research Institute, Peradeniya, SL.

This paper analyses the outbreaks of HS in two herds consisting of 1165 and 1617 buffaloes, respectively. The overall mortality in the two herds was 8.2% and 2.3%, respectively. In both herds the highest mortality was recorded in the 6-18 month age group. No deaths occurred among animals over 4 years of age and only one death occurred in animals under 6 months of age although these 2 age

groups in the two herds together constituted 47.6 % and 11.5 % respectively of the herd strength. Mortality in the 2-4 year age group was also negligible. The prophylactic measure against HS adopted on both farms was vaccination with the oil adjuvant vaccine at 4 months of age followed by annual revaccination thereafter. It was found that in the two herds, 91.4 % and 84.2 %, respectively of the animals that died, were those which had received only a single vaccination. It is postulated that older animals are immunised as a result of repeated vaccination and that for better protection of young stock, several booster doses of vaccine need to be given at short intervals in the first two years of life, in addition to the primary vaccination.

H-27 DE ALWIS, M.C.L. and PANANGALA, V.S. **A biochemical and serological study of strains of *Pasteurella multocida* associated with haemorrhagic septicaemia in cattle and buffaloes in Sri Lanka.** *Ceylon Veterinary Journal* (1974) **22,** 58-65. Veterinary Research Institute, Peradeniya, SL.

The objective of this investigation was to study the cultural and biochemical characteristics and to define the serological status of strains of *Pasteurella multocida* isolated from outbreaks of HS in Sri Lanka. Fifty different isolates of *P. multocida* were subjected to biochemical examination. Twenty seven of these were examined serologically. These isolates were found to be catalase, oxidase, indole and nitrate positive, and urease and citrate negative. They failed to liquefy gelatine, grow on McConkey medium or produce hydrogen sulphide. All isolates consistently fermented glucose, sucrose and sorbitol. The fermentation of maltose, mannitol, xylose and arabinose was variable. Serologically, the isolates tested belonged to capsular type B (Carter), and somatic type 6 (Namioka and Murata).

H-28 DE ALWIS, M.C.L. and SUMANADASA, M.A. **Naturally acquired immunity to haemorrhagic septicaemia among cattle and buffaloes in Sri Lanka.** *Tropical Animal Health and Production.* (1982) **14,** 27-28.

The phenomenon of naturally acquired immunity (NAI) to haemorrhagic septicaemia (HS) is already established among cattle and buffaloes in Thailand. The objective of this investigation was to determine the incidence of NAI to HS among cattle and buffaloes in Sri Lanka and to ascertain its likely role in the epizootiology of the disease. Unvaccinated animal were selected from high incidence (504), moderate incidence (212) and low incidence (209) areas. Immunity was assessed by the indirect haemagglutination test. Titres of 1 in 10 and above were regarded as positive. The incidence of NAI was related to the incidence of HS in the region and ranged from 0.47% in the low incidence areas to 7.2% in the moderate incidence areas and 36.1% in the high incidence areas. The difference were significant at a probability level of 0.005. No animals below 2 years of age in the low and moderate incidence areas were naturally immune, whilst 3.3 and 12 percent respectively were immune among the 2 year olds. In the high incidence areas 12.8% of under 2 year olds and 48.3% of over 2 year olds were found to be naturally immune. Even in the same herd naturally immune animals vary from time to time. This investigation provided reasonable evidence that in Sri Lanka the phenomenon of NAI contributes significantly towards the mortality patterns in the different regions of the island.

H-29 DE ALWIS, M.C.L. and VIPULASIRI, A.A. **An epizootiological study of haemorrhagic septicaemia in buffaloes and cattle in Sri Lanka.** *Ceylon Veterinary Journal* (1980) **28,** 24-35. Veterinary Research Institute, Peradeniya, SL.

A study of the haemorrhagic septicaemia (HS) status was carried out in the enzootic dry zone of Sri Lanka. Data were collected from farmers using a questionnaire. The survey involved 22,297 buffaloes in 803 herds and 20,878 cattle in 870 herds, and covered epizootics that occurred during the period 1978-1980. It was found that 48.4% of the buffalo herds and 38.5% of the cattle herds had experienced epizootics during the period covered by the survey. Mortality due to HS was significantly higher in buffaloes than in cattle ($p<0.001$). Nearly two-thirds of all HS losses in buffaloes and four-fifths in cattle were in the under 2-year age group. In herds with a higher frequency of incidence of HS, the mean mortality was lower than in those with a lower frequency of incidence. The percentage of herds infected was low in small herds of under 10 animals (20.9% and 22.6% for buffaloes and cattle, respectively) and increased progressively reaching 98.3% and 82.6% for herds of over 50 animals. Only 36.5% buffaloes and 34.0% cattle had been subjected to prophylactic vaccination. Prophylactic vaccination significantly reduced the percentage of herds infected, but not the mortality. Vaccination in the face of epizootics also reduced mortality. The incidence of HS was mainly seasonal, the rise in incidence commencing in August and reaching a peak in October while the seasonal monsoon rains started in September and reached a peak in November.

H-30 DE ALWIS, M.C.L., WIJEWARDANA, T.G., GOMIS, A.I.U. AND VIPULASIRI, A. A. **Persistence of carrier status in haemorrhagic septicaemia (*Pasteurella multocida* serotype 6:B infection) in buffaloes.** *Tropical Animal Health and Production*

22, 185-194. Veterinary Research Institute, Peradeniya, SL.

Fifty-seven buffaloes were experimentally infected or naturally exposed to haemorrhagic septicaemia (HS). Of these animals 32 became immune carriers. They were observed in groups for periods up to 360 days to monitor the appearance of pasteurellae in the nasopharynx and the antibody status. In most animals pasteurellae appeared in the nasopharynx for a short period initially and disappeared. The organism reappeared intermittently and the longest observed period of reappearance was 215 days after exposure. All animals showed rising antibody titres with a peak lasting 150 to 180 days and declined thereafter. Pasteurellae persisted in the tonsils and were isolated from 20 out of 27 carriers after slaughter. The longest period when isolation was made after slaughter was 229 days. The organism lodged in the tonsils was unaffected by antibacterial therapy using drugs to which the organism displayed *in vitro* sensitivity. It is concluded that in HS, carrier animals exist in an active as well as a latent state, the former appearing for short intermittent periods between long latent periods, when pasteurellae continue to remain in the tonsils which constitute a long-term reservoir.

H-31 DE ALWIS, M.C.L., WIJEWARDANA, T.G., SIVARAM, A. and VIPULASIRI, A.A. **The carrier and antibody status of cattle and buffaloes exposed to haemorrhagic septicaemia: Investigations on survivors following natural outbreaks.** *Sri Lanka Veterinary Journal* (1986) **34,** 33-42. Veterinary Research Institute, Peradeniya, SL.

A total of 87 cattle and buffaloes in 3 herds were examined for the presence of HS-causing pasteurellae in the nasopharynx, on 5-6 occasions during periods of 213, 190 and 161 days. The percentage of carrier animals detected in the herds ranged from 12% to 40%. In the groups of animals, 80% to 100% developed antibody titres during this period. Fourteen of the 16 carrier animals displayed a carrier status only on one occasion, and one animal on consecutive occasions. One other animal showed evidence of intermittent appearance of the organism in the nasopharynx. Different animals showed up as carriers on each day of examination. It is postulated that in carrier animals, the organism may be present in some other site/s and appears in the nasopharynx intermittently. Further investigations with more animals and more frequent examinations are considered necessary to elucidate further, the nature of the carrier status in HS.

H-32 DE ALWIS, M.C.L., WIJEWARDANA, T.G. and VIPULASIRI, A.A. **The significance of the carrier animal in the epidemiology of haemorrhagic septicaemia.** In: *Proceedings of the 5th Conference of the Institute of Tropical Veterinary Medicine, 18-22 August, 1986. Kuala Lumpur, Malaysia.* pp. 99-100. Veterinary Research Institute, Peradeniya, Sri Lanka.

In order to elucidate exact nature of the carrier status in HS and its significance in the epidemiology of the disease an investigation was carried out on 35 young, non-immune buffaloes maintained in the premises of the Veterinary Research Institute. Nine of them were experimentally infected with HS and placed in contact with 26 others. In order to facilitate detection of the infecting strain, a streptomycin resistant strain was used as a marker. The animals were monitored for antibody development and the appearance of the organism in the nasopharynx for periods up to one year. Selected animals were slaughtered at varying times after exposure. During periods when nasopharyngeal cultures were negative attempts were made to isolate the organism from 14 different sites, most of them being lymph nodes. The most consistent site of isolation was the tonsils and the longest period after exposure when isolations were made was 229 days. It appears that among buffaloes that survive exposure to HS, a high proportion become 'latent' carriers. In such animals, the organism persist in the lymphoid tissue, particularly the tonsil but may appear in the nasopharynx intermittently, when they become active carriers or shedders. Such animals are presumably the source of infection to susceptible in-contact animals, in fresh outbreaks.

H-33 DEP, H.M.S.S. **"Mycoplasma" of the respiratory tract of buffalo calves in Sri Lanka.** *M.Phil. Thesis* (1991) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Nasal swabs collected from 148 buffalo calves, one day to less than 10 months old, were examined for the presence of "mycoplasmas" in four farms in Sri Lanka, located at Polonnaruwa, Nikaweratiya and Mawalawatte. Thirty three per cent of these buffalo calves had respiratory disease at the time of sampling. The other 67 per cent were apparently normal, but in contact with the calves showing respiratory disease. "Mycoplasmas" were detected in 18.4% (9/49) of clinically sick calves, and in 13% (13/99) of normal calves. The majority of the calves (28.6 per cent) yielding mycoplasmas were in the 181 day to less than 10 months age group. The association between the presence of *Mycoplasma bovigenitalium* in nasal swabs and clinical respiratory disease in sick animals was not

significant (P> 0.01). It must be realised that the sampling carried out was limited. However, there is the possibility of other species of "mycoplasmas" being associated with respiratory disease in buffalo calves. "Mycoplasma" isolates were characterised on the basis of sensitivity to digitonin, fermentation of glucose, formation of films and spots, reduction of tetrazolium salts, aesculin hydrolysis and by serological tests, *viz.* growth inhibition, metabolism inhibition and indirect immunofluorescence, using antiserum prepared against reference cattle mycoplasms strains. Of the 22 buffalo "mycoplasma" isolates, 12 were *Mycoplasma bovigenitalium, 5* were *Mycoplasma bovirhinis,* 3 were *Acholeplasma laidlawii* and the other two could not be identified. With repeated sampling of 12 buffalo calves, naturally infected with mycoplasmas in the Polonnaruwa farm, mycoplasma strains were recovered on more than one occasion from four buffalo calves. Except in one buffalo calf, the other nine haboured mycoplasmas, recovered from each calf were biochemically and serologically similar at every isolation. The buffalo "mycoplasma" isolates, *viz. M. bovigenitalium, M. bovirhinis* and *A. laidlawi* were closely related to the reference strains which were derived from cattle. Antigenic heterogenicity was seen among the "mycoplasma" isolates even though they belong to a single species. The antibody titres measured by the metabolism inhibition test in paired sera of 15 buffalo calves, infected as well as non-infected, showed that only some calves had a fourfold rise, or a high antibody titre against *M. bovigenitalium* isolates. This is the first report of the isolation and characterisation of buffalo calf "mycoplasmas" in Sri Lanka.

H-34 DEP, H.M.S.S., WIJEWANTHA, E.A. and MAHALINGAM, S. **Isolation of a mycoplasma species from the upper respiratory tract of a buffalo calf.** Sri Lanka Veterinary Journal (1990) **37,** 40. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Nasal swabs collected from 148 buffalo calves (age: 1 day to 10 months) from four farms (Polonnaruwa, Nikaweratiya, Narangalla and Mawalawatta) were examined for the presence of "mycoplasmas". At the time of sampling, 33% of these buffalo calves had signs of respiratory diseases whilst the balance 67% were apparently normal. "Mycoplasma" were detected in 18.4% (9/49) of clinically sick calves, and in 13% (13/99) of normal calves. The majority of the calves (28.6%) yielding mycoplasmas were from 6 months to less than 10 months of age. "Mycoplasma" isolates were characterised on the basis of sensitivity to digitonin, fermentation of glucose, formation of films and spots, reduction of tetrazolium salts, aesculin hydrolysis and by serological tests namely, growth inhibition, metabolic inhibition and indirect immunofluorescence, using antiserum prepared against reference cattle mycoplasma strains. Out of the 22 buffalo "mycoplasma" isolates, 12 were *Mycoplasma bovigenitalium*, five were *Mycoplasma bovirhinis*, 3 were *Acholeplasma laidlawii*. Two of the isolates could not be identified. This is the first report of the isolation and characterisation of buffalo "mycoplasmas" in Sri Lanka.

H-35 DE SILVA, D.D.N. **Domosedan as a sedative analgesic in indigenous buffalo** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka. NARESA Press. 1996 pp. 451-456 Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Detomidine HCl (Domosedan, Farmos, Finland) is an imidazole derivative which acts upon α-2 adrenoreceptors. Its sedative/analgesic effect in horses is well documented. In Sri Lanka, the limited availability of an effective sedative/analgesic drug for buffaloes for such purposes as immobilization, preoperative medication, analgesia and restraint of intractable animals for handling and transportation prompted the present study to evaluate the effectiveness of Detomidine HCl as a sedative analgesic. Four dosages 0.1, 0.2, 0.4 and 0.8 ml/100 kg of 1% detomidine HCl solution were tested in 32 male and female buffaloes (8 months to 8 years). Clinical observations as well as rectal temperature, pulse rate and respiratory rate measurements were made prior to and at 1, 5, 10, 15, 20, 30, 45, 90 and 120 minutes after intramuscular administration of the drug into the gluteal region. The results indicated that the dosage of 0.1 ml/100 kg caused only a mild sedation with limited practical use, whereas dosages of 0.2 and 0.4 ml/100kg produced desirable sedative/analgesic effects for clinical examination, preoperative medication, minor surgical procedures and transportation. The highest dosage level of 0.8 ml/100kg produced complete immobilisation characterised by recumbency, very deep sedation and marked analgesia. In general, detomidine caused bradycardia, reduced pulse pressure and salivation while with higher dosages it produced regurgitation. The degree of sedation and analgesia were dose dependent.

H-36 DE SILVA, D.D.N., DANGOLLA, A. and DE SILVA, L.N.A. (1991) **Preliminary studies on sedative and analgesic effects of Detomidine (Domosedan) in buffaloes.** *Sri Lanka Veterinary Journal* **38,** 26 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Detomdine hydrochloride is a new non-narcotic sedative/analgesic drug used in horses. It is an imidazole derivative which acts upon alpha-2 adrenoreceptors. Since the availability of sedative analgesic drugs for buffaloes for various purposes is limited this study was planned to explore the possibility of the use of Detomidine as a sedative/analgesic in this species. In the trial four dosages namely 0.1, 0.2, 0.4, and 0.8 ml/100kg of 1% solution was used intramuscularly in 18 animals whose ages ranged from 8 months to 8 years. Rectal temperature, pulse rate and respiratory rate were measured prior to and at min 1, 5, 10, 15, 20, 30, 45, 60, 90, and 180 after the injection. Qualitative observations *viz.* ataxia, drowsiness, salivation, relaxation of jaw, recumbency, response to painful stimuli etc. were also made after the injection. The results indicated that the dosage of 0.1 ml/100kg caused only a mild sedation which was unlikely to be of any practical use. Whereas dosages of 0.2 ml/100kg and 0.4 ml/100kg was useful to produce desirable sedation for clinical examination, transportation and pre-operative medication. The final dosage of 0.8 ml/100kg produced a very deep sedation associated with recumbency. This dosage was useful for complete immobilisation of the animal. In general, Detomidine caused bradycardia, hypotension, salivation and with higher dosages caused regurgitation. Degree of sedation and analgesia was dose dependent.

H-37 DHANAPALA, S.B. and FERNANDO, C.H. **A record of *Dinobdella ferox* (Blanchard), a leech found in the nasal cavities of a buffalo, with notes on leeches infesting domestic animals in Ceylon.** *Ceylon Veterinary Journal* (1958) **6,** 51-54. Veterinary Research Laboratory, Peradeniya, SL.

A few leeches from the nasal cavities of a buffalo in Matale on examination appeared to be specimens of *Dinobdella ferox* (Blanchard). Attempts to dislodge them with a pair of forceps were unsuccessful until their hold had been weakened by chloroform vapour. They were 20-30 cm long and 1.25-2 cm broad and dirty green in colour. *Dinobdella ferox* lives in swamps, tanks and ponds. When cattle drink water from these places, they crawl into the nasal cavities to suck blood. Brief accounts of other leeches which commonly attack domestic animals in Ceylon are given together with records of leeches attacking domestic animal and man. Instances of leeches acting as intermediate hosts for protozoan blood parasites and causing death of domestic birds are recorded. Precautions against leech bites and the effectiveness of various repellents used against leeches are discussed.

H-38 DHARMASENA, S.P., CHANDRASEKHERAN, N.V., KARUNANAYAKE, E.H., HORADAGODA, N. and MULLERIYAWA, I.S. **Evaluation of a species-specific DNA probe for the detection of *Setaria digitata* infection in buffaloes and goats.** In: *Proceedings of the Forty sixth Annual Session of the Sri Lanka Association for the Advancement of Science, December 1990. Colombo, Sri Lanka.* A-04. Faculty of Medicine, University of Colombo, Colombo, SL.

A highly sensitive and species-specific DNA probe for *S. digitata* has been developed. Recent field studies on the evaluation of this probe in cattle indicated that this probe was more sensitive than conventional methods used for microfilaria detection. The present report describes further evaluation of *S. digitata* probe in buffaloes, a natural host for parasites, and in goats where migration of immature worm is known to cause the paralytic disease, cerebrospinal nematodiasis. Blood samples from goats (n=98) and buffaloes (n=92) were examined by dot-blot assay using ^{32}P labelled cloned DNA as a probe. The DNA probe detected *S. digitata* infection in 50% of goats and in 20% of the buffaloes. Hence the DNA probe we have developed could be used in the detection of microfilariae of *S. digitata* in goats and buffaloes.

H-39 FERNANDO, S.T., GUNAWARDENA, V.K., MASOODI, M.A. and RAJAPAKSE, R.P.V.J. **Serum and colostral precipitin reactions in buffalo cows and colostral transmission of antibodies to the calves.** *Buffalo Journal* (1987) **2,** 195-203. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Buffalo cows at 5-6 months of pregnancy were purchased from an area where *T.vitulorum* patent infections are prevalent in young calves and where high mortality at about 4 weeks after birth is presumably due to *T.vitulorum* infection. The animals were bled regularly and the serum harvested was stored at -20°C until required for use. Colostral whey was prepared from samples of colostrum following the technique of Kloosterman. Extracts of embryonated eggs (EA) prepared with phosphate buffered saline pH 7.2, were used as the antigen. Sera of pregnant buffalo cows were examined for precipitin by the gel diffusion (GPT) and larval precipitin (IVP) tests. Precipitin were noted in the sera of most of the cows to *Toxocara vitulorum* embryonated egg antigen (EA) before, at, and after

parturition. The buffalo cows however did not reveal a patent adult infection in the intestines as was evident from the absence of *T.vitulorum* eggs in the faeces. It is thought that this serum precipitin reaction was presumably stimulated by latent larval infection in the tissue of the host. These antibodies were present in the colostrum for 3-4 days of parturition and they were transferred passively to the suckling calf. The precipitin (GPT) detected from about 24 hours of birth in the serum of the calf, lasted at detectable levels, for 28-35 days. The half-life of the maternal precipitin in the calf serum was not determined. Thus the maternal precipitin (GPT;IVP) transmitted by colostrum to calves did not seem to protect them from the development of a patent infections in their intestines from 17-24 days of birth. Likewise, the presence of serum precipitin in the calves did not seem to effect, also, the presumably pathogenic effect of *T.vitulorum* which sometimes resulted in the death of some calves.

H-40 FERNANDO, S.T., GUNAWARDENA, V.K., SIVANATHAN, S. and SAMARASINGHE, B.T. **Immunological response of pregnant buffalo cows and calves to *Toxocara vitulorum* infection.** In: *Proceedings of the 5th Conference of the Institute of Tropical Veterinary Medicine. Kuala Lumpur, Malaysia, 18-22 August, 1986* pp. 63-64. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, Sri Lanka.

Thirty four swamp buffalo cows, 4-6 years old and 4-6 months pregnant were allowed to graze freely on grass. Faecal, serum and colostrum samples of the cows and the faecal and serum samples of the calves were examined regularly, before, at and after parturition. The sera were examined for antibodies by the enzyme linked immunosorbent assay (ELISA), gel-diffusion precipitin (GPT) and *in vitro* larval precipitin (IVP) tests. Precipitins were detected in the sera of 28 cows, with *T. vitulorum* embryonated egg extracts when used as the antigens. Antibodies were detected in the colostrum too. Likewise in 17 of 26 calves born to these cows, precipitins were detected in the sera from 24 h of birth and but not at birth, indicating that the maternal colostral *T. vitulorum* antibodies are passively transferred to calves. The precipitins (GPT) in the sera of calves at 24 and 48 h of birth were identical to those in maternal colostrum and sera. The passive transfer of *T. vitulorum* maternal antibodies did not protect the calves from acquiring a patent infection pre or perinatally. Thus, it is evident that there are two phases in *T. vitulorum* infection. One is the latent phase, where the larvae remain encysted, presumably in the infective stage, in the body of the buffalo cows. The other is the patent phase which occurs in calves about 21 days after birth.

H-41 FERNANDO, S.T., GUNAWARDENA, V.K., WEILGAMA, D.J., TENNAKOON, B. and WICKRAMTILAKA, G.N. ***Neoascaris vitulorum* infection in buffalo calves: Life cycle, migratory behaviour and immune response of the hosts.** *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982 pp. 133. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Faecal samples of buffalo calves were examined from birth for a period of thirty days for nematode ova and it was observed that eggs of *Strongyloides* spp. appeared about day seven. *Neoascaris vitulorum* infection became patent by days 19-21 of age and by day 30 *Haemonchus* spp. and other trichostrongylid infections became evident. Since *N. vitulorum* is one of the most pathogenic species of nematode responsible for mortality in buffalo calves, studies on the life cycle of this nematode was undertaken. Preliminary studies revealed that *N. vitulorum* shows a marked somatic type of migration in mice and rabbits similar to that of *Toxocara canis*, roundworm of pups. Thus the migratory behaviour of *N. vitulorum* differed from that of *A.suum* which shows a tracheal type of migration. Studies on resistance of mice to reinfection reveal that immunity appears to be directed against the migration of larvae from liver to the lungs. The infective larvae immersed in the sera of rabbits experimentally infected with *N. vitulorum* formed precipitates at the oral orifices indicating the antigenicity of the oral secretions of the infective larvae.

H-42 FERNANDO, S.T., GUNAWARDENA, V.K., WELIGAMA, D.J., TENNAKOON, B. and WICKRAMTILAKA, G.N. **Of *Neoascaris vitulorum* in buffaloes life-cycle and migratory behaviour and some observations on the immunological response of the hosts** In: *Proceedings of the 2nd research co-ordination meeting on nuclear techniques for improved buffalo production 2-6 March 1981 Kuala Lumpur Malaysia.* pp. 75-81. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Faecal samples of buffalo calves were examined from birth for a period of thirty days for nematode ova and it was observed that eggs of Strongyloides spp. appeared from about day seven. *Neoascaris vitulorum* infection became patent by days 19-21 and by day 30 Haemonchus spp. and other Trichostrongylid infections became evident. Since *N.vitulorum* is one of the most pathogenic species of the nematodes responsible for mortality in buffalo calves, studies on the life-cycle of this nematode were undertaken. Preliminary studies

reveal that *N. vitulorum* shows a marked somatic type of migration in mice and rabbits similar to that of *Toxocara canis*, a roundworm of pups. Studies on resistance and migration in mice revealed that immunity is directed against the migration of larvae from the liver to the lungs. The infective larvae immersed in the sera of rabbits and buffalo calves experimentally infected with *N. vitulorum* formed precipitates at the oral orifices, indicating an antigenicity of the oral secretions of infective larvae.

H-43 FERNANDO, S.T., SAMARASINGHE, B.T. and GUNAWARDENA, V.K. **Immunological response of buffaloes infected with *Toxocara vitulorum*.** *Buffalo Journal* (1989) **2,** 205-218 Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Fourteen Murrah buffalo cows reared under experimental conditions on a farm were monitored for nematode infections by regular faecal examinations and counts of nematode eggs per gram of faeces (epg) were made. In all except one animal *Toxocara vitulorum* infection became patent from 19-30 days after birth. Three calves died at about the time of maximal epg counts were present in the faeces. In the other calves, the epg counts fell to zero or near zero levels at 43-76 days after birth. Nine calves that had cleansed themselves of the natural infection were experimentally infected orally when 98-259 days of age with single or repeated doses of infective eggs ranging from 50,000-150,000. The experimental infection did not become patent in any of these calves indicating that the calves had acquired a substantial degree of resistance to the development of an experimental infection or infections. Since previously uninfected control calves from the previous natural infection or is at least partly referable to the immunological maturity resuiting from increase in age of the calves. It was noted also that an experimental infection superimposed on calves that had cleansed themselves of natural infection, reached the liver and lungs. The antibody responses of the calves were elucidated by the Enzyme-Linked-Immunosorbent Assay (ELISA) and Ouchterlony gel diffusion test (GPT). The ELISA titres rose gradually with the increase in epg and continued to rise following the decrease in epg after the peak counts are reached. A phenomenon similar to 'self-cure' in some helminth infestations occurred also with *T.vitulorum* infestation in calves. This reaction, however, occurred spontaneously without any reinfection.

H-44 FERNANDO, S.T., SAMARASINGHE, B.T. and GUNAWARDENA, V.K. **Immunoglobulin classes of antibodies in the sera of buffaloes infected with *Toxocara vitulorum*.** *Journal of the National Science Council of Sri Lanka.* (1989) **17,** 213-228. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Serum samples of buffalo calves naturally infected with *Toxocara vitulorum* were fractionated by means of 'Sephadex' G-200 gel filtration. On gel filtration, the buffalo sera separated into three peaks sometimes with two minor peaks between peak 1 and 2 as were those of other domestic animals. IgM and α_2 macroglobulins were eluted mostly with the peak 1 and the trough following this peak. The IgG's were eluted largely with the peak 2 and the trough following this peak. On further fractionation the bulked and concentrated eluates of peak 2 resolved into two subclasses consisting of IgG_2 and IgG_1. The antibody activity of these classes were examined by the enzyme-linked immunosorbent, gel diffusion, *in vitro* larval precipitin and passive cutaneous anaphylaxis techniques (ELISA, GPT, IVP, PCA). A phosphate buffered saline extract of infective *T.vitulorum* eggs was used as the antigen. The ELISA activity was distributed throughout the peaks 1 and 2, the trough between these peaks and that following peak 2. The GPT and IVP antibodies were present in the IgG_1 and not in IgG_2 the immunoglobulin subclasses constituting the peak 2. The PCA activity was confined largely to the ascending part of peak 1 in the sera collected during the prepatent and patent phases of the infection whereas this activity was mostly confined to two minor peaks preceding peak 2 in the sera collected from days 174 of birth but after the experimental infection with 50,000-100,000 infective eggs on day 160.

H-45 FERNANDO, W.W.H.S. **Foot and mouth disease in buffaloes in Sri Lanka**. In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982 pp. 146-148. Animal Virus Laboratory, Polgolla. SL.

Foot and mouth disease in buffaloes in Sri Lanka has not been systematically investigated despite the importance of this species as a source of milk, draught power, dung and meat. Both wild and domesticated buffaloes in the country suffer from the disease. The severity of the disease in buffaloes vary between outbreaks but is much less evident compared to cattle. Very often there is no salivation or lameness. In the more acute form of the disease, only the feet are affected and very occasionally a single minute blister or erosion may be observed at the apex of the tongue. The lesions in the feet are however, very much milder and cause no lameness or deformities. Recent studies have indicated that the wild buffaloes may serve as a reservoir for the foot and mouth virus. Preliminary investigations on

the immune response of buffaloes to the FMD vaccine suggests that it is not too favourable when compared to that in cattle. Investigation of the possible role of the buffalo as a reservoir of the virus and a likely source of FMD infection is of vital importance for the control and eradication of this disease among domesticated cattle and buffaloes.

H-46 HETTIARACHCHI, R. **Status Report - Sri Lanka** In: *Proceeding of the 4th International Workshop on Haemorrhagic Septicaemia, 11-15 February 1991. Kandy, Sri Lanka.* FAO/APHCA Publication: 1991/13 [Edited by De Alwis, M.C.L. and Wijewardana, T.G.] Bangkok, Thailand, FAO. 1991 pp. 42-47. Department of Animal Production and Health, Peradeniya, SL.

Haemorrhagic septicaemia (HS) is believed to have occurred in Sri Lanka since the early part of the Twentieth century, resulting in sporadic death of cattle and buffaloes, annually. As laboratory diagnostic facilities during that period was limited the disease was not confirmed. The first confirmed outbreak of the disease occurred in the year 1955/56, when the disease broke out in epizootic proportions. Since then, a definite pattern has been established in the incidence and distribution of the disease in the country. Though outbreaks occur at all the times of the year, those occurring during the wet months tend to spread to more areas. Annual mass-scale vaccination programmes which commenced in 1984, has resulted in a significant reduction in the number of cases. The mass-scale vaccinations which have been carried out from June to September improved the immune status of the animals during the stress period, and this would have shifted the peak of seasonal occurrence. HS is diagnosed and confirmed by several serological and biochemical tests. The serological test used include the Indirect Haemagglutination Test (IHA), Agar Gel Precipitation Test (AGPT), Counter-Immuno Electrophoresis (CIEA) and a rapid slide agglutination test. An Enzyme-Linked Immunosorbent Assay (ELISA) has also been developed for serodiagnosis, with the financial assistance through the of FAO/IAEA Co-ordinated Research Programme. Control of the disease is effected by routine prophylactic vaccination. Ring vaccination is adopted in the face of an outbreak together with restrictions on animal movement to and from infected areas

H-47 HIRAMUNE, T. and DE ALWIS, M.C.L. **Haemorrhagic septicaemia carrier status of cattle and buffaloes in Sri Lanka.** *Tropical Animal Health and Production* (1982) **14**, 91-92. Veterinary Research Institute, Peradeniya, SL.

The objective of this study was to determine the percentage of carriers of *Pasteurella multocida* in relation to the incidence of HS with a view of ascertaining the role of carriers in the epizootiology of the disease. Nasal swabs were collected from 839 cattle and buffaloes on 20 different farms in HS enzootic and non-enzootic areas. Swabs were examined for *Pasteurella multocida*. The isolates were identified by biochemical tests and then serotyped. Of the 589 animals examined from enzootic areas 16 (2.7%) were found to be carriers. No carriers were found in the 250 animals that were examined in the non-enzootic areas. All isolates belonged to capsular type B and somatic type 6; they were pathogenic to mice and rabbits but not for poultry. Thirteen of the 16 positive isolations of *P.multocida* from the nasopharynx were made from animals in 8 herds where the disease had occurred within 6 weeks prior to examination. The highest carrier rate of 22.7% was observed in 4 herds where HS had occurred a week previously and diminished to 1.9% in herds where the diseases occurred 6 weeks previously. A significant aspect of this study is the association between the recent incidence of HS in the herd and the rate of isolation of the organism from the nasopharynx. This study confirms that following an epizootic of HS, the surviving, clinically normal, in-contact animals carry virulent pasteurellae in their nasopharynx and that the proportion of such carriers are highest soon after an outbreak and diminishes rapidly thereafter. During this periods such animals could excrete the organism in the nasal secretions and could constitute a source of infection to susceptible animals.

H-48 HORADAGODA, N.U. **Common diseases of the buffalo.** In: *Water buffalo- Improved Utilisation Through New Technologies.* [Edited by Subasinghe, D.H.A. *et al.*] Colombo, Sri Lanka. National Science Foundation. 1998 pp. 67-76. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

It may be true that buffaloes are relatively resistant to most viral and protozoan diseases which affect cattle. On the other hand they are susceptible to certain bacterial and parasitic infections more than cattle. For example, the round worm infection caused by *Toxocara vitulorum* affects buffalo calves more severely than cattle calves similarly haemorrhagic septicaemia, caused by the Gram-negative bacterium, *Pasteurella multocida* affects buffaloes more than cattle. Therefore it is a fallacy to assume that buffalo diseases are the same as those present in cattle. This chapter briefly describes the common diseases of the buffalo with particular reference to the cause(s), clinical signs, prevention and control. The diseases are broadly classified as those caused by parasites, bacteria and viruses while separate sections on common diseases affecting body systems and those affecting calves are also included.

This chapter on buffalo diseases is intended for the general reading but teachers, extension workers and students may find the information useful.

H-49 HORADAGODA, N.U. and BELAK, K. **Demonstration of *Pasteurella multocida* type 6:B (B:2) in formalin-fixed paraffin-embedded tissues of buffaloes by the Peroxidase Anti-Peroxidase (PAP) technique.** *Acta Veterinaria Scandinavica* (1990) **31,** 439-495. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This report describes the use of a rabbit polyclonal antibody for immunohistochemical detection of *P. multocida* serotype 6:B antigen in formalin fixed paraffin-embedded tissues from the buffalo. Tonsils from experimentally induced HS carriers and lungs, kidney, intestines and liver from animals that died following experimental infections were tested. Tissue samples from non-infected buffalo calves and tonsils collected from cattle calves were used as negative controls. All tissues were fixed in 10% neutral buffered formalin and embedded in paraffin. Sections were processed and incubated for 45 min with a 1:5000 dilution of Pasteurella rabbit antiserum followed by 30 min. incubation with swine anti-rabbit IgG and rabbit PAP complex diluted 1:20 and 1:100, respectively. Peroxidase activity in tissues was visualised by incubating section for 8 min in TBS containing 0.06% (w/v) diaminobenzidine and 0.034% (v/v) hydrogen peroxide. Finally the sections were rinsed in water, counter stained in Mayer's haematoxylin. Antigens to *P. multocida* were confined to the lumen of the tonsillar crypt while the lining epithelium and lymphoid tissues were completely devoid of any immunoreaction. In the lungs diffuse immuno staining was present in alveoli with increased concentration within the alveolar macrophages and lymphatics of the interlobular septae and pleura. In the kidneys, intestines and liver, staining was present exclusively in the blood vascular system indicating the terminal septicaemia associated with HS.

H-50 HORADAGODA, N.U., BELAK, K., DE ALWIS, M.C.L., GOMIS, A.I.U. and VIPULASIRI, A.A. **Localisation of *Pasteurella multocida* serotype 6:B in the tonsils of carrier-buffaloes using an immunoperoxidase technique.** In: *Proceeding of the 4th International Workshop on Haemorrhagic Septicaemia, 11-15 February 1991. Kandy, Sri Lanka.* FAO/APHCA Publication: 1991/13 [Edited by De Alwis, M.C.L. and Wijewardana, T.G.] Bangkok, Thailand, FAO. 1991 pp. 104-108. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, Sri Lanka.

The localisation of *Pasteurella multocida* in the tonsils of experimentally produced haemorrhagic septicaemia-carrier buffaloes was examined by the peroxidase anti-peroxidase technique using a polyclonal antiserum prepared in rabbits. Immunostaining of formalin-fixed, paraffin embedded tissue sections of the tonsils from infected animals revealed *Pasteurella multocida* in the lumen of the tonsillar crypts. The epithelium lining and lymphoid tissue were devoid of any immunoreaction. In the crypts, diffuse immunostaining was present amidst the desquamated epithelial cells and necrotic material while intracellular immunoreactivity was not detected in the tonsils of non-infected buffalo and bovine calves used as controls. In all carrier animals *Pasteurella multocida* was isolated from the tonsils. The calves also demonstrated high antibody titres to the disease. The findings of this study indicate that pasteurellae in the tonsils of haemorrhagic septicaemia carries are confined to the lumen of the tonsillar crypts.

H-51 HORADAGODA, N.U., BELAK, K., DE ALWIS, M.C.L., GOMIS, A.I.U. and VIPULASIRI, A.A. **Immunoperoxidase evaluation of buffalo tissues in acute haemorrhagic septicaemia.** *Annals of the New York Academy of Sciences* (1998) **849,** 490-493. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This study was undertaken to elucidate the tissue distribution of *Pasteurella multocida* serotype 6:B, the causative organism of haemorrhagic septicaemia (HS), an acute, highly infectious fatal disease of buffaloes and cattle, particularly in Asia. Six buffalo calves (7-12 months) were inoculated intranasally with *P. multocida* serotype 6:B. Tissues were collected at necropsy, fixed in buffered formalin, processed and paraffin-embedded sections examined for immunostaining by the peroxidase anti-peroxidase technique (Acta vet. scand. 1990, 31: 493-495). The lesions in the lungs were characteristic of an acute fibrinous pneumonia with diffused immunostaining of the affected alveoli. Intense staining was observed within the cytoplasm of macrophages present inside the alveolar space as well as in the interlobular septae that bordered the affected alveoli. In the pericardium, staining was generally diffused with several foci of intense staining resembling colonies of the organism. In the gastrointestinal tract, the immunoreaction was largely confined to the blood vessels of the submucosa and serosa while in the kidney the immunostaining was present in the glomerular tuft and in blood vessels of the renal cortex and medulla. Staining was also present in the Kupffer cells of the liver. The immunoreaction in the lymph nodes were confined to the capillaries in the paracortical area. The tissue localisation reported herein enhanced the

understanding of the pathogenesis of HS in the buffalo during the acute phase of the infection.

H-52 HORADAGODA, N.U., DE ALWIS, M.C.L., GOMIS, A.I.U., MOLLIGODA, S.C. and VIPULASIRI, A.A. **Pathological studies of haemorrhagic septicaemia in buffalo calves.** *Sri Lanka Veterinary Journal* (1991) **38,** 32-33, [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Haemorrhagic septicaemia (HS) is identified as an important cause of mortality among buffaloes in Sri Lanka as well as in many Asian countries. Despite the wide prevalence of the disease there is a dearth of information on the pathogenesis. This was pursued in the present study following an experimental infection (intranasal) of buffalo calves with *Pasteurella multocida* serotype 6:B. The incubation period of the infection varied from 18 to 66 hours. Clinically, the animals were depressed, dyspneic, anorexic and had an increased temperature (104-106^0 F). The latter phase of the clinical course was characterised by recumbency and a sudden drop in temperature to subnormal levels. Submandibular and brisket oedema observed in HS in cattle was not a prominent clinical feature in these buffaloes. The length of the entire clinical course of the disease in the buffalo calves lasted between 2 and 5 days. The pathological lesions at post-mortem were largely confined to the thoracic cavity. The pleural cavity contained a large accumulation of effusion. There was pneumonic consolidation of the anterio-ventral region of the lungs with a marked thickening of the overlying pleura which was also adherent to the costal wall. The pericardium was also markedly thickened and adherent to the pleura. Several areas with petechial and ecchymotic haemorrhages were observed in the subepicardium tissue around the base of the heart and in the subendocardium of the ventricles. The only significant lesion in the abdominal cavity was the presence of diffuse haemorrhage of the mucosa in the abomasum and the proximal small intestines. Histologically, the pneumonic lesions were characterised by an acute fibrinous bronchopneumonia. In the pleura and interlobular septae, there was an extensive deposition of fibrin together with oedema, leucocyte infiltration and a dilatation of lymphatics. The pericardial changes indicated a fibrinous pericarditis associated with a proliferation of connective tissue. *Pasteurella multocida* was consistently recovered from the nasopharynx following inoculation. The organism was also isolated from venous blood during the latter phase of the clinical course and from heart blood at necropsy.

H-53 HORADAGODA, N.U., DE ALWIS, M.C.L., WIJEWARDANA, T.G., BELAK, K., GOMIS, A.I.U. and VIPULASIRI, A.A. **Experimental haemorrhagic septicaemia in buffalo calves.** In: *Proceeding of the 4th International Workshop on Haemorrhagic Septicaemia, 11-15 February 1991. Kandy, Sri Lanka.* FAO/APHCA Publication: 1991/13 [Edited by De Alwis, M.C.L. and Wijewardana, T.G.] Bangkok, Thailand, FAO. 1991 pp. 73-80. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Field cases of HS usually occurs in remote areas where laboratory facilities are not available for close monitoring of the clinical course and pathogenesis of the disease. This drawback has been overcome by reproducing the disease experimentally in susceptible animals using a virulent field isolate. The clinical signs, gross and microscopic lesions of haemorrhagic septicaemia in eighteen Lanka buffalo calves was studied following oral, intranasal and natural infection. The incubation period and the clinical course varied from 24 h to 66h and from 14 h to 110 h respectively, depending on the route of infection. The general sequence of clinical signs in the order of appearance were increased rectal temperature, anorexia, dyspnoea, salivation and recumbency. Oedematous swelling in the ventral, cervical and brisket region was only observed in some animals infected intranasally. Haematological studies demonstrated a leucopenia with advancing disease. It is likely that the inflammatory reactions of visceral organs and the endotoxin of the organism is responsible for the alteration of circulatory leucocyte numbers. The prominent lesions observed at necropsy were congestion of the lungs with varying degrees of pneumonic consolidation of the anterioventral lobes, pleurisy, thickening of the pericardium, and diffuse, subepicardial petechial haemorrhages. Histologically, the lung lesions comprised a fibrinous bronchopneumonia with thickening of the interlobular septae associated with oedema and dilatation of the lymphatics. *Pasteurella multocida* organisms, located by immunoperoxidase labelling, were found in the cytoplasm of alveolar macrophages and the interlobular septae of the lungs. Using standard bacteriological methods, the organism was demonstrated in the venous blood for only a few hours before death. However, at necropsy, *P.multocida* was consistently recovered from heart blood.

H-54 HORADAGODA, N.U., ECKERSALL, P.D., WIJEWARDANA, T.G. and HORADAGODA, A, **Acute phase protein response in the buffalo following infection with *P. multocida.*** In: *Proceedings of the 53rd Annual Sessions of the Sri Lanka Association for the Advancement of Science, Matara, Sri Lanka.*

1997 pp. 34 Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Acute phase proteins (APPs) are a group of liver-derived, serum proteins which alter in concentration in response to infection, injury or an inflammatory process. In human and veterinary medicine, APPs have proved to be useful markers for detecting inflammatory diseases. APPs in animals vary with species. In this study we have examined the haptoglobin (Hp) and alpha-2 acid glycoprotein (AGP) responses in the buffalo, an important domesticated ruminant in Asia and a species in which there is no information on APPs. Seven, 3-5 months old, Lanka buffalo calves of either sex weighing 45-60 kg were used in this study. An acute phase response was induced in 5 animals following intranasal inoculation of *P. multocida* serotype B:2 (approx 10^9 viable organisms), 2 animals given phosphate buffered saline by the same route served as controls. Jugular blood was collected immediately before infection and at 6,12,24,36,48,60,72,96 and 120 h post-infection. Serum Hp was assayed in an auto analyser (Cobas mira, Roche) while the AGP was measured using a commercial kit (Saikin Kagaku Inst. Japan) based on radial immunodiffusion in which anti-bovine AGP is incorporated into the agarose gel. In the infected buffalo calves, there was a rise in Hp from baseline of 0.78 ± 0.14 g/l (mean ± sd) to reach a 2 fold increase by 24 h followed by a 5-fold increase on day 5, post-infection. Changes in AGP were apparent only after 48 h when a 2-fold increase was observed and this was followed by a 3-fold increase on day 5, post-infection. There were no detectable alterations in Hp and AGP levels in the controls. This study has demonstrated that (a) both Hp and AGP are acute phase proteins in this species, (b) baseline values of haptoglobin in the buffalo (0.78 g/l) is higher than that reported for sheep and cattle (<0.2 g/l) and (c) anti-bovine AGP cross-reacts with buffalo AGP

H-55 HORADAGODA, N.U., ECKERSALL, P.D., WIJEWARDANA, T.G., PACKIARAJAH, P. and THALAGODA, S.A. **Clinical and haematological responses of buffaloes following intravenous administration of endotoxin extracted from *Pasteurella multocida* serotype B:2.** In: *Proceedings of the 5th World Buffalo Congress. 13-16 October 1997. Castera, Italy.* pp. 611-615. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The effects of endotoxin extracted from *P. multocida* serotype B:2 the causative agent of haemorrhagic septicaemia in Asia were studied in buffaloes following intravenous administration. Six animals were given endotoxin (1μg/kg) extracted from a field isolate of the organism while 3 animals given phosphate buffered saline by the same route served as controls. Clinical examination was performed and jugular blood was collected for haematology before inoculation, immediately after inoculation and periodically thereafter. The demeanour of the animals was expressed as dullness scores and on this scale the highest scores were obtained 1 to 3 hours after endotoxin inoculation. The clinical signs observed following endotoxin inoculation included salivation, dyspnea, lowering of head and sternal recumbency. There was also a transient pyrexia between 3 and 12 hours, post-inoculation. The most significant change in the haematology was the rapid onset of a marked leucopenia 3 hours, post-inoculation. This was followed by a rapid increase in circulating leucocytes resulting in a leucocytosis by 48 hours. The changes in leucocytes paralleled that of the neutrophil counts. There were no significant alterations in the haemoglobin content, packed cell volume and the erythrocyte counts. The results of this study indicate that endotoxin may play a role in the pathogenesis of HS in buffaloes.

H-56 HORADAGODA, N.U., HODGSON, J.C., MOON, G.M., WIJEWARDANA, T.G., THALAGODA, S.A. and ECKERSALL, P.D. **Tumour necrosis factor-α response in buffalo calves following intravenous inoculation of endotoxin.** In: *Proceedings of the Fifth International Veterinary Immunology Symposium, 6-13 November, 1998. Punjab, India.* pp. 79. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Studies on the pathogenesis of haemorrhagic septicaemia (HS), a highly infections fatal disease in buffaloes and cattle have indicated endotoxin to be a major virulence factor in the serotypes (B:2 and E:2) of *Pasteurella multocida* responsible for the disease. These observations have been pursued by examining the acute phase response and the kinetics of TNF-α induced by endotoxin extracted from the organism. Six buffalo calves (3-5 m; 45-60 kg) were inoculated intravenously with endotoxin (1 μg/kg) extracted from a field isolate of *P. multocida.* Blood was collected one hour prior to inoculation, at the time of inoculation, followed by collections at 1,2,3,4,5,6,8 and 12 hours, postinoculation. TNF-α was estimated by radioimmunoassay. Within one hour of inoculation the calves became dull, tachypnoeic, anorexic, restless and had an increase in rectal temperature. The serum TNF-α increased within 1 hour and reached a peak by 3 hours and rapidly declined to preinoculation level by 6 hours after inoculation. TNF-α concentration varied between animals and

ranged from 10 to 140 ng/ml. Three control animals given PBS by same route did not show any clinical signs and the TNF-α concentration was undetectable or 0.4 ng/ml. The results indicate that TNF-α is a major cytokine responsible for the initiation of the acute phase response in the buffalo that is induced by endotoxin from HS-causing pasteurellae.

H-57 HORADAGODA, N.U., HODGSON, J.C., WIJEWARDANA, T.G. and ECKERSALL, P.D. **The acute phase response of the water buffalo following infection with *Pasteurella multocida* serotype B:2.** In: *Proceedings of the International Society for Animal Biochemistry. 13-17 July, 1998. Hiroshima, Japan.* pp.50. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The acute phase response (APR) is a cytokine-mediated, non specific and non immune host response to tissue injury that is manifested locally as well as systemically through changes such as fever, alterations in the serum protein composition and trace mineral redistribution. The APR plays a major role in protecting the host but investigations in animals have shown significant species variations. The aim of this study was to elucidate the APR in the buffalo in order to understand the pathogenesis of haemorrhagic septicaemia, an acute, septicaemic disease caused by *Pasteurella multocida* serotype B:2 which affects buffaloes and cattle in Asia. Eight, 3-5 month old Lanka buffalo calves (45-61 kg) of either sex were used in this experiment. The animals were screened for the absence of *P. multocida* in the nasopharynx and serum antibodies against the organism. Five animals were infected intranasally with a field isolate of *P. multocida* serotype B:2 while 3 animals given PBS through the same route served as controls. The mean rectal temperature in control buffaloes varied around 37.5°C while the infected animals exhibited a hyperthermia which lasted for the five days of the experiment, with the temperature rising to 41 °C after 36 hours. There was no significant difference in the haematological parameters measured between infected and control animals. The serum haptoglobin concentration in the control animals remained stable (0.7-0.9 g/l) during the experiment while in the infected animals there was a steady rise (mean ± SEM) in the haptoglobin from 0:86 ± 0.02 g/l to 3.81 ± 0.55 g/l. Conversely, the serum acid glycoprotein started to rise 72 hours after the infection and then showed a continuing rise to reach a mean of 313 ± 68 μg/ml in the samples taken at the 120 hour time point. The mean serum iron concentration in the infected buffaloes showed a steep fall from 16.6 ± 2.1 to 4.4 ± 1.1 μmol/l over the first 24 hours following infection and thereafter, the concentration stabilised between 3 and 4 μmol/l till the end of the experiment. The serum zinc concentration in the infected buffalo also showed a fall from 8.8 ± 0.9 to 4.1± 0.4 μmol/l over the first 60 hours after infection, and thereafter stabilised between 4.4 and 4.8 μmol/l. There were no significant changes in the serum iron or zinc concentrations of the controls. In contrast to iron and zinc, the serum copper concentration in infected buffaloes showed a gradual increase from 48 hours to reach a final mean concentration of 20 ± 1.6 μmol/l at 120 hours while in the controls the levels remained relatively constant. No TNFα response was observed in any of the infected animals during the course of the disease. The APR recorded herein appears to mirror some of the findings reported in cattle following *P. haemolytica* infection.

H-58 HORADAGODA, N.U., WIJEWARDENA, T.G., MULLERIYAWA, I.S., RAMYA KUMARI, H.M.R. and VIPULASIRI, A.A. **Development of an enzyme-linked immunosorbent assay for detection of serum antibodies to haemorrhagic septicaemia.** In: *Strengthening Animal Reproduction Research and disease Diagnosis in Asia through Application of Immunoassay Techniques.* IAEA publication No. IAEA-TEDOC-736, pp. 185-193. .Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

An indirect enzyme-linked immunosorbent assay (ELISA) was developed using a heat-stable extract of *Pasturella multocida* serotype 6:B to detect antibodies to haemorrhagic septicaemia (HS) in serum from cattle and buffaloes. These sera were tested at 1:400 dilution and the optical density was compared with a standard curve. The results were expressed in ELISA units. There was 91% agreement when the ELISA results were compared with the indirect haemagglutination test using field samples. The ELISA was used to detect specific serum antibodies in buffaloes after vaccination with an HS-oil adjuvant vaccine. The first three months after vaccination showed a gradual rise in HS antibody concentration, which was followed by a marked increase over the next 14 days when a second vaccination was given at 3 months. Nine months after the initial vaccination the animals were challenged intranasally with 10^9 colony-farming units of *P. multocida.* All animals survived. This suggests that the ELISA is capable of detecting antibodies responsible for protection. Colostral derived antibodies to HS were also detected by ELISA in new born buffalo calves. The antibody concentration increased markedly within 24 hours of colostral consumption but declined within 28 days of birth. The immune response to *P. multocida* in

rabbits was also measured by ELISA. A 50-fold increase in the antibody concentration occurred within 36 days of vaccination. The ELISA developed in this study proved to be useful for measuring antibodies to *P. multocida* in cattle and buffaloes and will assist in monitoring antibody responses following vaccination against HS.

H-59 KURUWITA, V.Y., PERERA, B.M.A.O., CHANDRATILLEKE, D. and SAMARASINGHE, W.P.P. **Some observations on Ehrlichia infections in domestic animals.** *Sri Lanka Veterinary Journal* (1986) **34,** 64-65, [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This paper presents some comparative aspects of *Ehrlichia* infections in dogs, cats, cattle and buffaloes. Over a period of 6 months, blood smears were obtained from dogs presented to the University Small Animal Clinic. Of these 77 (25%) were positive for Ehrlichia-like bodies in lymphocytes. In some of these cases, concurrent diseases such as babesiosis (23%) and filariasis (6%) were present. The main clinical signs exhibited were elevation of temperature, anorexia, emaciation, enlargement of all palpable lymph nodes, lumbar pain, congestion of lungs, injected conjunctivae or anaemia. Signs such as diarrhoea, halitosis, vomiting and loss of hair were less common, while epistaxis, erythematous patches of the skin and seizures were seen rarely. In cases where epistaxis and seizures were not seen, treatment with tetracyclines and B vitamins resulted in definite clinical improvement. Two cats with similar symptoms were also found to be positive for *Ehrlichia*, with no other detectable causative agents. One such animal responded to treatment with tetracyclines. In cattle, over 20 cases were encountered and they showed signs similar to those of babesiosis which included anorexia, constipation, lack of ruminal movements, lung congestion and enlargement of superficial lymph nodes. Although body temperature was elevated by 3-4 ^{0}F, anaemia was not pronounced. Blood smears stained with Leishmann failed to show any intra-erythrocytic parasites. However, lymphocytes from peripheral circulation and from biopsy material of lymph nodes showed Ehrlichia-like organisms. There was no response to repeated treatment with Berenil, but parental tetracycline for 3-4 days resulted in recovery in all animals. Routine haematological examinations of apparently healthy buffaloes have often showed Ehrlichia-like organisms in lymphocytes. Although the total erythrocyte counts were reduced, these were not significantly different from those in animals free of such organisms. Both elementary bodies and morula-like clusters have been seen in animals affected by Ehrlichiosis.

H-60 KUMARASWAMY, S. **Brucellosis among buffaloes in Sri Lanka.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982 pp. 154-155. Department of Animal Production and Health, Peradeniya. SL.

The causative organism of the disease among buffaloes in Sri Lanka was identified as *Brucella abortus* biotype 1, whereas the organism responsible for the disease among Zebu cattle initially was *Brucella abortus* biotype 3. Published information on the comparative susceptibility of cattle and buffaloes to brucellosis and the resulting clinical effects is rather scarce. An opportunity presented itself to study these aspects in this country in fairly large organised herds comprising 641 Zebu cattle and 803 buffaloes. The overall incidence of the disease among the adult population of above 1 year of age, in the two herds was 21.8% for Zebu cattle and 24.2% for buffaloes. The incidence within each species for cows, heifers, bull calves and bulls decreased in that order and followed more or less a similar pattern. During the first year of infection in the Zebu population, 19% of the expected calvings ended in abortions and the corresponding figure for buffaloes was 22%. Over a period of three years, 36% and 38% of cows in the two species respectively, aborted. Thus the susceptibility and the clinical effects of this infection in buffaloes and Zebu cattle can be considered to be similar. Limitations to large scale surveys into incidence and control of this disease among both buffaloes and cattle in this country, were identified and research was directed into these areas. The present situation as regards Brucellosis in the country is that although the incidence in the herds originally affected has decreased considerably due to the control measures, the infection has diffused into the neighbouring areas and the national herd incidence could be considered to be around 2%.

H-61 MASOODI, M.A. **Immunopathological studies of *Toxocara vitulorum* in buffalo calves and rodents.** *Ph.D. Thesis.* (1985) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya. Peradeniya, SL.

Studies on the migratory behaviour of *Toxocara vitulorum* in mice demonstrated extensive somatic migration into the liver, lungs, kidneys, brain and other visceral organs despite restrictions of larval development at the second (infective) stage. Immunisation of mice with two small doses of *Toxocara vitulorum* or *Toxocara canis* induced a strong resistance to a challenge with a large

infection of *Toxocara vitulorum*. The manifestation of immunity in mice differed with the type of immunisation. Mice with homologous immunisation were able to inhibit the establishment of the larvae in the liver while mice with heterologus immunisation did not have a significant affect on the establishment of the larvae in the liver. Monitoring of *Toxocara vitulorum* eggs in the faeces of buffalo calves from birth revealed that eggs of the parasites appeared around 19-21 days and that it was preceded by eggs of Strongyloides species which appeared in the faeces between day 9 and 16. The patent period of *T.vitulorum* infections lasted up to 2.5-3 months with marked variation in the peak egg count. Colostral antibodies passively transmitted to calves from the dam do not appear to have any effect in protecting infections acquired by calves either pre-, peri- or postnatally. Reinfection of buffalo calves with large doses of infective eggs of *T. vitulorum* after they had cleansed themselves of a natural infection acquired from birth, did not result in a patent infection. Instead it induced strong precipitin reaction in the calves. Buffalo calf serum collected at different stages of natural and experimental infections when fractionated by gel filtration yielded three main peaks. The first peak consisted largely of IgM and α2-macroglobulin while the second peak consisted mostly of non-antibody protein. Further fractionation of the second gel filtration peak (IgG's) by ion exchange chromatography produced two peaks representing two subclasses, IgG_1 and IgG_2. ELISA assay demonstrated antibodies both in the IgM and IgG fractions with a higher IgG_1 activity as opposed to IgG_2. Gel diffusion and *in vitro* larval precipitins were also confined to the IgG_1 and not IgG_2.

H-62 MASOODI, M.A., WETTIMUNY, S.G.DE.S. and FERNANDO, S.T. **Pathological studies of toxocariosis in buffalo calves.** *Ceylon Veterinary Journal* (1985) **33,** 41 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Toxocariosis of buffalo calves is not only a condition of economic importance but also of zoonotic significance. Larval migration of *Toxocara vitulorum* in man leads to severe damage of vital organs. In view of its significance as a zoonotic disease it was decided to investigate the pathological manifestation of toxocariosis in buffalo calves. Ten swamp buffalo calves naturally infected with *Toxocara vitulorum* were examined for gross and microscopic lesions. The only lesion present in the alimentary tract was haemorrhages which occurred in 7 out of the 10 calves. The type of haemorrhages were both petechial (3) and ecchymotic (4). In one calf with intestinal petechiation, 120 worms were present in the small intestine. Histologically, an inflammatory reaction characterised by a mixed cell population of polymorphonuclear leucocytes, mononuclear leucocytes and eosinophils was noted. The haemorrhagic tracts and inflammatory changes may be attributable to damage caused by larval penetration. The livers of all animals showed haemorrhagic tracts and small granulomatous lesions which were about 1 mm in diameter. The granuloma consisted of the larva, surrounded by lymphocytes and eosinophils and sometimes by polymorphs. Small areas of perilobular infiltration by lymphocytes were also noted. The kidneys were characterised by small haemorrhages. The lungs showed areas of atelectasis, petechiation and small greyish foci especially in the diaphragmatic lobe. These granulomas had a microscopic picture very similar to the ones seen in the liver. There was also an interstitial pneumonia of a patchy distribution in most cases.

H-63 PEIRIS, G.S. and KARUNASENA, S.B. **A study on the incidence and distribution of two diseases of reproduction of buffaloes in Sri Lanka.** In: *Proceedings of the Symposium on Buffalo Research in Sri Lanka, 7-10 March 1989. Kandy, SL.* pp. 44-45. Veterinary Research Institute, Peradeniya, SL.

The objectives of the study were to determine whether the two diseases of reproduction namely, brucellosis and leptospirosis were present in buffaloes in Sri Lanka and to what extent they were prevalent in the country. Samples were obtained from state sector buffalo farms and private sector herds located in different areas of the country. Milk and serum samples were collected and serological tests were carried out for the detection of brucellosis and leptospirosis. Based on the results obtained with milk samples, brucellosis was present in 5 state farms and 10 veterinary surgeon ranges. Serum samples from aborted animals showed the presence of brucella infection in 4 state farms and 8 veterinary surgeon ranges. Leptospira antibody reactors were detected in 4 state farms and 4 veterinary surgeon ranges in serum from aborted animals. The distribution of brucellosis in the country was mainly in the Eastern province, North Central Province, North Western Province and the Hambantota district in the Southern Province. The presence of serological reactors to leptospirosis indicated that abortion in buffalo cows in 4 farms and 4 veterinary surgeon ranges may have been due to leptospirosis.

H-64 PEIRIS, G.S. **Studies on the infectious conditions of reproduction in the buffalo in Sri Lanka.** In: *Final Report of the SAREC/NARESA Buffalo Research Programme* (1986) Veterinary Research Institute, Peradeniya, SL. 6 pp.

The objectives of this study were to determine the incidence of brucellosis, leptospirosis, campylobacteriosis, and trichomoniasis among buffaloes in Sri Lanka. Although infectious bovine rhinotracheitis is recognised as an important infectious disease leading to infertility in cattle it was not included in the present investigation owing to the lack of facilities. Samples were collected from both state and private sector buffalo farms. Milk was examined for the presence of brucellosis using the Milk Ring Test. In buffalo herds with a history of abortion, serum from individual animals was examined by the Rose Bengal test and serum agglutination test for brucellosis. Further, the serum was examined by the Rapid Microscopic Slide Agglutination Test for detection of leptospirosis. Preputial washings from buffalo stud bulls and vaginal mucus from buffalo cows were tested for campylobacteriosis and trichomoniasis. The preputial samples were cultured in selective bacteriological media for the isolation of *Campylobacter foetus* and also examined microscopically for the detection of *Trichomonas foetus*. Further, preputial samples were also examined by the fluorescent antibody test for the detection of the campylobacter organism. Vaginal mucus samples were also tested in the vaginal mucus agglutination test for campylobacteriosis using *Campylobacter foetus* culture preparation as antigen. Brucellosis was detected in 4 state buffalo farms and 13 veterinary surgeon's ranges. Serological reactions to leptospirosis were detected in 4 state sector farms and 4 veterinary surgeon's ranges. The limited studies carried out to detect campylobacteriosis and trichomoniasis did not indicate the presence of the diseases in the farms tested.

H-65 PEIRIS, L.K.P.N. and DE ALWIS, M.C.L. **Simplified techniques for haemorrhagic septicaemia oil adjuvant vaccine production.** In: *Proceeding of the 4th International Workshop on Haemorrhagic Septicaemia, 11-15 February 1991. Kandy, Sri Lanka.* FAO/APHCA Publication: 1991/13 [Edited by De Alwis, M.C.L. and Wijewardana, T.G.] Bangkok, Thailand, FAO. 1991 pp. 117-120. Veterinary Research Institute, Peradeniya, SL.

A simple technology for haemorrhagic septicaemia (HS) oil adjutant vaccine (OAV) production was developed in Sri Lanka. A seed culture was selected from among several cultures from six Asian countries on the basis of the ability to consistently produce good capsulation and dense cultures. A simple and economic medium was developed in a simple culture vessel using an improvised water bath to eliminate the need for a warm room. A simple sparger aeration system was developed. The emulsification formula contained less lanolin than the standard formulation, but was stable for 6 months at 4° C. This simple model for HS, OAV production has been used in a field laboratory elsewhere, with a production capacity of up to 30,000 doses of vaccine per week.

H-66 PINTO, M.R.M., WANASINGHA, D.D., NAVARATNAM, C. and WELIANGE, L.V. **Studies on tuberculin sensitivity on livestock in Sri Lanka. VI. Sensitivity to tuberculins from *Mycobacterium intracellulare* and *Mycobacterium kansasii* in cattle (*Bos sp.*) and buffaloes (*Bubalus bubalis*).** *Sri Lanka Veterinary Journal* (1988/89) **36,** 21-29. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

Tuberculin testing of cattle and buffaloes was carried out using the single intradermal comparative tuberculin test, with four different antigens, including the standard mammalian and avian PPDs (Purified Protein Derivatives) and two other PPDs from *Mycobacterium intracellulare* and *Mycobacterium kansasii*. The dose of each PPD administered was 0.1 ml containing 10,000 tuberculin units (t.u) of mammalian PPD and 2,500 t.u (by protein equivalent) of each of the other PPDs. The antigens were administered to four prepared sites, two on each side of the neck and the patterns of sensitisation to these antigens were determined. The animals tested were in herds located in state owned farms, in different agro-climatic and geographic zones in the country. The total number of animals tested were 1060 cattle and 292 buffaloes. The results indicated that there were geographical variations in the sensitivity patterns. This investigation showed changes of sensitisation with altitude, not in agreement with earlier findings that the prevalence of sensitisation was lower at high altitude and highest was at sea level.

H-67 PINTO, M.R.M., WANASINGHE, D.D. and RAVINDRAN, K.V. **Studies in tuberculin sensitivity of livestock in Ceylon.** *Ceylon Veterinary Journal* (1973) **21,** 10-15. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

From clinical and abattoir experience in Ceylon, it is thought that tuberculosis in buffaloes is rare. This study deals with patterns of tuberculin sensitivity in buffaloes; data on sensitisation of cattle is also presented for comparative purposes. Two herds of buffaloes, at Tamankaduwa (274 animals) and Ridiyagama (261 animals) livestock farms were tested by the single intradermal differential (comparative) tuberculin test using mammalian and avian purified protein derivatives (PPDs). The test was read at 48 hrs to 72 hrs after administration of tuberculin and the results were recorded as the increase in skin thickness. It was found that

"specific" sensitisation to both mammalian and avian tuberculin's does occur in Ceylon, but sensitisation to the latter was far more common. The study showed that 28% of buffaloes at Tamankaduwa and 18% at Ridiyagama exhibited mammalian reactions of 4 mm or over. But when one considers only dominant mammalian reactions (exceeding the avian reaction by 1 mm or more) to be more suggestive of mammalian infection, then only 9% at Tamankaduwa and 7% at Ridiyagama can be considered to be tuberculosis infected. On the other hand, avian infection appears to be much more common in the buffalo, with 50% as compared with 34% in cattle at Tamankaduwa, and 32% as compared with 3% equal to or larger than 4 mm. According to the results, the degree of avian sensitisation in buffalo was also more than in cattle in the same locality. It is suggested that this difference is due to the increased occurrence of infection of buffaloes by non-tuberculous mycobacteria, probably because of the habit of wallowing in mud. It is suggested that this is due to the flocks of water birds inhabiting this area and contaminate the surroundings with avian tubercle bacilli. But the more likely explanation for increased avian sensitisation is that, infection is due to mycobacterium of the environment, eg: soil, mud, water etc, and that infection with these produces cross sensitisation to avian PPD.

H-68 PRIYANKARAGE, R.H. and WIJEWANTHA, E.A. **Preliminary studies on the occurrence of *Clostridium perfringens* type A enterotoxigenic strains in calves.** In: *Proceedings of the Annual Research Sessions of the Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, 3 December 1994. Peradeniya, Sri Lanka.* pp. 25. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Clostridium perfringens Type A is an important cause of enteric disease in man and is now recognised to be a cause of enteritis in animals as well. An important aspect of enteric disease caused by *Clostridium perfringens* Type A, is the production of enterotoxin by sprouting organisms. These organisms can be difficult to culture and spores often require heat shocking (80°C for 10 min.) before they will grow in the laboratory. The present study was undertaken to determine the occurrence of *Clostridium perfringens* Type A enterotoxigenic strains in neat cattle and buffalo calves. The investigation was carried out using modified culture media and heat shocking techniques. Of thirty faecal samples tested, three were found to be positive for *Clostridium perfringens* Type A. After further isolation of the organism, the strains will be tested for enterotoxin production and serologically typed.

H-69 RAJAPAKSE, A.I.U., DE ALWIS, M.C.L., RATHAKRISHNAN, S. and VIPULASIRI, A.A. **Further studies on the stability and potency of the haemorrhagic septicaemia oil-adjuvant vaccine.** *Sri Lanka Veterinary Journal* (1987) **36**, 53-54 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

In order to reduce the viscosity and thereby facilitate the injectability of the haemorrhagic septicaemia oil-adjuvant vaccine (OAV), the percentage of the emulsifying agent lanoline was reduced to 4% as compared to 8-12% used in standard formulations. Earlier studies indicated that the Sri Lankan OAV prepared in this manner, appeared to be less stable and that its potency dropped more rapidly with storage when compared with reports on similar vaccines produced elsewhere. The present study was designed to (a) determine whether these properties of the vaccine were influenced by the lanoline content and (b) to determine the validity of the active mouse protection test as an index of cattle/buffalo immunity. Three batches of HS-OAV were prepared with 4%, 6% and 8% lanoline. They were then stored for one year at either 4°C or at room temperature. Periodic tests were carried out on the stability and potency in mice. Tests were also made on potency in cattle using OAV prepared from different dilutions of bacterin. Passive protection conferred by sera of vaccinated cattle, to mice against a standard challenge was taken as an index of cattle immunity. The viscosity and stability of the vaccine increased with increasing lanoline content. The highest stability and least drop in potency with storage was recorded with 8% lanoline at a storage temperature of 4°C. Comparison of cattle potency and mouse potency using dilutions of vaccine indicated that, whilst cattle potency dropped rapidly with dilution of vaccine, mouse potency remained high at even greater dilutions when tested by current methods. Whilst recognising that the mouse is a convenient animal to test the potency of the vaccine, the test needs to be modified and a correlation with cattle potency has to be established, before the mouse potency can be considered as valid index of cattle immunity. Secondly, if the lanoline content is reduced in order to lower the viscosity, the storage period of the vaccine should not exceed 6 months at 4°C.

H-70 RAJAPAKSE, R.P.V.J. **Immunological response of buffalo cows and calves to *Toxocara vitulorum* infection.** *PhD Thesis* (1992) Faculty of

Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Maternal transfer of *Toxocara vitulorum* antibodies from naturally infected buffalo cows to their calves was studied in 12 buffalo cow-calf pairs. The antibody response to *T. vitulorum* was determined by means of the enzyme linked immunosorbent assay (ELISA) and gel precipitin test (GPT). Excretory and secretory antigens from infective larvae (TVL2ES) were used as antigens. Specificity of antigen was evaluated by the lymphocyte transformation test as well as the immuno-fluorescent test. The effect of maternal antibodies on *T. vitulorum* infection in the calves was elucidated. Infection was monitored by McMaster technique. Calves which suckled colostrum which had a high ELISA titres and showed a low eggs per gram (epg) count in their faeces at and during the patent infection when compared with calves which suckled low titred colostrum. Thus a highly significant inverse correlation between colostral and calf serum antibody titres and peak epg of the calves was evident ($p<0.01$). *In vitro* and *in vivo* action of colostrum immunoglobulins and their subclasses were determined in a mouse model. Whole colostrum antibody showed a highly protective activity against oral challenge infection. The IgG_1, IgG_2 and IgM types showed a significant protective activity against an oral challenge ($p<0.01$, <0.01, <0.001) but IgG_1 was relatively more protective than IgM and IgG_2. Further, immunogenicity of somatic antigen preparations from infective larvae (TVL2) and TVL2ES, were determined in the mouse model. Mice were immunised with the TVL2ES and TVL2 antigens using four weekly doses (0.36 mg/dose). Immunisation by the oral route with infective eggs, four doses of five hundred eggs administered weekly, conferred a significant degree of immunity to an oral challenge with *T. vitulorum* infective eggs. However, the level of protection conferred by these antigens varied. In particular TVL2ES conferred almost 100% immunity against a challenge infection on day five. Finally, using *in vitro* circum-larval precipitin tests, it was shown that only infective larvae isolated from milk showed oral and body precipitates. It was further confirmed by immuno-fluorescent staining technique that both infective larvae and milk larvae of *T. vitulorum* showed fluorescence in their orifices as well as cuticle but not *T. canis* or *Strongyloides* larvae. Therefore it is suggested that *in vitro* circum-larval precipitin test is a good technique for the diagnosis of *T. vitulorum*.

H-71 RAJAPAKSE, R.P.V.J. and FERNANDO, S.T. **Immunological response of buffalo cows and calves to *Toxocara vitulorum* infection and colostral transfer of antibodies from the cows to their calves.** In: *Proceedings of the Annual Research Sessions, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, 19 December 1992. Peradeniya, Sri Lanka.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Twelve buffalo cows and their calves were used in this experiment. Anti-*Toxocara vitulorum* antibodies were detected by gel diffusion precipitin test (GPT) and Enzyme Linked Immunosorbent Assay (ELISA). Excretory and secretory antigens of infective larvae of *T. vitulorum* (TVL2ES) were used as the antigen. Eight cows showed serum precipitin during pregnancy. At parturition these antibodies appeared in their colostrum and they persisted in colostrum from day 1-5 of lactation. The calves born to twelve cows did not reveal any anti-Toxocara antibodies in their serum before being fed with colostrum. However, after they were fed with colostrum from their dams which had serum *Toxocara* antibodies, these antibodies appeared in the calf serum. Further, the precipitin reaction in GPT and the antibody titres determined by the ELISA were comparable to those of their dams. The course of the patent infection of *T. vitulorum* in twelve calves were elucidated by determining the Toxocara eggs per gram of faeces (EPG), at four day intervals from seven days to three months. Infection became patent in all calves between 15-26 days and peak EPG counts varied from 32,000 to 178,000. There was an inverse relationship between the EPG and the maternal transfer antibody titres of the ELISA.

H-72 RAJAPAKSE, R.P.V.J., FERNANDO, S.T. and ABEYNAYAKE, P. **Anthelmintic effect of benzimidazoles on larvae of *Toxocara vitulorum* infections in mice.** *Sri Lanka Veterinary Journal* (1988/89) **36,** 46 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Toxocara vitulorum is a common nematode causing parasitic enteritis and high mortality of buffalo calves in Sri Lanka. This study was designed to determine the *in vivo* larvicidal activity of benzimidazoles in experimentally infected mice. Fenbendazole and Febantel were chosen for the study due to its known efficiency, safety and absence of residual effects. Seventy five mice were fed with 5,000 infective eggs each and were divided into three equal groups. Group A was kept untreated, Group B was treated with 0.15mg Fenbendazole ('Panacur'; Hoechst) and Group C with 0.12mg Febantel ('Rintal'; Bayer). A single dose of the medication was given orally 48 hours after inoculation. The effectiveness of treatment was assessed by the number of larvae recovered from the liver, lungs and kidneys of mice sacrificed at 4, 5, 6

and 7 days after inoculation. In the control group, the highest number of larvae (mean ± SEM) recovered on day 4 was 1964± 310. A greater proportion of these larvae was in the liver (1100±169) and lungs (831±91). From day five to day seven, the total larval counts decreased but the larvae in the kidneys increased. The total larval counts in medicated groups were significantly ($p<0.01$) lower than those in control group although the patterns of distribution in the three organs were similar.

H-73 RAJAPAKSE, R.P.V.J., LLOYD, S. and FERNANDO, S.T. ***Toxocara vitulorum:* maternal transfer of antibodies from buffalo cows *(Bubalus bubalis)* to calves and levels of infection with *T. vitulorum* in the calves.** *Research in Veterinary Science* (1994) **57,** 81-87. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The levels of antibody to the excretory/secretory antigens of the infective larvae and adults of *Toxocara vitulorum* were measured by gel precipitation and ELISA, in the serum and colostrum of 12 buffalo cows naturally infected with *T. vitulorum* and in the serum of their calves. The antibody levels were compared with the extent of *T. vitulorum* infection as judged by faecal egg counts in the calves. The patterns of the bands of the larval and gel precipitating antibodies in cow serum, taken one month before calving, in cow colostrum and in calf serum were very similar. Nine cows and their calves had gel precipitating antibodies but the remaining three cows and their calves did not. The ELISA detected anti-larval antibodies in the colostrum of all 12 cows and calves. With the exception of one calf, there was strong correlation ($r=0.902$) between the antibody titre in cow colostrum and the titre of passively acquired antibody in calf serum. The titres of these passively acquired antibodies declined to their lowest levels in calves 12 to 25 days of age. The antibody concentrations then began to increase up to day 42 and remained stable for the remainder of the experiment (105 days). The titres of antibodies to the antigens of the adult worms, examined in four cows and their calves, were lower than the titres to the larval antigens. The calves absorbed this anti-adult antibody from the colostrum and the antibody levels reached a plateau between days 12 and 30 and remained stable for the rest of the experiment. The peak titres of antibodies to the larval antigens in the cows' colostrum and in the serum of their calves both passively acquired and produced showed a significant inverse correlation with the maximum faecal egg count *of T. vitulorum* in the calves ($r=-0.728$ to -0.81)

H-74 RAJAPAKSE, R.P.V.J., VASANTHATHILAKA, V.M.S.M., LLOYD, S. and FERNANDO, S.T. **Collection of eggs and hatching and culturing second-stage larvae of *Toxocara vitulorum in vitro.*** *Journal of Parasitology* (1992) **78,** 1090-1092. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Eggs of *Toxocara vitulorum* were harvested from faeces of infected buffalo calves and embryonated *in vitro.* Optimum conditions for hatching and culture of the second-stage larvae were determined. Maximum hatch of larvae occurred from eggs that were decoated by treatment with saturated $Ca(OCl)_2$ for 16-24 min followed by treatment with CO_2 and incubation at 37°C. Larvae could be cultured in RPMI-1640 medium for up to 3 months but survived for only 3 weeks in Eagle's minimum essential medium.

H-75 RANATUNGA, P. **1. Investigation of the efficacy of sulphadimidine in preventing coccidiosis of buffalo calves. 2. Further confirmatory evidence for prenatal ascaris infection in buffalo calves.** *Ceylon Veterinary Journal* (1960) **8,** 20-25. Veterinary Laboratory, Peradeniya, SL.

When faecal samples from calves were examined daily from 10 to 25 days after birth, it was found that oocysts of coccidia were first noticed on the 11th day and reached a peak on around day 21. Sulphadimidine at the dosage rate of 45 mg. per pound body weight on the first day, followed by half this dosage for the next two days seemed to have no appreciable effect in preventing the development of infective oocysts in very young buffalo calves. The second generation of oocysts seemed to appear in approximately 48 hours. Its beneficial results may have been due to the action on intestinal bacteria. The mortality among buffalo calves in this particular disease outbreak was more likely due to ascariasis. Ascariasis in the buffalo calves appear to be a result of prenatal infection.

H-76 ROBERTS, J.A. **The persistence of larvae of *Toxocara vitulorum* in Asian buffalo cows.** *Buffalo Journal* (1993) **3,** 247-251. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

The numbers of *Toxocara vitulorum* transmitted by buffalo cows at each three successive calvings when continuously infected from the environment, showed a significant concordance, indicating that there was a maternal host factor having some control over levels of infection. The level of transmission was related to neither the age nor the parity of the cows. When some of the cows were transferred to an environment in which infection from the environment did not occur, they

continued to transmit infection to their calves for up to three years. The half life of the larvae in the tissues of the cows was estimated to be one to two years. The period of treatment necessary to ensure eradication of the parasite is five years, the sum of the duration of persistence of infective eggs in the environment (two years) and the persistence of larvae in the tissues of the maternal host. Some larvae which were in the tissues of cows through a complete parturition cycle, were not re-activated at the time of parturition, but were re-activated at the next parturition.

H-77 ROBERTS, J.A. ***Toxocara vitulorum* in ruminants.** *Veterinary Bulletin* (1993) **63,** (6) 545-568. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

This paper is a critical review of literature of *T.vitulorum,* the pathogenic ascarid of large ruminants that still kills calves in developing countries of the humid tropics where draught power is a constraint on paddy cultivation and where usually a cow cannot be milked if the calf is not present. Control procedures are available, and this review is written in the hope that the disease will be better understood, and that control procedures will be more effectively and more widely used.

H-78 ROBERTS, J.A. **The life cycle of *Toxocara vitulorum* in Asian buffalo (*Bubalus bubalis*).** *International Journal for Parasitology* (1990) **20,** 833-840. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

A procedure for labelling *Toxocara vitulorum* larvae with 75 selenium is described. Labelled larvae are infective when administered into the small intestine and portal vein of buffalo of all ages. Only very young calves are infected after oral administration. The labelled larvae are used with an enhanced fluorographic autoradiographic procedure to study the dynamics of the infection in non-pregnant and pregnant buffaloes. Larvae penetrate the wall of the small intestine between 2 and 8 hours after administration. Most larvae go straight to the liver *via* the portal vein but a few enter the mesenteric lymph nodes. Over the next 90 hours some larvae migrate to the lung and a few to muscle, brain, kidney and peripheral lymph nodes. Most remain in the liver. Over the next 3-7 weeks, the larvae grow by about 10% and no moulting is observed. In a pregnant host, larvae grow to 500-600 μm in liver and lung 1-8 days before parturition and migrate to the mammary gland around the time of parturition. In the mammary gland they grow to about 1200μm and pass into the milk during the 7 days after parturition.

H-79 ROBERTS, J.A. **Field trials of a single treatment for *Toxocara vitulorum* in Asian buffalo (*Bubalus bubalis*).** *Buffalo Journal* (1990) **1,** 113-123. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

An extensive field trial of the procedure of treating buffalo calves aged 10 to 16 days to control the important nematode *Toxocara vitulorum* is described. Extension material was provided and the program was started on four institutional farms and in four village areas associated with milk co-operatives. Control was excellent in the first year but broke down in one institutional farm and in two village areas in the second year mainly due to disruptions arising from civil unrest. Successful programs can be established on institutional farms by providing instructions, anthelmintics and basic extension material. For milk co-operatives an active extension program which incorporates the control procedure in a livestock production package appears to be an advantage. There are still problems in reaching village small holders with only one or two draught buffalo. Of the drugs which are effective against immature parasites pyrantel appeared to be best because it is cheap, readily available, supplied in appropriate tablet size and has a high therapeutic index. A standard dose of 250 mg can be given with safety to all 10 to 16 day old buffalo calves regardless of body weight.

H-80 ROBERTS, J.A. **The egg production of *Toxocara vitulorum* in Asian buffalo (*Bubalus bubalis*).** *Veterinary Parasitology* (1990) **37,** 113-120. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

The egg production of *Toxocara vitulorum* in Asian buffalo has been studied. Eggs were first present in the faeces of calves when they were 22.3±1.6 days old. In calves treated with pyrantel when 3 days old, the age at first patency was extended by 3.5 days indicating that there was no pre-natal transmission. Calves on only half the milk of the cow had a significantly longer prepatent period of 27.7±2.2 days. The peak egg output occurred in calves 35.7±2.6 days old and had a duration of 5.5±2.5 days with 98,000±63,700 eggs per gram of faeces. The duration of the patent period was 35±12 days. The average lengths of populations of mature female parasites from different hosts at the time of peak egg output or older, ranged from 15.0 to 31.0 cm and was correlated with those of the males in the same

populations (10.6-20.4 cm). The size of females was not effected by intraspecific competition. The proportion of males in the populations was 0.39±0.11. The egg output per female per day at the peak was 110,000±58,000 and was correlated with the size of the females at autopsy, but the egg output for female per day at the time of autopsy was lower and was not correlated, so it was concluded that the drop in egg counts was the result of reduced fecundity. The fertility of the eggs from faeces was >92% throughout. The drop in egg production was not affected by administration of dexamethasone or by restricting calves to a milk diet, so it is suggested that the drop may be due to an ageing process in the parasite. The importance of the age of the calf in determining the pathogenic significance of egg counts, and in epidemiological studies, is emphasised. Reports of substantially different prepatent and patent periods are discussed.

H-81 ROBERTS, J.A. **The extraparasitic life cycle of *Toxocara vitulorum* in the village environment of Sri Lanka.** *Veterinary Research Communications* (1989) **13,** 377-388. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

The extraparasitic life cycle of *Toxocara vitulorum* of buffalo in the villages of Sri Lanka is related to observations on buffalo behaviour, experimental studies on the development and persistence of the eggs in soil and in wallows and the presence of eggs in village locations. Calf faeces on soil were rapidly incorporated by insect activity and the eggs developed only slightly slower than in the laboratory. Some infective eggs persisted 3-4 cm deep for 17 months, finally dying during a prolonged hot, dry period. Eggs in a wallow developed intermittently over 16 months as it was flushed with rain water, and eventually died when the wallow dried out. When infected faeces were placed in water, decomposition caused some material to rise to the surface and eggs developed. In villages, eggs are ubiquitous where young calves are kept but survive best where there is moisture and shade around animal pens and wallows. Cows and calves acquire infection from infective eggs in wallow water, soil and pasture, while calves may also be infected from contamination on the udder and teats of the cows. The larvae resulting from this infection do not mature until the infection is passed to the calf through the milk of the cow. At least 72% of village calves have patent infections and current treatment procedures do not reduce the prevalence. The possibility of *T. vitulorum* causing human *visceral larva migrans* is discussed.

H-82 ROBERTS, J.A. ***Toxocara vitulorum*: treatment based on the duration of the infectivity of buffalo cows *(Bubalus bubalis)* for their calves.** *Journal of Veterinary Pharmacology and Therapeutics* (1989) **12,** 5-13. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

Treatment of buffalo calves *(Bubalus bubalis)* at different times after birth demonstrated that transmission of *Toxocara vitulorum* from the cow to the calf *via* milk occurs in all calves during the first 2 days after birth, decreases to 53% by 6 days, 10% by 8-9 days and 2% from day 10 onwards. This may be because the larvae are no longer in the milk or because the calf has become resistant to the establishment of a new infection. The results also emphasise the importance of mammary transmission of the parasite. Against immature parasites, the efficacy of pyrantel and levamisole was 97%; febantel was 100% on one farm and only 35% on another; piperazine 42% and thiabendazole 35%. Santonin was ineffective in four calves. Against mature parasites the efficacy of pyrantel was 100%; febantel was 100% in one farm but only 35% on another; oral levamisole 83%; cutaneous levamisole 73%; oxfendazole 89% and piperazine 57%. Nevertheless, piperazine reduced the infection to levels which were probably not pathogenic. In general, the efficacy against mature parasites were similar to that against immature parasites. Treatment of 10-16 day old calves with an anthelmintic, which is effective against immature parasites, is recommended. This procedure greatly reduces contamination of the environment and also precludes the pathogenic effect of a large number of immature or mature parasites.

H-83 ROBERTS, J.A. and FERNANDO, S.T ***Toxocara vitulorum*: A treatment schedule based on the dynamics of the transmission of the parasite from the buffalo cow to the calf.** *Ceylon Veterinary Journal* (1988/89) **36,** 45 [Abstract]. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

The period during which a buffalo cow can transmit *T. vitulorum* to her calf was studied by treating calves with levamisole (7.5 mg/kg body weight). Each calf was treated once, on one of days between day 1 and 15 after birth. All calves treated when 1 to 3 days old, developed patent infections. Approximately 50% of the calves treated from days 4 to 7 developed patent infections. Infection in calves treated from day 8 onwards was rare and at a very low level. Thus, it is possible to control *T. vitulorum* in the buffalo by treating infections before they become patent. The pathogenic effects of the infection are prevented and there is no re-infection

of the environment. Levamisole was effective against the immature parasites. Piperazine, thiabendazole and santonin were not effective. Febantel was not consistent in its effect. It is recommended that livestock officers and extension officers select one day of the week as the treatment day. On that day of every week, all calves aged 10 to 15 days, should be treated. Other studies indicated that buffaloes in Sri Lanka require no further anthelmintic treatment during their lifetime.

H-84 ROBERTS, J.A., FERNANDO, S.T. and SIVANATHAN, S. ***Toxocara vitulorum* in the milk of buffalo *(Bubalus bubalis)* cows.** *Research in Veterinary Science* (1990) **49**, 289-291. Graduate School of Tropical Veterinary Science and Agriculture, James Cook University, Townsville 4811, Australia.

The nematode parasite *Toxocara vitulorum* is transmitted through the milk of Asian buffalo *(Bubalus bubalis)* and Bos species. The duration of excretion of *Toxocara vitulorum* larvae in the milk of buffalo cows determines the optimum time for treating calves. *T vitulorum* have been collected from the milk of buffalo cows from 1 to 24 days after parturition. Ten local buffaloes were maintained on a coconut plantation. When possible, colostrum was collected before suckling. The cow and the calf were separated soon after parturition. Twice daily for 28 days, milk was collected manually from the left side of the mammary gland while the calf was allowed to suck from the right side. The volume collected was recorded and milk was diluted with at least an equal volume of phosphate buffered saline (pH 7.2) containing 0.1% commercial detergent. It was left to sediment for a minimum of three hours, after which the supernatant fluid was removed and the sediment was washed through a nylon filter with the mesh size of 25 µm. The residue was fixed in FAA (formalin 5%, ethanol 50%, acetic acid 5%, water 40%) at 70°C and larvae were counted under a stereomicroscope at x 20 magnification. Studies on 10 calves showed that a few larvae occur in the colostrum of some cows before the calf had suckled, but most are present from the day after calving and for a further five days. From day 9 onwards, very few larvae were found in the milk. The total number of larvae found was comparable with the number of adult parasites collected from calves of cows with similar histories. The larvae were 1254±60 µm long and 36±6.7 µm in diameter at the ventriculus, figures which are substantially different from some published results. If calves are treated when 10 days old with an anthelmintic effective against immature parasites, re-infection by the transmammary route is unlikely to recur.

H-85 SAMARASINGHA, B.T. **Immunological response of mice, rabbits and buffalo calves to *Toxocara (Neoacaris) vitulorum* (Goeze, 1782) infection.** *PhD Thesis* (1985) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Immunological response of mice, rabbits and buffalo calves to *Toxocara vitulorum* infection was studied by enzyme-linked immunosorbent assay (ELISA), gel-diffusion precipitins (GPT), immunoelectrophoresis and *in vitro* larval precipitins (IVP) tests. Several antigens of *T. vitulorum* including embryonated egg antigen, whole worm antigen, and perienteric fluid (PF) from the adult *T. vitulorum* were used. In a few instances, embryonated egg antigen of *T. canis* (TCE) was used to study any cross-reactivity. The immunoglobulin classes in the sera of buffalo calves at different stages of natural and experimental infections were also characterised by gel filtration and ion exchange chromatography followed by immunoelectrophoresis. In rabbits, attempts were made to study the serum immunoglobulin classes by ELISA using commercial horse-radish peroxidase (HRP) conjugated IgG F (ab') 2 (H and L) and IgM (chain specific). The *in vitro* action of sera from rabbits and buffalo calves infected with *T. vitulorum* on the infective-stages of *T. vitulorum* larvae was examined to ascertain the specificity of the reaction. These studies were further supported by immunofluorescent tests. The trend in the antibody response of buffalo calves measured by ELISA was correlated with that of faecal *T. vitulorum* egg counts. Serum antibodies to *T. vitulorum* were detected in buffalo calves by ELISA from about 24 hours after birth. The antibody titres increased with the rise in egg counts but continued to increase even after egg counts had fallen to zero levels. On reinfection, the ELISA response remained unchanged. Experimental infection of rabbits with *T. vitulorum* yielded an initial IgM type response which was short lived followed by a persistent IgG type response. The GPT and IVP reactions were used to ascertain the trend and nature of the antibody response in rabbits and buffalo calves. The antibodies to *T. vitulorum* infection in rabbits reacted with TVE and TCE in GPT test in the presence of 0.85 percent NaCl in the gel, whereas the buffalo antibodies to *T. vitulorum* precipitated well with the same antigens in the presence of 8 percent NaCl. The *in vitro* precipitin test using sera from *T. vitulorum* infected rabbits and buffaloes revealed the presence of precipitates at the natural orifices and body of infective *T. vitulorum* larvae but not in *T. canis* larvae. This indicates the species specificity of the test. The indirect immunofluorescent studies on the larvae suggests that circumlarval precipitates are formed by a

reaction of serum antibodies presumably with the excretions and secretions from the larvae. The fluorescent reaction was very marked around the oesophagus and the lips, but the cuticle showed comparatively less fluorescence. Colostrum from buffalo cows reared under free grazing conditions throughout their gestation period revealed precipitins to TVE antigens, which was identical with that elicited in buffalo calves by an experimental infection. These buffalo calves which were naturally infected with *T. vitulorum* at birth had cleansed themselves of the patent infection at the time of experimental infection. *In vitro* precipitins however, were not observed in the sera of the calves before the experimental infection.

H-86 SHANMUGALINGAM, K. **Neoascariasis in buffalo calves in Ceylon. I. The incidence of *Neoascaris vitulorum* (Goeze 1782) in buffaloes, cattle and goats.** *Ceylon Veterinary Journal* (1956) **4,** 46-50. Veterinary Research Laboratory, Peradeniya, SL.

A considerable number of deaths are often encountered in suckling buffalo calves due to infestation with the nematode, *Neoascaris vitulorum*. Sixty six buffalo calves were chosen for the study and individual dung samples were examined daily from birth to 35-40 days. Floatation technique using a concentrated solution of common salt was used to recover eggs of *Neoascaris vitulorum* from samples of faeces. As qualitative examination was considered sufficient, no egg counts were made. Calves which were 'positive' for *Neoascaris vitulorum* during the early part of their life became 'negative' between the 20th and 40th day postpartum. The present work indicates that *Neoascaris vitulorum* reaches sexual maturity within the body of the host, at an average age of between 15th and 31st days of the calf. Therefore it was suggested that treatment should be aimed at eliminating all or most of the worms before they attain sexual maturity and the strategic period for such an attempt appears to be on or before the 15th day, postpartum. According to the available data, the most probable mode of infection is prenatal. Neoascariasis occured in neat cattle calves too. Ascarid eggs, similar to that found in calves are recorded for the first time in goats in this country.

H-87 SILVA, I.D. **Functional efficiency of buffalo neutrophils.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 457-471. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The functional efficiency of neutrophils of the buffalo was studied by measuring their phagocytic and postphagocytic bactericidal activities. The observations were derived from simultaneous *in vitro* comparative evaluations using blood and milk neutrophils, and three common mastitis causing bacteria, namely, *Staphylococcus aureus*, *Streptococcus agalactiae* and *Eschesichia coli* in pure and mixed cultures. The percent phagocytosis (PP) was optimum at 45 minutes and was highest for *Staph. aureus* (86%) followed by *Strep. agalactiae* (77%) and *E. coli* (74%), in pure cultures. The total phagocytic efficiency for pure or mixed bacterial cultures was similar, although with mixed cultures, a majority of neutrophils (40%) phagocytised both species of bacteria while others preferentially phagocytized one species. With mixed cultures of *E. coli* and *Staph. aureus* a significant preference was seen for *Staph. aureus* (approximately 40% PP) while with a mixed culture of *E. coli* and *Strep. agalactiae*, a significant preference was seen for *Strep. agalactiae* (approximately 32% PP). Thus, the affinity of phagocytising *E. coli* was much less in the presence of *Staph. aureus* or *Strep. agalactiae*. The postphagocytic bactericidal activity (PPBA) of blood neutrophils was optimum at 60 minutes. The degree of resistance to PPBA was similar with all three bacteria, but was relatively lower with *E. coli*. Experimental induction of aseptic subclinical mastitis resulted in a high cell count of 5.6×10^6/ml of milk after 18 hours. About 90% mastitis of those cells were neutrophils which were as efficient as blood neutrophils with the highest PP of 83% for *Staph. aureus* and similar PP for *Strep. agalactiae* and *E. coli* (65%). However, the phagocytic process was relatively slower for *Strep. agalactiae*.

H-88 SILVA, I.D. **Phagocytic efficiency of buffalo *(Bubalus bubalis)* blood neutrophils for common mammary pathogens.** *Buffalo Journal* (1993) **2,** 181-185. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The present study describes a simultaneous comparative evaluation of the phagocytic activity of buffalo neutrophils against three mastitis causing bacteria (*Staphylococcus aureus, Streptococcus agalactiae and E. coli*) Blood was collected into two 10ml vaccutainers without anticoagulant to obtain fresh serum. The methods of isolation of neutrophils from buffalo blood, preparation of bacterial cultures, phagocytosis assay and the staining procedures are described. Stained smears were examined microscopically under an oil immersion objective (x 1,250). According to the results, phagocytosis was highest for *Staph. aureus* (86.1%) followed by *Strep. agalactiae* (77.4%) and *E. coli* (73.5%). Phagocytosis of *Staph. aureus* was not much different from that of *Strep. agalactiae* but

was significantly higher than that of *E. coli*. A similar study carried out previously on phagocytic activity of cattle neutrophils for the same strains of the above three bacteria opsonised with cattle serum, showed that phagocytosis was high for *E. coli* (81.3%) and *Strep. agalactiae* (77%) and intermediate for *Staph. aureus* (63.6%). When compared with cattle, the percent phagocytosis of buffalo neutrophils were 22.5% higher for *Staph. aureus*, 7.8% lower for *E. coli* and similar for *Strep. agalactiae*. This explains the findings that buffaloes are more resistant to mastitis caused by *Staph. aureus* than cattle.

H-89 SILVA, I.D. **A comparison of the phagocytic efficiency of buffalo *(Bubalus bubalis)* blood and milk neutrophils.** *Sri Lanka Veterinary Journal* (1993) **40,** 7-14. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This study describes simultaneous *in vitro* comparative observations on the phagocytic activity of neutrophils isolated from blood and milk, during an experimentally induced aseptic mastitis. The percent phagocytosis of neutrophils isolated from blood was highest for *Staphylococcus aureus* (84.2%) followed by similar phagocytic activity for *Streptococcus agalactiae* (76%) and *Escherichia* coli (74.8%). The induction of mastitis resulted in a high cell count in milk (5,600/μl) and 90% of those cells were neutrophils. When compared with the blood neutrophils, the percent phagocytosis of neutrophils isolated from milk was also the highest for *S. aureus* (82.7%). The percent phagocytosis for *E. coli* (65.5%) and for *S. agalactiae* (65.2%) were similar. Neutrophils isolated from milk were as efficient as blood neutrophils in their phagocytic activity when allowed to interact with serum opsonized *S. aureus* and *E.coli* separately, for 15 and 30 minutes. However, the phagocytic process in milk neutrophils was slower for serum opsonised *S. agalactiae* but reached the expected level for blood neutrophils when incubated for 30 minutes. The findings revealed that the *in vitro* phagocytic efficiency of buffalo neutrophils which appear in milk during the early stages of acute mastitis, is similar to that of blood neutrophils.

H-90 SILVA, I.D., AMBAGALA, A.P.N. and SILVA, K.F.S.T. **Preliminary observations on the application of California mastitis test on buffalo *(Bubalus bubalis)* milk.** In: *Proceedings of Annual Research Sessions, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, 3 December 1994. Peradeniya, Sri Lanka.* pp.18 Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The applicability of the California Mastitis Test (CMT) on buffalo milk was studied since the established CMT scores for cattle milk may not be valid for buffalo milk. This is because the maximum somatic cell count (SCC) of normal buffalo milk was 375,000 cells/ml compared to a maximum of 200,000 cells/ml of normal cattle milk, in addition to changes in chloride ion concentration (Cl^-) in milk. The SCC, pH & Cl^- of the milk samples of 18 clinically normal buffalo cows used in this study were in the normal range. Aseptic mastitis was induced in one cow by infusing sterile distilled water into the udder. Mastitic milk which was collected 18 hours after induction had a SCC of $58x10^6$/ml, CMT score of 3 and Cl^- of 0.164 %. Micro litre volumes of this induced milk was mixed with various volumes of the sample milk, to obtain varying concentrations of somatic cells/ml. This procedure was repeated for the remaining 17 milk samples. The CMT revealed that cell concentrations up to 200,000/ml gave a negative score; between 406,000 and $1.5x10^6$/ml gave a trace reaction; between $3.1x10^6$ and $6.2x10^6$/ml gave a weak positive (Score of 1) reaction; a count of $9.3x10^6$ to $25x10^6$/ml a distinct positive (Score of 2) reaction and over $31x10^6$/ml gave a strong positive (Score of 3) reaction. Since only the cell count affects the CMT scores, these preliminary observations show that the range of SCC for any CMT score in buffalo milk is different from that of cattle milk. The experiments will continue further to categorise the exact range of cell counts for each CMT score and to establish the Cl^- and pH of mastitic buffalo milk.

H-91 SILVA, I.D., KULACHELVY, K. and ALLEN, J.D. **Preliminary observations on a seroepidemiological survey of brucellosis in cattle and buffaloes in Sri Lanka.** In: *Proceedings of Annual Research Sessions, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, 3 December 1994. Peradeniya, Sri Lanka.* pp.5. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The nation wide prevalence of brucellosis in cattle and buffaloes in Sri Lanka was measured by using the Enzyme Linked Immunosorbent Assay (ELISA) to detect serum antibodies for *Brucella abortus*. Accordingly, 4245 animals (approximately 0.2% of population) in the private sector from 23 districts were sampled according to a stratified sampling technique, based on the animal population and the number of Divisional Secretariat Areas (DSA) per district. As some districts were slightly under or over represented, the overall adjusted prevalence in cattle and buffaloes were calculated as 5.4% and 3.4%, respectively. A high prevalence was observed in cattle in Puttalam (19.7%), Ampara

(10.9%), Anuradhapura (9.5%), Nuwara Eliya (8.7%), Hambantota (6.8%), and Matale (5.4%) districts; an average prevalence in Kurunegala (4.5%) district; low prevalence in Gampaha (2.7%), Ratnapura (2.2%), Vavuniya (2.0%), Moneragala (1.7%), Colombo (1.0%), Matara (0.9%), and Kandy (0.4%) districts; zero prevalence in Galle, Kalutara, Badulla, Pollonnaruwa and Kegalle. In contrast, a high prevalence in buffaloes was observed in Puttalam (21.1%), Ratnapura (12.5%), Ampara (10.0%); an average prevalence in Hambantota (5.1%) and Moneragala (4.2%) districts; low prevalence in Gampaha (3.8%), Matara (3.8%), Kalutara (2.9%) and Kurunegala (2.7%); zero prevalence in Colombo, Kandy, Matale, Galle, Kegalle, Nuwara Eliya and Polonnaruwa. A greater prevalence in cattle was associated with the following risk factors; intensive and extensive management practices; increasing age; greater stock densities; dry zone low country and wet zone up country climates. However, in buffaloes, the only risk factor was the dry zone low country climate. There were no associations with the breed and sex in both cattle and buffalo.

H-92 SILVA, I.D. and SILVA, K.F.S.T. **Total and differential cell counts in buffalo (*Bubalus bubalis*) milk.** *Buffalo Journal* (1994) **2,** 133-137, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This study describes the cytology of non-mastitic milk of Surti, Murrah and Lankan buffaloes and their crosses. The California Mastitis Test scores were negative in all samples and the pH of the milk ranged from 6.12 to 6.87 with a mean of 6.58. The findings revealed that the total somatic cell counts in normal buffalo milk varied from 50,000 to 375,000 per millilitre and a variation was observed in the counts among the buffaloes. The neutrophil which was the most frequently observed cell in buffalo milk constituted an average of 56% (22-88%) of the total somatic cell counts. The neutrophil cell count was much higher in buffalo milk than in cattle milk. The second most commonly observed leukocyte in buffalo milk was the lymphocyte which constituted an average of 28% (10-54%) of the total somatic cell counts. The macrophages, epithlial cells and eosinophils constituted an average of 8%, 5% and 1%, respectively, of the total somatic cell counts. These findings imply that in buffalo milk a large number of neutrophils are available for phagocytosis and destruction of invading pathogens. A unique observation in buffalo milk was the presence of cells showing nuclear morphology indicating cell necrosis, which constituted a small percentage (2%) of the total cell count.

H-93 SILVA, I.D. and SILVA, K.F.S.T **Are buffaloes better protected against mammary infections than cattle?** *The 49th Annual Session of the Sri Lanka Association for the Advancement of Science, December 1993.* pp. 11-12. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This work describes the phagocytic efficiency of neutrophils which are the most active phagocytes in the body. Phagocytic activity is an important defense mechanism against mammary infections. Since blood neutrophils migrate to the mammary tissue to destroy invading pathogens during an infection, neutrophils isolated from blood and milk of buffaloes were allowed to interact with mastitis causing bacteria. The phagocytic efficiency of neutrophils isolated from blood was highest for *Staphylococcus aureus* (86%), followed by similar activity for *Streptococcus agalactiae* (77%) and *Escherichia coli* (74%). Out of somatic cell count of 140,000/ml (50,000-375,000/ml) in normal buffalo milk, 56% (22-88%) were neutrophils. Experimental induction of aseptic mastitis resulted in a high cell count in milk ($65x10^6$ ml) and 90% (86%-95%) of those cells were neutrophils. The phagocytic efficiency of milk neutrophils were also highest for *Streptococcus agalactiae* (65%) and *Escherichia coli* (66%). In a previous study on cattle the percent phagocytosis of blood neutrophils was highest for *Escherichia coli* (81%), followed by *Streptococcus agalactiae* (77%) and *Staphylococcus aureus* (64%). Accordingly, the phagocytic activity of buffalo blood neutrophils was 22.5% higher for *Staphylococcus aureus* and 7.8% lower for *Escherichia coli* while it was similar for *Streptococcus agalactiae*. Normal cattle milk contains up to 500,000 somatic cells /ml with a neutrophil concentration less than in normal buffalo milk (26%-29%). Cattle milk neutrophils are known to have a significantly reduced phagocytic activity for *Staphylococcus aureus* when compared with their blood counterpart. These findings explain the reported observation that buffaloes are more resistant to mastitis caused by *Staphylococcus aureus* than cattle.

H-94 SILVA, I.D., SILVA, K.F.S.T., AMBAGALA, A.P.N. and COORAY, R. **Markers of inflammation in buffalo milk.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 403-414. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Immunity in milk against invading pathogens is asserted by phagocytes and serum factors. The somatic cell count (SSC) in buffalo milk ranged from 50,000 to 375,000/ml, of which

56% (range 22-88) were neutrophils which are the most active phagocytes in the body. The lymphoctes constituted 28% (range 10-54) of the SCC, and the rest consisted of macrophages (8%), epithelial cells (5%) and eosinophils (1%). The presence of a small percentage (2%) of cells undergoing necrosis was a unique observation. The pH of the buffalo milk was 6.5 (range 6.1-7.0). In inflammation, the vascular permeability in the gland increases permitting leukocytes and serum factors in blood to enter the lacteal secretion. Experimentally induced aseptic subclinical mastits elevated the SCC from 50,000/ml to $75x10^6$/ml. and 90% of these were neutrophils. The presence of serum factors in normal milk was detected by the electrical conductivity (EC) and chloride ion percentage (C1%) which were 3.86 milli Siemens/cm and 0.11%, respectively. The entry of serum factors into milk preceeded the entry of cells, and a raise in EC to 4.87 mSiemens/cm (or above the mean plus twice the standard deviation, 4.46 milli Siemens/cm) and a rise in C1% to 0.14% were observed in milk following induction of subclinical mastitis. Significant alterations were not detected in acidity percentage and pH. The CMT negative milk had $5x10^{-10}$ moles/ml of adenosine 5'-triphosphate (ATP) and the values elevated with increasing SCC. A significant increase to $33x10^{-10}$ moles/ml was obtained for milk with CMT scores 2 which had an average SCC of $4.25x10^6$/ml. Streptococci were the major bacteria isolated from subclinical mastitic samples while 44% of the samples did not yield any bacteria on culture. Therefore SCC, EC, C1% and ATP are markers of subclinical mastitis in the buffalo.

H-95 SUNIL-CHANDRA, N.P. **Studies on rotavirus infection of buffalo calves in Sri Lanka.** *M.Phil. Thesis* (1988) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Faecal samples collected from 150 buffalo calves 1 to 150 days old were examined by the Enzyme Linked Immunosorbent Assay (ELISA) test for group A, rotavirus antigen. 27.3 per cent of these calves were having diarrhoea at the time of sampling. The rest were non-diarrhoeic, but incontact with them. Antigen was detected in 36.6 percent of diarrhoeic animals, and in 11.9 percent non-diarrhoeic animals. There was a significant association between the presence of antigen in faeces and diarrhoea in these animals ($P<0.001$). By the screening ELISA test using monoclonal antibodies the strongly positive specimens belonged to subgroup I rotavirus. The weakly positive specimens however, could not be subgrouped. Antigen was detected in diarrhoeic calves in the age group 1-60 days, but none in the 61-150 day group, indicating, the former group to be more susceptible to clinical disease. Apparently healthy calves, too, were infected with buffalo rotaviruses. This is the first study establishing the presence of rotavirus in buffalo calves in Sri Lanka, and its association with diarrhoeas in these animals. Three strains of rotavirus were isolated from faecal material collected from five diarrhoeic buffalo calves in MA104 cells. For virus isolation, pretreatment with trypsin, incorporation of trypsin in the maintenance medium, and rolling of the inoculated cell cultures at 37°C was necessary. These strains required adaptation before distinct cytopathic effects were produced. One of the isolates, 11C, selected for study was also known to a group A rotavirus by ELISA, with subgroup I specificity. Using post infection sera obtained from mothers, cattle and buffalo, a close antigenic relationship was observed between this isolate and U.K. bovine rotavirus whereas the buffalo and human subgroup II rotavirus strains were distinct. The test used to distinguish these strains was the blocking ELISA test. Antirotaviral antibodies in the sera of buffalo calves rose to very high levels from negative levels on the 1st days of their life, subsequent to colostrum suckling as tested by the blocking ELISA test. These maternally derived antibodies declined to negativity by the 33rd to 56th day. Five buffalo calves which were diarrhoeic and in which antigen was detected, were excreting virus in spite of having circulating antibodies. Virus was not detectable for more than seven days, in a natural rotavirus infection studied. In 63.4 per cent of the diarrhoeic animals rotavirus was not detected, indicated that other entero-pathogens too, other than rotavirus, were associated in these diarrhoeas.

H-96 SUNIL-CHANDRA, N.P. and MAHALINGAM, S. **Isolation and sub-grouping of rotaviruses from buffalo calves in Sri Lanka.** *Research in Veterinary Science* (1996) **60,** 187-189. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Twenty eight faecal specimens from Sri Lankan buffalo calves shown to be positive for rotavirus group A antigen were sub-grouped by an enzyme-linked imunosorbent assay, by using monoclonal antibodies prepared against subgroup I and II antigens. Thirteen of the 28 specimens which were classified as strongly positive belonged to subgroup I. Three of five faecal specimens inoculated onto roller cultures of MA 104 cells yielded group A subgroup I rotavirus. As with other group A rotaviruses isolated from human beings and young animals, the buffalo isolates required pre-treatment with trypsin, and to have trypsin incorporated in the maintenance medium and the inoculated cell cultures to be rolled; at least six serial passages were required before distinct

rotavirus cytopathic effects were produced in the MA 104 cells.

H-97 SUNIL-CHANDRA, N.P. and MAHALINGAM, S. **Study of natural rotavirus infection in buffalo calves in Sri Lanka.** *Tropical Animal Health and Production* (1995) **27,** 221-224. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This paper reports an investigation into an outbreak of rotaviral infection in buffalo calves in relation to their clinical status. virus excretion, nature of the virus spread to in-contact calves, as well as the acquisition and decline of maternally derived serum antibodies. Twelve buffalo calves from the same herd and aged between one and 93 days were maintained as 2 separate groups, 5 km apart. Group 1 comprised 4 calves which were tethered in the field most of the day; the 8 calves of group 2 were held in overcrowded conditions and housed most of the day. Faecal samples from diarrhoeic or in-contact calves were examined for presence of rotavirus at weekly intervals over a period of 74 days. Diagnosis of rotavirus diarrhoea is based on the detection of rotavirus group A antigen. Faecal samples diluted in phosphate buffered saline (1/10) were screened for rotavirus group A antigen by indirect double antibody sandwich procedure and positive samples confirmed by the blocking ELISA.

H-98 SUNIL-CHANDRA, N.P. and MAHALINGAM, S. **Rotavirus-associated diarrhoea in buffalo calves in Sri Lanka.** *Research in Veterinary Science* (1994) **56,** 393-396. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Faecal samples from 150 buffalo calves, 1 to 150 days old, located in various districts of Sri Lanka, were examined for group A rotavirus antigen by a screening Enzyme Linked Immunosorbent Assay (ELISA). Positive samples were confirmed by the blocking ELISA. In the calves studied, 27.3 % were diarrhoeic, and the rest were non-diarrhoeic but were in contact with the animals showing diarrhoea. Antigen was detected in 36.6% of the diarrhoeic animals and in 11.9% of the non-diarrhoeic animals. There was a strong association between the presence of the antigen in faeces and diarrhoea in these animals (X^2=46.98; P<0.001). Of the 146 serum samples examined for anti-rotaviral antibodies, by the blocking ELISA, at a single serum dilution (1:20) against a constant dose of antigen (8 units), 68.5% were positive indicating a wide-spread infection with the virus in the population studied. This is the first record of the detection of rotavirus and its association with diarrhoea in buffalo calves in Sri Lanka.

H-99 SUNIL-CHANDRA, N.P. and MAHALINGAM, S. **Application of ELISA in the diagnosis of rotavirus infections in buffalo calves.** *Buffalo Journal* (1994) **2,** 237-248. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The conditions for diagnosis of group A rotavirus infection in buffalo calves by Enzyme Linked Immunosorbent Assay (ELISA), were optimised in terms of the type of microtitre plates, all reagents and the cut off points for positivity. Irradiated polystyrene plates were the plates of choice. The optimal dilution for the clinical samples (faecal extracts), capture and detector antibodies and the enzyme conjugate were 1:10, 1:5,000 and 1:300, respectively. Further, we found that the cut off point for positivity by the screening ELISA was an optical density (OD) of ≥0.170 at 450 nm wave length, and for confirmation, when blocking activity was ≥2.7 by screening ELISA and ≥50% blocking activity in the confirmatory blocking ELISA. Samples having P/N value of <2.7 but ≥2.1 and<50% but ≥30% blocking activity, were regarded as weakly positive. In addition, pre and post colostral buffalo sera as negative and positive control sera respectively, were used for detection of anti-rotaviral antibodies by the blocking ELISA. This study establishes that the ELISA technique can be profitably used (once required parameters are defined), in the diagnosis of rotavirus infection in buffalo calves.

H-100 SUNIL-CHANDRA, N.P. and MAHALINGAM, S. **Application of Enzyme Linked Immunosorbent Assay (ELISA) in screening of faecal specimens from buffalo calves for detection of enteric viruses.** *Sri Lanka Veterinary Journal* (1987) **35,** 49-50, [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Many viruses are difficult to grow in cell culture. Moreover, they either have an abortive replicative multiplication cycle with minimal cytopathic effects or do not produce any cytopathic effects at all. To overcome these difficulties newer techniques such as electron microscopy and ELISA have been developed. This paper describes the application of this method to detect Rotavirus group antigen in faeces of diarrhoeic buffalo calves. Of these, several ways in which the ELISA can be used, we employed the indirect double-antibody sandwich method. For the successful development of this system several parameters were examined. Microtitre plates from different sources and different solid phase materials were tested and gave variable

results. Irradiated polystyrene microtitre plates were the best and gave minimal background colour development with control antigens. Optimal dilutions of capture antibody, detector antibody and peroxidase labelled goat anti-guinea pig IgG were obtained for use in the test by checker board titrations. Known positive and negative antigen controls were always included in every micro-ELISA plate due to the difficulty of controlling some variables such as day to day variations of temperature and plate to plate variations. Tween-20 and bovine serum albumin were added in the test procedure to minimise non-specific adherence of other globulins and constituents of faecal extracts to the solid phase. 33' 55' tetramethyl benzidine (TMB) peroxidase system was used, being inexpensive and non-carcinogenic. It was necessary to expose the rotavirus group antigen in order to carry out this test. This was achieved by pre-treatment of faecal extracts with the chelating agent EDTA (0.01 M Ethylene Diamine Tetracetic acid, disodium salt). EDTA has the effect of stripping out the outer shell of the complete rotavirus particles by chelating Ca^{2+} which is responsible for the integrity of inner and outer capsids.

H-101 SUNIL-CHANDRA, N.P. and MAHALINGAM, S. **Isolation of buffalo calf rotavirus in embryonic monkey kidney cell cultures.** *Sri Lanka Veterinary Journal* (1987) **36,** 56 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Rotaviruses are important in the aetiology of diarrhoea in infants, calves, piglets and lambs. Humans and most of the animal rotaviruses are difficult to grow in cell cultures. The present paper describes the isolation of strains of rotaviruses from buffalo calves. Two hundred and thirty four faecal samples obtained from 150 buffalo calves (1 d to 5 m) were examined for the presence of rotavirus group antigen by the indirect ELISA test. Faeces from 13 (8.7%) of 150 of these calves were found to contain rotavirus antigen. Faecal samples from 5 of these calves, which were diarrhoeic at the time of sampling were inoculated onto monolayer MA 104 (embryonic Rhesus monkey kidney-continuous cell line) cells which were then rolled at 37°C. Three of the five samples yielded virus by the 3rd passage and cytopathic (CPE) changes were distinct by the 5th passage. The CPE consisted of spindling and rounding of cells, formation of cytoplasmic processes, detachment of the cells from the cell sheet and floating of detached cell ends like feathers of a chicken wing. The isolates were confirmed by testing the infective tissue culture fluid for rotavirus group antigen by the indirect immunofluorescence test. When attempts were made to re-isolate the virus from original faecal samples after one year of storage at -70°C, only a third of the original specimens yielded the virus.

M-102 SUBASINGHE, D.H.A. and FERNANDO, M.S. **Immunity to foot and mouth disease in the buffalo: Colostral immunity in the neo-natal calf and it's duration.** In: *Proceedings of the Commonwealth Seminar on Immunobiologicals 25-28 February, 1988. Bangalore, India.* Veterinary Research Institute, Peradeniya, SL.

This experiment was designed to study the transfer of maternal antibodies to foot and mouth disease (FMD) in the buffalo through the colostrum from immune dam to the calf, and also the period of their retention as circulating antibodies in the calf. Twelve Murrah buffalo cows in the terminal stage of gestation from a state farm (Polonnaruwa) were selected for the experiment. The experimental group consisted of 8 cows, and 4 were kept as controls. The experimental animals were immunised with the FMD vaccine produced in Sri Lanka in the Virus Laboratory at Polgolla. Each of the experimental cows were given a 3ml dose of FMD Type 'O' vaccine subcutaneously. The serum samples were collected immediately prior to administering the vaccine and at 21 days post vaccination (before calving). Blood samples were drawn from the calves born to the experimental and control dams prior to colostrum intake and 48 hours after birth (i.e. after colostrum feeding). Subsequent serum samples were collected from the calves at 7,30,60,120 and 180 days after birth. The antibody response in the serum samples were measured by performing, serum neutralizing titre (SNT) to FMD type 'O' in roller tube cultures of BHK21 cells. Variable virus constant serum method was used to assay the level of neutralising antibodies. The experimental group of cows showed a mean post vaccinal serum neutralising titre of 2.80 (21 days post vaccination) as against a titre of 0.32 in the control group. The pre vaccinal titres were 0.58 and 0.54 in the experimental and control animals respectively. The calves born to experimental as well as control dams did not exhibit the presence of any antibodies to FMD virus prior to colostrum ingestion. However, at 48 h the calves born to experimental dams showed a low SNT level of 2.45, while the calves of the control dams showed a very low SNT level of 0.28. Subsequent blood samples taken from the new born calves at 7 days to 180 days at different time periods after birth showed a decreasing trend in the level of maternally derived antibodies (MDAs) with increase in age. It was also evident that when the cows were immunised in late pregnancy MDAs in the buffalo calf persisted at a high level up to a period of 4 months and decreased thereafter to a very low level at 6 months. This experiment demonstrated that the transfer of maternal immunity to FMD in the new

born buffalo calf occurred solely through the ingestion of colostrum from the dam and the level of MDAs circulating in the calf was proportional to the serum antibody level of the dam.

H-103 TOKHI, A.M. **Studies on the bacteriology of *Escherichia coli* strains from calves (*Bos taurus*) and buffalo calves (*Bos bubalus bubalis*) in Sri Lanka with special reference to their enterrotoxin production and antibiotic sensitivity patterns.** *M.Phil Thesis* (1985) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Two hundred and seventy three strains of *E.coli* were isolated from faecal or intestinal contents from calves and buffalo calves housed in farms in the dry and wet zones of Sri Lanka. The ability to produce toxin(s) and the relationship of these toxin(s) producing *E. coli* strains to diarrhoeal disease of calves and buffalo calves were studied. Forty eight strains of *E. coli* produced Vero cytotoxin (VT). Twenty eight per cent of 134 diarrhoeic calves and buffalo calves yielded VT producing strains of *E. coli*, but such strains were from calves. These differences were statistically highly significant ($P< 0.001$). The VT produced by 35 strains of *E. coli* were antigenically related to the VT produced by human *E. coli* strains when tested by neutralisation of toxin with *Shiga* antitoxin, but the VT produced by 5 strains were distinct. This study shows for the first time an association of VT producing *E. coli* with diarrhoeal disease of calves and buffalo calves and an antigenic relationship between *Shiga* toxin and VT of *E. coli* isolated from calves and buffalo calves. The ST producing strains of *E. coli* were isolated from 40 (15 per cent) of 273 animals in this study. 24 (18 per cent) of 273 animals in this study . Twenty four (18 per cent) of 134 diarrhoeic and 6 per cent of 87 apparently healthy calves and buffalo calves yielded ST producing *E. coli* strains. These differences were statistically significant ($P<0.05$). LT producing *E. coli* strains, though present in 11 per cent of the 273 isolates, were not associated with calf and buffalo calf diarrhoeal disease, in the present study. When the 273 isolates of *E.coli* were tested for their pathogenicity to adult mice, the results revealed that 100 (74 per cent) of 134 diarrhoeic isolates and 40 (46 per cent) of the 87 isolated from apparently healthy calves and buffalo calves were pathogenic. These differences were statistically significant ($P<0.0001$). Serotyping of the isolates with twelve antisera showed that although some isolates could be serotyped with these antisera the majority of the isolates gave either cross reactions or no agglutination. It is concluded that there was a multiplicity of 0 antigens amongst *E. coli* isolates from calves and buffalo calves in Sri Lanka. The antibiotic sensitivity patterns of the 273 isolates of *E. coli* revealed that the maximal resistance was recorded against bacitracin (100 per cent), followed by polymixin B (99 per cent), erythromycin (98 per cent), penicillin (98 per cent), chloramphenicol (97 per cent), ampicillin (88 per cent), neomycin (48 per cent) and tetracycline (42 per cent).

H-104 VASANTHATHILKA, V.W.S.M. and FERNANDO, S.T. **Use of nitrocellulose bound *Toxocara vitulorum* second stage larval excretions secretions antigens for transformation of primed lymphocytes of buffaloes.** In: *Proceedings of the Annual Research Sessions, Faculty of Veterinary Medicine and Animal Science University of Peradeniya, 19 December 1992. Peradeniya, Sri Lanka.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Toxocara vitulorum excretory secretory (ES) antigen prepared by *in vitro* culturing of L2 stage larvae when subjected to 3 to 20% sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE), revealed a minimum of 49 antigen compartments. The molecular weights (MW) of antigen compartments ranged from 14.5 to 380 kDa. The antigen compartments transferred on to nitrocellulose (N/C) by Western blotting, were separated into 10 groups by cutting the strips containing bound antigen according to their MW. The strips were dissolved in dimethyl sulfoxide (DMSO), precipitated with 0.05M carbonate/bicarbonate buffer and re-suspended in RPMI medium. Transformation studies with lymphocytes from, both naturally infected and hyper-immunised buffaloes revealed that these lymphocytes markedly recognised antigens contained in strip numbers 2, 3 and 4 (antigen band 2 to 11). All the other strips except for strip number 9 were also recognised by lymphocytes but to a lesser degree. Antigen band in strip number 9 (band 38 to 43) had shown no response for lymphocyte transformation. But they did not have any suppressive effect either. The need to study the protective activity of these separated antigen compartments in a mouse model was justified.

H-105 VASANTHATHILAKA, V.W.S.M. FERNANDO, S.T. and LLOYD, S. ***In-vitro* transformation of buffalo lymphocytes: Immunological responsiveness of lymphocytes to mitogens and antigens of *Toxocara vitulorum* during pregnancy**

and in the immediate post parturient period. *Sri Lanka Veterinary Journal* (1992) **39,** 15-22. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Toxocara has a complex life cycle. The embryonated eggs reach the infective stage in about 15 days under optimal conditions. After ingestion, the larvae encyst in the tissues mostly in the liver and lungs. During pregnancy larvae migrate to the mammary gland. At parturition larvae are excreted through colostrum and milk. Larvae enter the calf through the transmammary route and reach maturity in the intestines. Five pregnant buffalo calves, one non-pregnant buffalo cow and one male buffalo bull were used for collection of blood for *in vitro* transformation of lymphocytes during the peri-parturient period. The mitogens and antigens used were Concanavalin A (Con-A) and Pokeweed mitogen (PWM) and *T. vitulorum* L2 ES (excretory secretory antigens of L2 larvae), L2 antigen and adult worm excretory secretory antigen (A dES).. It was observed that the maximum degree of stimulation of lymphocytes for Con-A and PWM were at the concentrations of 1 g/well and for *Toxocara vitulorum* second stage larval excretory secretory antigen (TVL2ESAg) at the concentration of 20 g/well. With somatic second stage larval antigen (L2 Ag) and with adult worms, ES results obtained were variable. A marked decline on immunological responsiveness of lymphocytes of pregnant buffalo cows was also observed a few days before calving and lasted for 10 to 11 days after calving. In the control animals, lymphocyte responsiveness remained at the upper levels throughout the experiment.

H-106 VIPULASIRI, A.A., WIJEWARDANA, T.G. and DE ALWIS, M.C.L. **A note on the effects of storage temperature and time on the potency of haemorrhagic septicaemia oil adjuvant vaccine.** *Sri Lanka Veterinary Journal* (1982) **30,** 19-21. Veterinary Research Institute, Peradeniya, Sri Lanka.

A haemorrhagic septicaemia oil adjuvant vaccine was tested for potency using the active mouse protection test at different intervals after storage at 4°C, constant 30°C and at room temperature (varying from 17°C to 33°C). The results indicated no appreciable drop in potency up to 6 months after storage at 4°C. However, a significant drop in potency was observed when the vaccine was stored at room temperature beyond one month.

H-107 WANASINGHE, D.D. **Mastitis among buffaloes in Sri Lanka.** In: *Proceedings of the First World Buffalo Congress, 27-31 December 1985. Cairo, Egypt.* pp. 1331-1333. Veterinary Research Institute, Peradeniya, Sri Lanka.

This study was conducted in farms where both buffaloes and cattle are reared together. The herds were visited at the time of evening milking for sampling and each animal was sampled only once. The collection and examination of the samples were done according to the recommendations of the National Mastitis Council of USA. Separate milk samples from each quarter were collected from 493 buffaloes and 240 cows. For the bacteriological examinations, the samples were cultured on sheep blood agar within 8 hrs of collection. Plates were incubated at 37^{0}C and examined after 18 h and 48 h. Appearance of more than 3 bacterial colonies was recorded as a positive growth and were identified primarily by their colonial morphology. After cultural examination, the milk samples were subjected to California Mastitis Test (CMT). The CMT was conducted according to the method described by Schalm and Ziv-Silberman. Any gross abnormality observed in the milk, suggestive of clinical mastitis was recorded. The number of blind teats in the cows was also recorded. The results show that the incidence of mastitis and udder infections in buffaloes is much less than in cattle. With regard to the aetiological agents, it appears that staphylococcal infections in buffaloes are strikingly lower than in cattle. These results lead to the conclusion that buffaloes are more resistant to udder infections than cattle, particularly to *S. aureus* infections. However, further studies are required to confirm these findings and ascribe possible reasons for the difference.

H-108 WANASINGHE, D.D., PINTO, M.R.M., NAVARATNAM, C. and WELIANGE, L.V. **Studies on tuberculin sensitivity of livestock in Sri Lanka. VII. An investigation of the possible identities of mycobacteria causing infection, and of the accuracy of diagnosis with the standard single comparative intradermal tuberculin test.** *Sri Lanka Veterinary Journal* (1988-89) **36,** 31-41. Veterinary Research Institute, Peradeniya, SL.

An attempt was made to establish the identity of possible infecting mycobacterial agents in cattle and buffaloes using a battery of four skin test antigens from different species of mycobacteria. These four mycobacteria produced dominant reactions suggestive of infection in only a few of the animals tested. It was thought that this could be due to, either the infecting mycobacterium being organisms other than those from which PPDs used for skin testing here were obtained, or due to multiple infections. The accuracy of diagnosis using the standard single intradermal comparative tuberculin test was also assessed with the four antigen test. It was found that in the majority of

instances, the diagnosis of "mammalian" infection with the former test was probably erroneous.

H-109 WANASINGHE, D.D., RAMAKRISHNASWAMY, A. and SOMARATNE, M. **Incidence of mastitis in buffaloes in Sri Lanka.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982 pp. 149-153. Veterinary Research Institute, Peradeniya, SL.

Milk samples from 1636 quarters of 409 mammary glands of buffaloes and 648 quarters of 162 mammary glands of cattle managed under similar conditions were examined physically, bacteriologically and by the California Mastitis Test (CMT). In buffaloes, 0.6% of quarters had clinical mastitis, 6% were blind due to mastitis during previous lactations, 30% showed a positive reaction to CMT and 7.5% yielded pathogenic bacteria. The corresponding findings in relation to cattle were that 2.5% quarters had clinical mastitis, 6.5% were blind, 55% were positive to CMT and 31.2% were positive to pathogenic bacteria. Thus the incidence of mastitis and udder infections in buffaloes was very low, particularly when compared with cattle. The incidence of staphylococcal infections in buffaloes was strikingly low (0.2%). The percentage of bacteriological isolations from CMT positive quarters of buffaloes and cattle, was very low (13.9%) when compared to cattle (42.9%). The isolation of mastitis pathogens from CMT negative quarters from buffaloes and cattle were 4.5% and 17% respectively. Considering the relatively high percentage of blind quarters and the low incidence of udder infections detected in buffaloes, it is suspected that an organism not detected by the routine techniques used, was involved. In view of the low incidence of mastitis and udder infections in buffaloes, they could be considered a superior species for milk production over cattle.

H-110 WEILGAMA, D.J. **Observations on *Schistosoma nasale Rao*, 1933 infections in the vertebrate and snail hosts** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 427-438. Faculty of Medicine, University of Peradeniya, Peradeniya, Sri Lanka

Carcasses of cattle and buffaloes were examined for *S. nasale* infections during the period August 1992 to November 1993 at the Colombo abattoir, Government Livestock Farms and in the field. Infections were detected in 5.9% cattle and in 23.9% buffaloes. In contrast, the infection rate at the Narangalla Buffalo Research Station was 91%. Monthly examination of nasal secretions of these infected buffaloes showed *S. nasale* eggs persisting up to 8 months. The only clinical sign observed was a thick nasal discharge. Snails belonging to six species were examined although in the natural disease only *Indoplanorbis exustus* is infected. The infection rate, however, was low (0.55%). Laboratory bred snails (F gen) of *I. exustus* from Narammala, Peradeniya, Nikaweratiya and Girandurukotte were tested and only snails from Peradeniya and Girandurukotte were susceptible. Miracidial doses of 1, 4, 6 and 10 per snail produced infections, and infection rates of up to 50% were obtained. Higher doses (20/snail) caused heavy snail mortality. The prepatent period varied from 30 to 59 days and cercarial emergence peaked in the morning hours (800 -1130 hr). Attempts to infect snails of *Bithynia sp.* and *Bulimus sp.* failed. The cercaria were observed to migrate through skins of rats, mice and guinea pigs but schistosomulae were recovered only from lungs of mice, 5 to 7 days post exposure. Attempts to infect calves in the laboratory were not successful. Circumoval Precipitin Test (COPT) was developed and was found to be useful in detecting *S. nasale* infections in cattle and buffaloes. COPT produced clear precipitin reactions around schistosomulae with sera of infected cattle and buffaloes.

H-111 WEILGAMA, D.J. **Ecto and haemoprotozoan parasites of the water buffalo *in* Sri Lanka** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982 pp. 134. Veterinary Research Institute, Peradeniya, SL.

Ectoparasites and haemoprotozoans encountered in buffaloes in Sri Lanka appear to vary between climatic zones. In the dry zone, the most prevalent ectoparasites affecting buffaloes were the blood suckling flies of the families *Tabanidae*, *Muscidae* and *Simullidae*. Myasis causing flies such as *Chrysomia bezziana* was also observed in buffaloes. In contrast, buffaloes in the wet zone were affected primarily by *Stomoxys calcitrans.* Ticks affecting buffaloes were also found to differ in the two zones. Ixodids species such as *Hyalomma marginatum issaci*, *Amblyomma integrum*, *A. testudinarium* and *Rhipicephalus haemaphysaloides* were common in the dry zone while *Boophilus* spp. and *Haemaphysalis bispinosa* were collected occasionally. In the wet zone, however, only mild infestations involving the latter three species were encountered. Lice infestations are common among buffaloes in all parts of the country. Sucking lice such as *Haematopinus* spp.. and *Linognathus* spp. and biting lice like *Bovicola* spp. have been identified and are largely responsible for the decrease in condition and anaemia in young buffalo

calves. Mite infestations are rare. Two species namely, *Psoroptes communis* var. *bovis* and *Chorioptes* spp. were isolated from buffaloes. Of the haemoprotozoan parasites, Trypanosomes and two species of Theileria, namely *Theileria annulata* and possibly *T. mutans* were detected. In the wet zone and in most other areas, the relatively non-pathogenic organism, *T. mutans* was seen. It is believed that the ticks *Hyalomma marginatum issaci* and *Boophilus* spp. act as transmitters of *T. annulata* and *T. mutans,* respectively. In general, Trypanosomal infections were very rarely encountered and the only species identified was *T. evansi*.

H-112 WEILGAMA, D.J., PERERA, P.S., NANAYAKKARA, E. and NAMBUGE, D. **Observations on Theileriosis among cattle and buffaloes in Sri Lanka.** *Sri Lanka Veterinary Journal* (1986) **34,** 64, [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Theilarial infections are common among cattle and buffaloes in many parts of Sri Lanka. The infections among sampled cattle ranged from 35% in some areas to 100% in other areas whilst in buffaloes it varied from 20 to 80%. The infection rate was found to be higher in the dry zone. Theileria belonging to two species were encountered. The most common one resembled *T. orientalis*, and was found in many parts of the country whilst the other, *T. annulata*, was seen at Polonnaruwa. Ticks belonging to five genera namely, *Boophilus*, *Haemaphysalis*, *Rhipicephalus*, *Hyalomma* and *Amblyoma* were collected from cattle and buffaloes examined in this study. *H. bispinosa* ticks transmitted *Theileria* spp. from one calf to another under experimental conditions. *Hy. marginatum isaaci* and *R. haemaphysaloides*, however, failed to transmit the disease. Anaemia was a common sign found among cattle and buffaloes infected with *Theileria* spp. Calves infected experimentally, developed a parasitaemia of up to 11% and their packed cell volume and haemoglobin concentration declined by as much as 30% and 28% respectively. A marked increase in total leucocytes was seen in calves. In buffalo calves, this leucocytosis was due to increase in lymphocytes.. Anaemic changes were also seen in buffaloes whilst the parasitaemia recorded in this study was 5.2%. Long-acting tetracycline (Pfizer) was effective against *Theileria* spp. infection. There was, however, no additional benefit in using anti-malarials together with tetracyclines. Paravâquone (Clexon-Wellcome Foundation) cleared the infection in most animals after two injections.

H-113 WETTIMUNY, S.G.de.S. AND ABEYSENA, F.S. **Sarcosporidiosis in slaughtered neat cattle and buffaloes in Ceylon.** *Ceylon Veterinary Journal* (1966) **14,** 2-6. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Sarcosporidiosis is an infection seen most commonly in the skeletal muscles and to a lesser extent in the cardiac, lingual, laryngeal, pharyngeal and oesophageal muscles due to the organisms of the genus *Sarcocystis.* Sarcosporidiosis among food animals is of economic importance due to losses to the meat industry. The parasite is widespread in distribution and has been recorded in many parts of the world. This paper records the incidence of sarcosporidiosis among neat cattle and buffaloes in Sri Lanka and also describes the gross and histological appearance of infected muscles. Sarcocysts, in infected carcasses were both widespread as well as localised. In severely affected carcasses, the parasite was most frequently present in the muscles of the forelimb, hind limb and in the abdominal, thoracic and sub-lumbar regions. Other sites where the parasite was present included the tongue, heart and oesophagus. The sarcocysts appear as white, opaque, spindled shaped structures. Histologically, the sarcocysts in muscles appear as cylindrical, granular lobulated bodies of varying length with pointed or rounded edges. They lie along the long axis of a single muscle fiber. The cyst is lined by a inner thin basophilic wall and an outer thicker hyaline wall which lies in close association with the muscle of the host. The disease was prevalent in cattle and buffaloes from many parts of the country. Although the ingestion of infected meat may well be a mode of infection, sarcosporodiosis is rare in man, probably because meat is invariably cooked before consumption.

H-114 WIJEWARDANA, T.G. **Haemorrhagic septicaemia.** *Reviews of Medical Microbiology* (1992) **3,** 59-63. Veterinary Research Institute, Peradeniya, SL.

This paper is a review of the literature of haemorrhagic septicaemia (HS), a primary form of pasteurellosis that affects cattle and buffaloes and is caused by specific serotypes (B:2 and E:2) of the Gram-negative bacterium, *Pasteurella multocida.* The disease occurs in Asia, Africa, Southern Europe and perhaps in South America and is characterised by terminal septicaemia and high mortality. The paper reviews information relating to the organism, epidemiology, host species affected, the pathogenesis, diagnosis, treatment and control.

H-115 WIJEWARDANA, T.G. **The significance of the carrier animal in the epidemiology of haemorrhagic septicaemia in cattle and buffaloes.** *M.Phil. Thesis* (1986) Faculty of Veterinary

Medicine and Animal Science University of Peradeniya, Peradeniya, SL.

Investigations were carried out to study the nature and duration of carrier status of haemorrhagic septicaemia (HS) in cattle and buffaloes and its possible relationship to the antibody status. These studies were done on animals reared in the HS endemic areas and on those infected experimentally with HS and maintained in isolation in the laboratory premises. Observations made on animals slaughtered at a municipal abattoir is also reported. Detailed studies were also done on the organisms isolated from carrier animals. In 3 villages (Maeliya, Morotta and Moragollagama) in the HS endemic zone herds of cattle and buffaloes were monitored for their carrier and antibody status for periods of up to 213 days following natural outbreaks of HS. In Maeliya and Morotta, 5 (20%) and 3 (12%) of a herd of 25 buffaloes, were detected as carriers while at Moragollagama 4 of 10 (40%) buffaloes and 4 of 27 (14%) cattle were found to be carriers. The percentage of animals that developed antibodies in the 3 herds were 88%, 92%, and 90% respectively. In all these herds, the number of animals that showed antibodies was always higher than the number that became carriers. The percentage of carriers detected was highest immediately following an outbreak and the numbers diminished with time. In the study conducted at the laboratory premises, detailed observations were made on the carrier status of 26 buffaloes and 3 cattle maintained in close contact with buffaloes infected experimentally with HS. In buffaloes the organism was found to appear in the nasopharynx intermittently. Periods of days between two consecutive isolations seemed to vary and in some instances it was even 59 days. The maximum period for which an animal showed the presence of the organism in the nasopharynx, was 215 days post exposure. Autopsies were performed on 8 buffaloes and the organism was isolated from the nasopharynx and 8 other sites namely, parotid salivary gland, mandibular salivary gland, parotid lymph nodes, mandibular lymph nodes, retropharyngeal lymph nodes, haemolymph nodes and spleen.. Isolations, however, were not made from axillary lymph nodes, cervical lymph nodes, mediastinal and bronchial lymph nodes, mesenteric lymph nodes and hepatic lymph nodes. In a study done at the municipal abattoir, Kandy, 494 male adult cattle of mixed breeds originating from HS endemic areas, were examined and 76.6% of these were found to possess antibodies to HS. Nasopharynx of these animals were swabbed through the external nares before slaughter and directly after slaughter. The percentage of carriers detected by these two methods were 0.6% and 1.4% respectively. On culture, pasteurellae were isolated from the retropharyngeal lymph nodes of 2.2% of slaughtered animals. The possibility of goats being reservoir hosts of HS was also investigated. Sixteen goats with no antibodies to HS placed in close contact with buffaloes experimentally infected with HS, failed to become clinically infected or to develop antibodies or become carriers. However, when a similar group of goats were infected experimentally with doses ranging from 35 to 10^8 cattle minimum lethal dose (CMLD's), a few deaths due to HS occurred. Of 21 goats that were infected by the subcutaneous route, 2 died while 2 of 12 infected by inhalation also died. Of the 10 goats infected by the oral route, only 1 died. Few goats developed antibodies to the HS organism. The carrier status was seen in few goats and lasted for a maximum period of only 28 days. *P.multocida* was not isolated from any of the 18 goats that were autopsied. Of 254 goats examined at the municipal abattoir, Kandy, 26.7% showed antibodies against HS, but no isolations were made either from nasopharynx or from the retropharyngeal lymph nodes of these animals. A total of 40 isolates of *P.multocida* from carrier animals were subjected to a complete biochemical and serological study. The isolates from live carrier animals with a history of recent exposure to HS showed a remarkable uniformity in their biochemical and serological characters. A significant number of isolates from the abattoir animals, on the other hand, showed variations. A few representative isolates which were subjected to pathogenicity studies in buffaloes and in mice. proved that they were as pathogenic to mice as those obtained from HS outbreaks and were capable of producing the typical disease syndrome in susceptible buffaloes.

H-116 WIJEWARDANA, T.G., DE ALWIS, M.C.L. and BASTIANZ, H.L.G. **Cultural, biochemical, serological and pathogenicity studies of strains of *Pasteurella multocida* from carrier animals and outbreaks of haemorrhagic septicaemia.** *Sri Lanka Veterinary Journal* (1986) **34**, 43-57. Veterinary Research Institute, Peradeniya, SL.

The objective of this study was to compare the cultural, biochemical and serological properties and pathogenicity of *Pasteurella multocida* isolates from healthy carriers with those isolated from outbreaks of HS. A total of 40 isolates of *Pasteurella multocida* from clinically normal buffaloes and cattle were examined for cultural biochemical and serological properties. Of these, 17 isolates collected from the nasopharynx of carrier animals from herds with recent exposure to haemorrhagic septicaemia (HS), showed uniform biochemical and serological properties and were similar to the isolates from outbreaks of HS and the reference culture (serotype 6:B). Greater variation

in the biochemical and serological properties were observed among the remaining 23 isolates obtained from the nasopharynx and associated lymph nodes of cattle from endemic areas but with no recent history of exposure. The isolates from carrier animals were pathogenic to mice as those from outbreaks of the disease. Further, on experimental inoculation they reproduced the typical syndrome of HS in buffaloes.

H-117 WIJEWARDANA, T.G., DE ALWIS, M.C.L., GOMIS, A.I.U. and VIPULASIRI, A.A. **Persistence of the carrier status in haemorrhagic septicaemia in buffaloes.** In: *Proceeding of the 4th International Workshop on Haemorrhagic Septicaemia, 11-15 February 1991. Kandy, Sri Lanka.* FAO/APHCA Publication: 1991/13 [Edited by De Alwis, M.C.L. and Wijewardana, T.G.] Bangkok, Thailand, FAO. 1991 pp. 99-103. Veterinary Research Institute, Peradeniya, SL.

Previous field observations had indicated that, among cattle and buffaloes recently exposed to outbreaks of haemorrhagic septicaemia (HS), a high percentage of animals became carriers. The presence of the organism in the nasopharynx of these animals was transient, but in some, intermittent re-appearance was observed. In the present study, carrier animals produced experimentally, were closely monitored for the presence of pasteurella in the nasopharynx, and the antibody response. An attempt was made to determine where the organism persisted during periods when it disappeared from the nasopharynx. Fifty seven buffalo calves between 4 and 10 months of age, were either experimentally infected with HS or exposed to infected animals. Of these, a total of 32 calves became immune carriers. They were studied in groups for periods of up to 360 days, during which time the presence of pasteurella in the nasopharynx and antibody levels in serum were monitored. In most animals, the organisms could only be isolated from the nasopharynx for a short initial period after which they disappeared from this site. They could be isolated again intermittently, after varying lengths of time, the longest such period being 215 days after the initial exposure. All carrier animals showed rising antibody titres with a peak that lasted from 150 to 180 days post exposure. Following slaughter, the pasteurella could be isolated from the tonsils in 20 out of the 27 animals examined. In this study, the longest period after exposure that the organisms could be isolated from the tonsils was 229 days. The organisms lodged in the tonsils were apparently unaffected by antibiotics to which they were sensitive *in vitro*. Our findings indicated that HS carriers existed in 'active' or 'latent' states. During 'active' periods, the organism appeared in the nasopharynx but during long 'latent' periods, the organism persisted in the tonsils.

H-118 WIJEWARDANA, T.G., HORADAGODA, N.U. and DE ALWIS, M.C.L. **Clinical and pathological changes in buffaloes experimentally induced with haemorrhagic septicaemia.** *Sri Lanka Veterinary Journal* (1987) **35,** 46-47 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Eight buffalo cows were experimentally infected with *Pasteurella multocida* 6:B by different routes, in order to induce haemorrhagic septicaemia. Five animals were infected intranasally, 2 by oral route and the other by subcutaneous injection. Their clinical and pathological changes were observed and recorded. The clinical changes in order of appearance were inappetance, elevation of temperature, oedema in the submandibular area, respiratory distress and recumbency followed by death. The course of the disease varied from 30 to 120 hours. Gross lesions were observed mainly in the heart and lungs. Accumulation of gelatinous, oedematous fluid in the submandibular area was observed in 4 animals. Pericarditis to different degrees; either petechial or ecchymotic haemorrhages or both types were observed in the myocardium. Congestion or consolidation of the entire lung or part of it was a consistent change observed. In most cases adhesions were evident between the pleura and lungs. Haemorrhages were common in the intestines and the omentum. Organs from 4 animals were subjected to histopathological examination and the findings were similar. In the lungs, the interlobular septae and subpleural tissues showed marked thickening due to oedema and extensive connective tissue proliferation. The pulmonary blood vessels showed hyperaemia. The alveolar spaces contained pink staining fibrinous exudate. The alveolar septae were thickened with evidence of haemorrhages from alveolar capillaries. Histological examination of the spleen revealed subserosal haemorrhages and congestion, but liver cells were relatively normal. The kidneys contained areas of cell degeneration with a few regions of autolysis.

H-119 WIJEWARDENA, T.G., RANAWANA, S.S.E. and VIPULASIRI, A.A. **An epidemiological survey of haemorrhagic septicaemia in cattle and buffaloes in the dry zone of Sri Lanka.** *Sri Lanka Veterinary Journal,* (1995) **42,** 24 [Abstract] Veterinary Research Institute, Peradeniya, SL.

An epidemiological study of haemorrhagic septicaemia (HS) in Sri Lanka was first made in 1980. However, the better co-ordinated vaccination programme adopted later using a more potent vaccine and wider vaccination coverage could have

influenced the epidemiology of this disease. Increased awareness among farmers may also have contributed to better prevention measures. The present study was undertaken in such a background with a view to assess the impact in comparison with the 1980 study. The survey covering 7 districts, 19 veterinary ranges and 37 Assistant Government Divisions included 36,415 cattle and 28,543 buffaloes representing a total population of 387,600 cattle and 310,400 buffaloes. The incidence and mortality figures for HS in cattle and buffaloes have declined significantly since 1980. More cattle herds (17.5%) were infected than buffalo herds (14.7%) while in 1980 the reverse was true. The mortality figures for cattle (4.0%) and buffaloes (3.4%) have significantly reduced from the 1980 figures of 17.8% for cattle and 24.2% for buffaloes. The <2 year age group was the most susceptible. The larger herds had higher morbidity and incidence while the smaller herds were less affected. The mortality among those affected with HS was highest in the smaller herds. Although the 1980 study stated that the mortality was low when the frequency of incidence was high, the present study revealed a low mortality with low frequency of incidence. This was attributed to vaccinal immunity as against naturally acquired immunity in the previous study. In both studies, the incidence was recorded from August to December with a peak in September, which coincided with the end of the dry season and commencement of monsoonal rains. The majority (74%) of the farmers were aware that HS is preventable, with 72.5% of them practising vaccination as a preventive measure and 70.9% of them agreed that the vaccination is effective. Of the farmers practising vaccination, 76.9% followed annual vaccination with 17.1% opting for vaccination after an outbreak. This is a reverse trend from 1980. Veterinarians were the main source of advice (67%) for the farmers, followed by neighbours (7.8%) and local physicians (2.5%).

H-120 WIJEWARDANA, T.G., WIJEWARDANA, B.D.R., APPUHAMY, W.N.D.G.S. and PREMARATNE, K.R.V.P.M. **Prevalence of leptospiral antibodies in buffaloes in Sri Lanka.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 415-426. Veterinary Research Institute, Peradeniya, SL.

Infections among humans, domesticated and wild animals caused by *Leptospira interrogans* occur worldwide. In Sri Lanka the prevalence of leptospirosis among domesticated animals has not been determined. The present sero-epidemiological study was to determine the prevalence of leptospirosis among buffaloes in Sri Lanka. Buffaloes are closely associated with humans as they are reared for both draught and dairy purposes. The infection is a zoonosis. The data generated from the study would be useful in the formulation of future control programmes. Based on the prevalence of leptospirosis among humans, the districts of Anuradhapura, Badulla, Colombo, Galle, Gampaha, Kandy, Kegalle, Kalutara, Kurunegala, Matara, Polonnaruwa and Ratnapura were selected for the survey. From each Divisional Secretariat division within a district, serum was collected from 0.4% of the buffalo population, giving a total of 1500 serum samples. Each sample was examined by the microscopic agglutination test against a panel of 10 serovars of Leptospira that are representative of sero groups present in Sri Lanka. Those showing an agglutination at a dilution of 1:50 or above were considered positive. The overall prevalence was 41.93 %. The highest prevalence was in Badulla district (72.91%) while the lowest was in the Kegalle district (11.84%). The most common serovar was *weerasingha* (30.2%) followed by *pomona* (26.55%) and *hardjo* (24%). The least common serovar was *ceylonica* (0.7%). These serovars maintained in other hosts have become adapted to buffaloes.

Part II – Management and Utilisation

M-01 ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A., RANAWANA, S.S.E., JAYATILAKE, M.W.A.P. and PERERA, A.N.F. **New Management system for intensive buffalo farming for dairying: A preliminary report.** In: *Proceedings of the Annual Research Sessions, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, SL, 3 December, 1994.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Studies were conducted on the development of model farming units for intensive rearing of buffaloes for dairying for popularising among rural subsistence farmers in areas where extensive rearing of cattle and buffaloes was not possible. Following a survey in two locations and rapid rural appraisal, Mahaweli H area with acute shortage of communal grazing land was selected for the field trials. Dual purpose Surti breed was selected for the model units. On station feeding trials were conducted to develop a suitable low cost feeding method. A feeding regime consisting of *ad libitum* feeding of rice straw, along with limited quantities of green forage supplemented with multinutrient paste consisting of 700 gms of rice bran, 300 gms of molasses, 65 gms of urea and 100 gms of mineral mixture (Magnesium sulphate 25 gm, Dicalcium phosphate 25 gm, common salt 25 gm, Cobalt sulphate 3 mg, Zinc oxide 200mg) was selected as the test diet (Diet 1) for the field level testing. Ten field units were established at Thambuttegama in Mahaweli H area. These units were designed to keep three adult buffalo cows and their followers. The sheds were constructed with low cost material. Pure bred Surti animals with an average milk production of 3-5 litres a day during previous lactations were introduced to the units and were placed on a diet (3 kg of coconut poonac and 3 kg of rice bran per day) similar to the diet they received at the livestock farms prior to their purchase, for a period of one month. Following this familiarisation period, animals were placed on the test diet (Diet 1). Water was splashed on the animals 3-4 times a day, to compensate for wallowing and water for drinking was made available freely. The body weight at weekly intervals, milk yield at daily intervals and feed intake at daily intervals were taken. Dates of calving, dates of oestrus and services were also recorded. In addition, a record on daily expenses, income, labour usage were also recorded. After 4 months on Diet 1, 50 gms of fish meal were incorporated into the multinutrient block (Diet 2) and measurements were taken as described earlier. Animals were kept on this diet over a 6 months period. The milk yield of animals during the periods prior to the test diets and during the periods on Diet 1 and Diet 2, respectively were 4.5±1.45, 3.9±1.20, and 4.1±2.48 l/day. The body weight of animals during the same three periods, respectively were 493.7±41.54, 476.5±42.07 and 466±48.66 kg and there was no difference in body weights during the three different diet periods. The fibrous feed intake per day during the same three periods were 38.3±14.05, 39.1±11.06, kg and 40.35±13.71 kg per day, respectively. The cost of supplementary feed of pre-trial diet, Diet 1 and 2 were Rs.30.00, 3.50, and 5.50 per day. All three diets were capable of maintaining the body weights and milk yield of adult buffaloes without having obvious effects on health and reproduction. In conclusion, a feeding system based on rice straw and green/leguminous fodder supplemented with multinutrient paste consisting of rice bran-molasses-urea-minerals was capable of maintaining adult dairy buffaloes and this diet allows the cost of feed to be cut down by 90%. However, this intensive rearing of dairy buffaloes among rural farmers, nevertheless face some possible problems. They are namely, lack of suitable dairy type buffaloes for the farmers, restriction on transport and possession of molasses, malpractices at milk collecting network.

M-02 ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A., RANAWANA, S.S.E., JAYATILAKE, M.W.A.P. and PERERA, A.N.F. **Preliminary report on the development of an intensive model buffalo farming system for popularisation among subsistence farmers** *Sri Lanka Veterinary Journal* (1995) **42,** (1) 27. [Abstract] Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Studies are in progress to develop an intensive model farming system for rearing buffaloes by subsistence dairy farmers in areas where the pressure on land is intense. The Mahaweli H area with an acute shortage of communal grazing land and the dual purpose Surti breed which produced 3-5 litres of milk was selected for the model units. An on-station feeding regime consisting of *ad libitum* rice straw along with limited green fodder supplemented with a multinutrient paste consisting of 700 gms of rice bran, 300 gms of molasses, 65 gms of urea and 100 gms of mineral mixture (Magnesium sulphate 25 gm, Dicalcium phosphate 25 gm, common salt 25 gm, Cobalt sulphate 3 mg, Zinc oxide 200 mg) was selected as low cost test diet (Diet 1).

Ten field units designed to accommodate 3 adult buffaloes and their followers were established at Thambuttegama. During the first month each animal was given the same diet (3kg coconut poonac + 3kg rice bran /day) they were fed on the state farm, from which they were purchased. Water was splashed on the animals 3-4 times a day to compensate for wallowing and *ad libitum* supply of straw was made available as roughage in the diet. Following this period of adaptation they were placed on Diet 1 for 4 month. The animals were then placed on Diet 2 which was similar to Diet 1 except that the multinutrient mixture contained 5% fish meal and was prepared in the form of a lick block. The animals were on this diet for 6 months. The daily milk yield, body weight and daily feed intake during the period of adaptation, Diet 1 and 2 respectively are as follows: milk yields 4.5 ± 1.45, 3.9 ± 1.20 and 4.1 ± 2.48 l/day; body weights: 493.7 ± 41.54 , 476 ± 42.07 and 466 ± 48.66 kg and fibrous feed intake 38.3 ± 14.05 kg, 39.1 ± 11.06 kg and 40.35 ± 13.71 kg/day.

The preliminary results of this study showed that a feeding system based on rice straw and green leguminous fodder supplemented with a multinutrient paste consisting of rice bran-molasses-urea-minerals was capable of maintaining body weights and milk yields of adult dairy buffaloes. This feeding system has reduced the cost of feeding by 75%. However, rural farmers practising this intensive rearing of dairy buffaloes may face problems such as the lack of suitable dairy type buffaloes, restrictions on transport and procurement of molasses, and malpractices in milk collection and sale.

M-03 ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A., PERERA, A.N.F., RANAWANA, S.S.E., JAYATILAKE, M.W.A.P. and PERERA, B.M.A.O. **Transfer of technology in smallholder intensive buffalo farming: Results from a pilot study in Mahaweli system 'H'.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press 1996. pp. 67-94. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Buffalo and cattle farming has become increasingly difficult and uneconomic because of (1) increased pressure on agricultural land, (2) seasonal fluctuations in feed availability and quality, (3) low productive and reproductive efficiency and (4) unfavourable ratio between the price of milk and the price of feed. The conventional research and extension delivery system has failed to disseminate research information and to solve the problems faced by resource poor farmers. Therefore, this study based on the farming systems research approach was aimed at (a) developing a model for smallholder intensively managed buffalo farm units (SIMBU) incorporating technologies from research and (b) demonstrating the feasibility, and the cost and benefits of intensification of buffalo farming. The model for SIMBU was designed to maintain 3 adult dairy buffaloes. A feeding system consisting of native grass, tree fodder and rice straw supplemented with 1kg/day of urea-molasses-multinutrient mixture (UMMM) was developed.

The testing and refinement of the feeding system was conducted in 4 successive phases, with roughage as the basal diet supplemented with, 3kg of coconut poonac and 3kg of rice bran (Diet 1), 1kg/day of UMMM given as a lick for 4 months (Diet 2), 1kg/day of UMMM fortified with 50g of fish meal as a by-pass protein for 6 months (Diet 3), and 1kg/day of UMMM given as a block (UMMB) containing 12% urea, 40% molasses, 30% rice bran, 10% cement, 5% minerals and 3% fish meal for 12 months (Diet 4). For Diets 2,3 and 4, the mean (±SD) feed intake on DM basis was 10.0±3.5, 10.4±3.2 and 11.4±0.3 kg per day, respectively. During the four phases, the mean body weight (based on chest girth) was 441.3±95.9, 476.3±40.1, 467.2±45.9 and 464.1±27.1 kg and mean milk yield was 2.4±2.6, 3.9±1.1, 4.0±2.3 and 4.3±1.4 litres, respectively. The cost of supplementary feed per day declined from Rs. 24.00 for Diet 1 to Rs. 5.50 for Diet 4 (US $1=Rs. 55.00). The annual calving rate during the first year under SIMBU was 62% and calving interval 584±80 days. The mean birth weight of calves (30.42±1.9 kg) and growth rates during the first 12 months (256±73 g/day) were similar to those recorded for Surti buffaloes on state farms. The costs borne by the farmers were for labour (of which the opportunity cost was very low), for maintenance of the sheds, collection of straw, cutting native pasture and fodder, milking, care of the animals and assisting the project personnel in keeping records of inputs and outputs. The benefits to the farmers were the income from milk for meeting daily cash needs, cushioning the losses from crop failures, availability of manure for home gardens as well as for rice fields, use of female buffaloes for draught and an increase in total assets with progressive increase in herd size.

M-04 ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A., JAYATILAKE, M.W.A.P., PERERA, A.N.F. and PERERA, B.M.A.O. **Development of intensive buffalo management systems for small-holders in human settlement schemes in the dry zone of Sri Lanka.** In: *Proceedings of the Second Asian Buffalo Association Congress, 9-12 October 1996, Manila, Philippines.* pp. 63-74. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A farming system research study was initiated to demonstrate the feasibility of intensification of buffalo farming under dry zone conditions and to study the costs and benefits. A rapid rural appraisal (RRA) was conducted and a human settlement area in system H of the Mahaweli project was selected. Constraints were identified through a questionnaire survey and

RA. and a cluster of nine small-holder farmers were selected. A model for 'small-holder intensively managed buffalo units' (SIMBU) was designed for maintaining three adult dairy buffaloes on crop residues and agro-industrial by-products. One such unit was established on a state farm for demonstration, followed by nine units on the selected farmers' premises using family labour. Each SIMBU was supplied with two Surti buffalo cows and one heifer. Their average lactation yield was 1018±347 litres at the farm of origin. Based on prior information from on-station trials, a feeding system consisting of grass, tree fodder and rice straw *ad libitum,* supplemented with 1 kg/day of urea-molasses-multinutrient mixture (UMMM) containing 5.5% urea, 25.7% molasses, 60% rice bran and 8.6% minerals was selected. The testing and refinement of the feeding system was conducted in 4 successive phases, with roughage as the basal diet, supplemented with: 3 kg coconut poonac and 3 kg rice bran per day for one month (Diet 1, identical to that on farm of origin); 1 kg/day of UMMM given as a lick for 4 months (Diet 2); 1 kg/day of UMMM fortified with 50 grams fish meal for 6 months (Diet 3): and 1 kg/day a urea-molasses-multinutrient-block (UMMM) containing 12% urea, 40% molasses, 30% rice bran, 10% cement, 5% minerals and 3% fish meal for 12 months (Diet 4). For Diets 2, 3 and 4, the mean (±SD) feed intake on DM basis was 10.0±3.5, 10.4±3.2 and 11.4±0.3 kg per day. During the four phases, the mean body weight (based on chest girth) was 441±95.9, 476.3±40.1, 467.2±45.9 and 464.1±27.1 kg and mean milk yield was 2.4±2.6, 3.9±1.1, 4.0±2.3 and 4.3±1.4 litres, respectively. The cost of supplementary feed per day declined from Rs. 24.00 for Diet 1 to Rs. 5.50 for Diet 4 (US$ 1 = Rs 55). The annual calving rate during the first year under SIMBUs was 62% and the mean calving interval was 584±80 days. The mean birth weight of calves (29.4±1.9 kg) and growth rate during the first 12 months (256±73 g per day) were similar to those recorded for Surti buffaloes on state farms. The benefits to the farmers were: income from milk for meeting daily cash needs; cushioning the losses from crop failures; availability of manure for home garden and rice fields; use of non-lactating buffaloes for draught; and an increase in total assets with progressive increase in herd size. This study demonstrates the feasibility of intensive rearing of buffaloes on a low cost feeding system based on crop residues and agro-industrial by-products and the use of idle family labour. It has succeeded in convincing previously sceptical rural farmers that appropriate technology can be used to provide sustainable income from seemingly meagre resources, and confirms the value of the farming systems approach to technology generation and transfer.

M-05 ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A., PERERA, A.N.F. and PERERA, B.M.A.O. **Farming system research (FSR) approach to technology generation and transfer in small-holder buffalo production systems in Sri Lanka.** In: *Proceedings of the Annual Scientific Sessions of the Sri Lanka Veterinary Association 8 March, 1997. Colombo, SL.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Traditional method of rearing buffaloes extensively on communal grazing lands has become increasingly difficult and intensified farming is not economical because of unfavourable price ratio between farm-gate price of milk and compounded feed. The rural subsistence farmers are in desperate need of new technologies to cope with this challenge. Researchers approach to technology generation and transfer (TG & T) has also radically changed, as the conventional approach which implied the TG & T is a linear process from research station to passive recipients, the subsistence farmers, has continuously failed. Farming system research (FSR) approach has evolved from 1980s, as a reaction to this failure and changed the role of the farmer in the TG & T system, promoting the farmer from being a passive recipient to an active player. FSR model was adopted in this study which was aimed at (a) developing and further refinement of small-holder intensively managed buffalo model units (SIMBU) incorporating technologies from research, at farmers' premises and (b) demonstrating the feasibility, and the costs and benefits of intensification of buffalo farming.

A model for SIMBU was designed to manage with family labour and on conventional (i.e. natural grass and fodder) and non-conventional (i.e. crop residues such as rice straw) feed resources with strategic supplementation for deficient nutrients (e.g. catalytic feeding of urea-molasses-multinutrient mixture - (UMMM). The testing and refinement of the feeding system was conducted in 4 successive phases, with roughage as the basal diet supplemented with, 3kg of coconut poonac and 3kg of rice bran/day (Diet 1), UMMM given as a lick for 4 months (Diet 2), 1kg/day of UMMM fortified with 50g of fish meal as a by pass protein for 6 months (Diet 3), and 1kg/day of UMMM given as a block (UMMB) containing 12% urea, 40% molasses, 30% rice bran, 10% cement, 5% minerals and 3% fish meal for 12 months (Diet 4). For Diet 2,3 and 4 the mean (±SD) feed intake on DM basis was 10.0±3.5, 10.4±3.2 and 11.4±0.3 kg per day, respectively. During the four phases, the mean body weight (based on chest girth) was 441.3±95.9, 476.3±40.1, 467.2±45.9 and 464.1±27.1 kg and mean (±SD) milk yield was 2.4±2.6, 3.9±1.1, 4.0±2.3 and 4.3±1.4 litres, respectively. The cost of supplementary feed per day declined from Rs. 24.00 for Diet 1 to Rs.5.50 for Diet 4 (US$1=Rs. 55.00). The annual calving rate during the first year under SIMBU was 62% and calving interval 584±80 days. The mean birth weight of calves (30.42±1.9 kg) and growth rates

during the first 12 months (256±73 g per day) were similar to those recorded for Surti buffaloes on state farms. The costs borne by the farmers were for labour, of which the opportunity cost was very low, maintenance of the sheds, collection of straw, cutting native pasture and fodder, milking, care of the animals and assisting the project personnel in keeping records of inputs and outputs. The benefits to the farmers were the income from milk for meeting cash needs, cushioning the losses from crop failures, availability of manure for home gardens as well as for rice fields, use of female buffaloes for draught and an increase in total assets, with progressive increase in herd size.

M-06 ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A., PERERA, A.N.F. and PERERA, B.M.A.O. **Farming system research approach to technology generation and transfer in smallholder buffalo production systems in Sri Lanka.** In: *Proceedings of the 5th World Buffalo Congress, 13-16 October, 1997. Caserta, Italy.* pp. 879-883. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The conventional approach to technology generation and transfer (TG&T) has failed to help smallholder livestock farmers, who traditionally manage their cattle and buffaloes under extensive systems, to meet the new challenges imposed by shortage of grazing lands, which make intensification of such operations imperative. The farming system research (FSR) approach was therefore used in this study to (a) develop and refine a model for "smallholder intensively managed buffalo units" (SIMBU), incorporating improved technologies and greater integration with crops, and (b) demonstrate the feasibility, costs and benefits of such a system in overcoming the emerging problems of rural land use patterns. The SIMBU was designed to be constructed with low-cost materials and managed with family labour. The feeding system was based on natural grasses, tree legumes and crop residues as the basal diet, with catalytic use of urea-molasses-multinutrient mixtures (UMMM). This was developed, tested and refined over a two year period on the smallholders' premises in four successive phases: Diet 1 - basal diet supplemented with 3 kg each of coconut poonac and rice bran; Diet 2 - basal diet with 1 kg/day of UMMM as a paste containing 5.5% urea, 25% molasses. 60% rice bran and 9.5% mineral mixture; Diet 3 - basal diet with 1kg/day of UMMM as above but fortified with 50 g fish meal; and Diet 4- basal diet with 1 kg/day of UMMM given as a lick block containing 12% urea, 40% molasses, 30% rice bran, 10% cement, 5% mineral mixture and 3% fish meal. The mean (±SD) feed intake on DM basis on Diets 2, 3 and 4 were 10.0±3.5, 10.±3.2 and 11.4±0.3 kg/day, respectively. The mean body weight during the four phases were 441.3±95.9, 476.3±40.1, 467.2±45.9 and 464.1±27.1 kg and the mean milk yields were 2.4±2.6, 3.9±1.1, 4.0±2.3 and 4.3±1.4 l/day, respectively. The cost of supplementary feed per day declined from Rs. 24.00 (US$ 1=Rs.58) in Diet 1 to Rs. 5.50 in Diet 4. The benefits were (a) regular income from milk to meet daily needs and overcome the agricultural debt cycle, (b) cushioning the risk of crop failures, (c) manure for crops, (d) animal power for rice cultivation and (e) increase in the household assets. This on-farm study clearly demonstrated the feasibility of intensified buffalo farming, the value of crop residues and agro-industrial by-products as animal feeds, and the use of under-utilised family labour for income generation. It has also confirmed the value of the FSR approach in TG&T in the smallholder livestock sector in Sri Lanka.

M-07 ABEYGUNAWARDENA, H., SIRIWARDENE, J.A.de S., SUBASINGHE, D.H.A. and PERERA, B.M.A.O. **Getting livestock research into practice: Researchers' dilemma.** In: *Proceedings of the Multi-disciplinary International Conference on the occasion of the 50th Anniversary of Independence of Sri Lanka. 23-25 February, 1998. Peradeniya, Sri Lanka.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

In the past, agricultural research scientists have not been successful in generation and transfer of technologies in a manner that is acceptable for adoption by the end-user. The main reason for this has been the absence of strong linkages between the scientists, the extension agent and the end-user. This paper has critically reviewed the different R&D approaches that have been used in the past and brings out the superiority of the farming system research approach which is currently used in many countries. The paper sets out the experiences gained through application of the farming system research approach in R&D aimed at increasing the productivity of the water buffalo in intensively managed production system in the integrated crop-livestock smallholder farming sector. The importance of greater farmer involvement and participation in the entire process of R&D, beginning with the selection of target farmers, the diagnosis of the farming system, the development of technologies and the dissemination of information is described. Based on the experiences gained, the paper examines the factors that hinder the efforts of researchers and limit the value of the technologies generated, at the level of the end-user, particularly arising from the inconsistencies in policy formulation and implementation. The authors conclude that researchers must act as change agents both at levels of policy formulation and the field, and that their efforts should be supported by a conducive institutional environment.

M-08 ABEYGUNAWARDENA, H., PERERA, B.M.A.O., SUBASINGHE, D.H.A., SIRIWARDENE, J.A. de S. **Livestock research and development**

strategies aimed at smallholder farmers: A case for greater farmer participation. *Sri Lanka Veterinary Journal* (1998) **45,** (In press) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL

Research and development (R&D) in the agricultural sector plays an important role in increasing productivity of crops and livestock, in the alleviation of rural poverty and food security, both at household and national levels. The approach to R&D aimed at smallholder farming in developing countries has changed with passage of time towards improvement in its effectiveness ensuring maximum benefits from agricultural research, which is often funded by the state. In contemporary, literature a few approaches or models for technology generation and transfer have been described: transfer of technology, adaptive transfer of technology, farmer participatory research which includes farming system research (FSR) and farmer-first research (FFR). The purpose of this article is to share the experience of a group of researchers who adopted the FSR approach to R&D in smallholder buffalo farming system where the farmers were faced with poverty, indebtedness, restriction of herd movements and dwindling availability of communal grazing lands. Based on the past research findings and "appropriate" solutions to overcome these problems, a "Small-holder Intensively Managed Buffalo Unit" (SIMBU) was developed through on-station research. The suitability and adaptability of these "appropriate" technologies were then tested using the SIMBU model through on farm research. The FSR study demonstrates 1) the feasibility of intensification of rearing of buffaloes on a low cost feeding system, based on crop residues (rice straw) and agro-industrial by products (e.g. urea, molasses) using idle family labour, in an area where grazing land has dwindled and where animal movements are severely restricted; 2) the value of buffaloes (and cattle) in rural agrarian communities as a means of supplementing the meagre income from on-farm and off-farm activities and thereby helping them to stay out of the rural agricultural debt cycle and 3) the applicability and the superiority of the FSR approach in R&D in the transfer of technologies to resource poor peasants in rural Sri Lanka. Based on this experience, a co-ordinated approach to get research into practice is proposed.

M-09 ABEYGUNAWARDENA, H. and ABEYGUNAWARDENA, I.S. **Water buffalo: Classification, organ, distribution, myths and misconceptions.** In: *Water Buffalo - Improved Utilisation Through New Technologies.* [Edited by Subasinghe, D.H.A. *et al.*]. Colombo, SL, National Science Foundation Press, 1998. pp. 1-10. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The worlds total buffalo population is estimated to be 148.8 million and of this 96.5% is found in Asia where they form an integral component at the rural farming systems. According to phenotypic characteristics and habitat, buffalo is classified into 2 groups; river buffaloes found along the river valleys of Indo-Pakistan subcontinent and swamp type which in found in other parts of Asia. The former is considered as dairy breeds while the latter group is considered as draught animals. Buffaloes indigenous to Sri Lanka are phenotypically classed under the swamp type. The total buffalo population in Sri Lanka is estimated to be 0.8 million and they are concentrated in paddy growing area such as Kurunegala, Hambantota, Anuradhapura, Polonnaruwa, Ampara and Batticaloa districts. The traditional use of the buffalo in Sri Lanka is for draught, but since the recent past they are becoming recognized as dairy animals because of its hardiness, ability to convert coarse forages into edible products more efficiently than cattle and also because its milk is rich in fat.

M-10 ABEYGUNAWARDENA, H. and ABEYGUNAWARDENA, I.S. **Water buffalo farming in Sri Lanka; Production system, uses, potentials and constraints.** In: *Water Buffalo - Improved Utilisation Through New Technologies.* [Edited by Subasinghe D.H.A. *et al.*] Colombo, SL, National Science Foundation Press, 1998. pp. 11-22. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Rearing water buffalo along with cattle is a commonly found mixed farming activity among many rural households. Based on agro-ecology, cropping systems and use, several buffalo production systems are found in the country. Free grazing, extensive management system is found in paddy growing dry zone areas, while the semi-intensive and intensive, systems are found in intermediate and wet zone areas. The primary use of water buffalo still is for draught, while the animal is gaining recognition as a dairy animal in many areas. Buffalo accounts for 37% of the farm power, 33% of the meat supply and 25% of the milk production in the country. Almost all milk is converted into curd, a popular dessert in Sri Lankan households. Besides these the buffalo contributes substantially to organic manure production. Though, buffalo farming in becoming very valuable for the sustenance of the rural agrarian economy, its sustainability has been threatened with vast changes occurring in the land use systems in many rural areas.

M-11 ABEYGUNAWARDENA, H. SIRIWARDENE, J.A. de S. and PERERA, B.M.A.O. **Technology development and transfer through a co-ordinated research and farming systems approach.** In: *Water Buffalo - Improved Utilisation Through New Technologies.* [Edited by Subasinghe, D.H.A. *et al.*]. Colombo, SL, National Science Foundation Press, 1998 pp. 83-91. Faculty of Veterinary Medicine and

Animal Science, University of Peradeniya, Peradeniya, SL.

The paper gives a brief description of the events that led to the inter-institutional and multidisciplinary research and development programme with the main objective of developing management technology to utilise the potential of the buffalo as a multipurpose animal in contemporary crop stock integrated farming systems. The programme which was conducted in three places was spread over a period of 15 years. Phase I from 1984 to 1988 collected the baseline information and identified constraints to buffalo production. Phase II generated a package of technologies to overcome constraints through the farming system approach and during Phase III the research information was made available to extension workers and farmers by dissemination of this information through various activities. The paper describes briefly the main features of a smallholder intensively managed buffalo unit developed by the R and D programme.

M-12 ABEYGUNAWARDENA, H. SIRIWARDENE, J.A.de S. and SUBASINGHE, D.H.A. [Editors]. **Cattle and buffalo farming training manual for extension workers.** SAREC/NARESA Buffalo Research and Development Programme, Publication No. 16. Colombo, Sri Lanka. National Science Foundation Press.(1998). 113 pp. ISBN. 955-590-014-0. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The training manual is arranged in two parts. The training course covers important aspects of cattle and buffalo farming, in ten training sessions. Part I of the manual sets out the objectives, the lesson contents and the knowledge the participant is expected acquire from the lesson. Part II gives the background material and the technical information on each topic. The material provided is intended as a helps to trainers in the preparation of lecture notes to meet the specific needs of different levels of participants. The topics covered in the manual are (1) basic concepts of fibrous feed utilisation (2) use of urea-molasses-mineral supplements (3) use of tree fodders in feeding (4) feed formulation (5) body condition scoring (6) reproduction (7) breeding (8) health and diseases (9) management and (10) crop-livestock integration.

M-13 ABEYRATNE, A.S. **Use of buffalo for clay mixing in brick manufacture.** *Ceylon Veterinary Journal* (1981) **29,** 21 [Letters to the editor] Department of Animal Production and Health, Peradeniya, SL.

Brick makers usually engage buffaloes for clay mixing. A survey was conducted in November/December 1978 to collect information pertaining to the Kelani valley, namely Mabima, Malwana and Mulleriyawa; herd owners were visited and the data collected by means of a questionnaire. There were 31 buffalo herds with 206 animals in all; the mean herd size was 7. These buffaloes were of the indigenous swamp type; 118 (57.3%) of them were males, of which fifty (42.4%) were castrates. Except in the case of one herd where veterinary advice was sought, all the castrations had been performed by crude local methods. The age at first calving was 42 months. Milking was practised only in two herds, indicating that the buffaloes in the survey area were used exclusively for draught. Dung was not utilised in the case of 10 animals (33%) of the herds. The draught activities were those involved in rice cultivation and brick making. For pudding clay, buffaloes were harnessed in pairs or in groups of three; one to two such groups were made to tread on the clay. The working hours for this activity were usually from 08.00 to 11.00 hours, and again from 14.00 to 16.00 or 17.00 hours. Each buffalo, working both sessions prepared sufficient clay to make two to three thousand bricks a day.

M-14 BOGAHAWATTE, C. **Economics functions in domestic water buffalo milk production: Some evidence from the dry zone districts of Sri Lanka** In: *Proceedings of the First World Buffalo Congress 27-31 December, 1985, Cairo, Egypt.* pp. 649-660. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

In Sri Lanka in spite of the high demand and import of milk products, only 40 percent of the female buffaloes are being milked. The buffaloes are reared mainly for farm draught power requirements by Sri Lankan peasant farmers. Presently, emphasis has been made to revitalise the buffalo dairy industry to conserve the much needed foreign exchange and to reduce the protein-calorie malnutrition which is evident among the rural and estate children. The main objective of this study was to determine the econometric relationship of buffalo milk production in the Polonnaruwa and Mannar districts of the dry zone in Sri Lanka. A total of 195 buffalo farmers consisting of 100 from Polonnaruwa and 95 from Mannar were randomly selected for a field survey in 1982. A system of questions consisting of milk yield function, number of buffaloes function, stocking rate function, labour use function and marketable surplus functions were fitted and estimated by the 2 SLS. The results indicate that the use of high quality concentrate feeds would enhance the milk yields and stocking rate of the female buffaloes. However, this would require a reduction in the present price of concentrate feeds or increase in the price of raw milk being offered by the Milk Board. The prices of buffaloes are high compared to cattle and this trend would reduce the number of female buffaloes reared per farm. This would also be influenced by the availability of credit facilities for milk production. The use of labour for buffalo production depends on the extent of paddy cultivated per farm. An increase in milk production per farm and

higher prices for buffalo milk would be required to increase the marketed surplus of milk.

M-15 BOGAHAWATTE, C. and ATHULATHMUDALI, D.P. **Microeconomics of rural cattle and buffalo production: A comparative study in the Kurunegala district of Sri Lanka.** In: *The Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka 7-10 March, 1989. Kandy, SL.* Faculty of Agriculture, University of Peradeniya, Peradeniya, SL

In recent times the rising demand for milk, meat and energy has resulted in a growing interest in cattle and buffalo production in Sri Lanka. The resurgence of the importance of these animals as a source of milk, meat and draught power has necessitated greater efforts for harnessing this valuable resource. In general, the standard of cattle and buffalo management practices of the rural farmers have been relatively poor and this was partly responsible for the low efficiency of meat and milk production and slow growth rates of the cattle and buffalo population. The objective of this study was to compare the economics of cattle and buffalo production under rural farming conditions in the Kurunegala district. The field survey carried out in the three Assistant Government Agent's divisions of Kuliyapitiya, Polgahawela and Nikeweratiya in 1987 using a structured questionnaire with 210 randomly selected cattle and or buffalo farmers.

The mean herd size of the indigenous cattle and buffalo herds were 9.3 and 16.7 respectively. The sex distribution of the buffalo herd was nearly 1:1. The proportion of females were higher in the cattle herd, free grazing of animals was common. The mean milk yield of cattle and buffalo herds was found to be 1.53 and 2.01 litres/cow/day respectively. The draught cattle and buffaloes were used for farm work 50-65 days/year. The draught capabilities of these animals were similar. The draught/milk and draught cattle farmers recorded a net herd loss from their enterprises. The dual purpose and milk buffalo herd recorded a net herd profit. In mixed herds, only the dual purpose herd recorded a similar profit. These results indicated the apparent diseconomy of rearing indigenous cattle in the study area.

The estimated production function results showed the importance of concentrate feeding, management practices such as housing in improving productivity of cattle and buffalo herds. The extent of highland and lowland owned, farm gate price of milk, distance of milk transport and availability of credit facilities were some of the major factors affecting animal ownership. The demand for feeds is mainly affected by the availability of concentrates in the farm locality, the farm gate price of milk as compared to the price of feeds and the extent of common property resources in the vicinity of the farms,. The demand for animal farm power depended on the daily working hours of the animals, cost difference between tractors and animal power, and the type of soil.

M-16 BOGAHAWATTE, C. **Supply response of milk and management efficiency of cattle and buffalo production in Sri Lanka: A cross section study in wet zone and dry zone districts.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, SL, NARESA Press, 1996. pp. 95-110. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Milk accounts for approximately 3% of the daily per capita calorie consumption and 4.5% of the protein intake of an average Sri Lankan. Nearly 70% of the rural population is engaged in milk production. However, the domestic milk production from cattle and buffaloes is low and not sufficient to meet the local demand.

The main objective of this study was to determine the supply response of milk and management efficiency of cattle and buffalo farms in Kandy, Matara, Hambantota and Polonnaruwa districts in Sri Lanka. Kandy and Matara districts in the wet zone and Hambantota and Polonnaruwa districts in the dry zone were selected purposely. The sample consisted of 86 farmers from Kandy, 72 farmers from Matara, 75 farmers from Hambantota and 85 farmers from Polonnaruwa. Both cattle and buffaloes were reared in their farms. A field survey using a questionnaire was carried out between April 1991 and March 1992. The supply response model consists of milk productivity and herd size equations estimated by Ordinary Least Squares. The management efficiency of buffalo and cattle production was estimated by using the method of Timmer (1980) as modified by Russel and Young (1983).

There was considerable variation in the supply elasticities estimated for the districts. The supply elasticities for cow milk and buffalo milk in Kandy, Matara, Hambantota and Polonnaruwa were inelastic and low, indicating poor price responsiveness of the producers.

The result of technical efficiencies showed that the majority of the cattle and buffalo farms in the districts were not within 10% of their potential technical efficiencies. The variations of technical efficiencies between cattle and buffalo farms were relatively high within each district.

M-17 BUVANENDRAN, V. and KUMARATILAKE, W.L.J.S. **A study of production characteristics and management practices of the indigenous buffalo.** *Ceylon Veterinary Journal* (1977) **25,** 43. Veterinary Research Institute, Peradeniya, SL.

A survey on the production characteristics and management practices of the indigenous buffalo was conducted in five districts - Polonnaruwa, Hambantota, Ampara, Anuradhapura and Kurunegala.

The study was done by interviewing farmers chosen randomly in each district on the basis of a standard questionnaire. The number of farmers chosen in each district was 15-20. Data was collected on herd composition, reproductive traits, lactation performance, mortality, draught management practices, feeding systems and other aspects. The percentage of adults in the population was 47.6 of which 15.1 were males and 32.5 were females. Age at first calving was 44.2 months and calving interval was 15.8 months. Calvings were seasonal chiefly during November to February and July to August. Only 58% of farmers milked their animals. In these herds 63.4% of the animals were in milk and the mean milk yield per day was 2.1 pints. Average lactation length was 5.3 months. The mean mortality rate among calves below 1 year ranged from 12 to 30% in different districts, while adult mortality ranged from 7 to 19%. The incidence of mortality was highest during October - January and July - August. Buffaloes are used in land preparation for agriculture. The time taken to prepare one acre of land depends on the nature of the land. If the land is suitable for ploughing the mean time taken to prepare an acre is 9.5 days, whereas in muddy lands requiring puddling the mean time is 17.1 days per acre.

M-18 CHANDRASIRI, A.D.N. and PARANAGAMA, D.M. **Constraints pertaining to performance of crossbred buffaloes.** *Sri Lanka Veterinary Journal* (1994) **41,** 32-33. [Abstract]. Veterinary Research Institute, Peradeniya, SL.

A study on growth, adaptability and economics of crossbred buffaloes was carried out in the Kurunegala district and certain constraints which affect the performance of crossbred buffaloes were identified.

Only the (Murrah x Lanka) F_1 progeny were included in the study. Average herd size was 26 (9-56). Natural breeding was practised. There was no organised stud bull service or Artificial Insemination (AI) service available for the farmers. However, stud bulls were owned by 54% of the farmer and 32.4 % used bulls of adjoining farms. Most of the bulls were given on lease by a private organisation. The main criterion of selection of stud bulls was the phenotypic appearances. There was no system to identify superior dams and to breed them with genetically superior bulls. Calves born on the herd were used as replacement stock and therefore, the herd average remains constant. Worm infestation, diarrhoea and infectious diseases were the most common diseases among buffalo calves.

Although the objective of crossbreeding was to improve the milk production potential of Lanka buffaloes, only 5.7% farmers reared them purely for milk. Majority of the farmers reared buffaloes as a dual (milk + draught) or triple purpose (milk + draught + meat) animals. The average total milk production of crossbred F_1 cow was 3.7 l/day. Extensive system of management, low quality of feed, limited grazing lands, etc. could be the cause for limited production.

Only 29.4% farmers had water for their animals throughout the year. Other management problems are lack of shelter during rainy season, trespassing of animals to crop lands, lack of sales outlets for milk and surplus animals, inadequate pricing for milk and surplus stock, delay in payments and frequent rejection of milk.

The high average daily milk consumption per farmer family (1.73 litres) compared to per capita consumption in the rural sector express their unwillingness to sell milk.

M-19 CYRIL, H.W. and JAYAWEERA, A. **Factors affecting carcass and meat quality of indigenous buffaloes in Sri Lanka.** In: *The Role of the Buffalo in Rural Development in Asia,* [Edited by Perera, B.M.A.O. *et al.*] Colombo, SL, NARESA Press, 1996. pp. 137-147. Faculty. of Agriculture, University of Peradeniya, Peradeniya, SL.

Two separate studies were conducted to study the factors affecting carcass quality and meat quality characters of indigenous buffaloes. In the first study, 60 randomly selected buffaloes (live weights ranging from 100 kg to 450 kg) were used, and in the second study 90 randomly selected buffaloes were used. Various factors (e.g. dressing percentage, meat to bone ratio and organ percentage) affecting carcass quality of buffaloes were determined. Meat samples were analysed for chemical composition (e.g. protein, fat, ash and water content), colour and tenderness.

The results of the carcass quality study revealed that the dressing percentage and meat to bone ratio increased with increasing live weight. The dressing percentage increased (mean ± SD) from 47.99% ± 0.14 to 54.35% ± 0.0 and meat to bone ratio increased from 2.39 ± 0.45 to 4.74 ± 0.0. There was no significant difference between the dressing percentage of males (51.66% ± 3.14) and females (51.05% ± 3.32). The meat to bone ratio was found to be higher in males (3.06 ± 0.81) than in females (2.70 ± 0.72). The percentage of organs was higher in females than in males. With increasing live weight, the percentage of fore-quarters increase from 51.74 ± 3.13 to 57.94 ± 0.0 while the percentage of hind quarters decreased from 47.90 ± 0.16 to 42.05 ± 0.0.

In the meat quality study, differences were observed in water, protein, ash and fat contents of the meat of young animals and adult animals. Respective mean values were 76.25% ± 1.12, 21.26% ± 1.56, 1.72% ± 1.03, 1.13% ± 0.06, for young animals and 75.26% ± 2.19, 21.77% ± 1.89, 2.87% ± 1.27, 1.19% ± 0.22, for adult animals. The shear value of the meat of young animals (6.63 kg ± 1.69), was found to be significantly lower than that of adult animals (8.79 kg ±2.37). In most of the adult animals (57.89%), meat

colour was in the range of 7 to 9 while it was in the range of 1 to 3 for most of the young animals (78.52%). Between male and female animals, there was a difference in the water and fat contents of meat. For male animals, mean values of water and fat contents were 75.51% ± 1.39 and 2.41% ± 1.08, respectively, and for female animals, the values were 75.26% ± 2.59 and 3.00% ±1.44, respectively.

M-20 CYRIL, H.W. and SIRIWARDENE,, J.A.de S. **The Buffalo - A potential source of meat.** In: *Water Buffalo - Improved Utilisation Through New Technologies.* [Edited by Subasinghe, D.H.A. *et al.*]. Colombo, SL, National Science Foundation Press, 1998. pp. 37-42. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The paper dispels some myths and prejudices with regard to consumption of buffalo meat. It provides information on the growth characteristics, which makes the buffalo an efficient converter of feed to meat. The information on carcass meat characteristics and composition of meat shows clearly that water buffalo meat has relatively less fat and more protein than meat of cattle and a significantly higher meat to bone ratio. The information on the composition of meat shows that meat of buffalo below a body weight of 150 kg has more moisture and less fat than meat of buffaloes above 150 kg in weight. Colour of meat is not a reliable guide for identification of buffalo or other meat, the redness of meat is not only influenced by the species but also by the age of the animal, the pH and the anatomical location of the meat in the carcass.

M-21 DE SILVA, L.N.A. **Production systems and reproductive performance of indigenous buffaloes in Sri Lanka** *M. Phil Thesis* (1984). Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A field survey was conducted on the indigenous buffalo of Sri Lanka, to determine, the systems of their management, patterns of utilisation and reproductive performance and the interrelationship among these factors. The sample comprised 11,863 buffaloes (little more than 1% of the national population) kept on 528 holdings distributed in 16 of the 24 districts of the country. Buffalo farmers were visited, a questionnaire administrated and stock numbers were physically verified. Rectal examination was done on 1,300 breedable females in the sample in order to determine their reproductive status.

Almost all of the buffalo farmers were primarily engaged in paddy cultivation in small holdings, and supporting an average of 7.5 people. Their resources in terms of land, capital and stock were limited. Buffaloes were managed extensively (free grazing only) or semi extensively (tethered with or without free grazing). The main source of feed consisted of low quality herbage obtained from grazing; no supplementary concentrate feed was provided, The overall average herd size was 22.5 (range 5.3 - 53.6). On average, a herd was composed of 17.1% of 0-1 year olds, 13.0% of 1-2 year, 9.1% of adults heifers, 32.9% of cows, 14.9% of castrated males and 13.1% of entire males.

The main use buffaloes was in tillage. On the average, 92% of the farmers used their animals in land preparation (ploughing/puddling/levelling) in paddy cultivation and 82% used them in threshing the harvest. The mean age at initial use was 3.1 years and 82.9% farmers used both males and females. Number of buffalo days required to plough one acre of land from 4.0 to 7.8 days. Puddling generally required twice as many buffalo days as ploughing. The mean duration of work was 52.3 days/year. Milking of buffaloes was restricted to some districts. The overall mean lactation yield was 1.5 litres/day and lactation length varied from 5 to 6 months. The overall means for reproductive performance were: age at first calving 45.7 months, annual calving rate 57.8% and calving interval 18.9 months. Fertility was found to be comparatively higher in groups of buffaloes subjected to milking and limited suckling (calf separated during part of the day), and in those not used for work.

Haemorrhagic septicaemia and gastro-intestinal parasitism were reported to be the major disease problems. Proportion of farmers using vaccination to control infectious disease was 64.9%. Annual mortality rates among age groups 0-1 year, 1-2 years and adults were 25.4, 21.5 and 8.0%, respectively.

M-22 DE SILVA, L.N.A., PERERA, B.M.A.O., TILAKARATNE, L. and EDQVIST, L.E. [EDITORS]. **Production systems and reproduction performance of indigenous buffaloes in Sri Lanka.** Uppsala, Sweden. Swedish University of Agricultural Science. (1985) 142 pp. ISBN 91-576-22507. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This monograph gives the results of a field survey conducted on the indigenous buffaloes of Sri Lanka to determine the management systems, patterns of utilisation, reproductive performance and the interrelationship of the above factors. The sample comprised of 11,863 buffaloes in 528 holding in 16 districts studied. The survey sample comprised of 1 % of the national buffalo population and was representative of the various agro-ecological zones of the country.

The buffalo management systems were predominantly of the extensive (free grazing) or semi-intensive (tethered with or without grazing) types. In the dry zone and dry intermediate zones the "extensive systems" was practised, while in the intermediate low country, intermediate mid country, wet mid country the latter management system was practiced generally.

The main source of feed consisted of low quality herbage obtained from grazing. In some regions paddy straw was used to tide over the forage shortage during drought. Generally supplementary concentrates were not provided. The overall average herd size was 22.5 ranging from 5.3 to 53.6. On the average the herd composition was as follows: 0-1yr=17.1%, 1-2yr=13.0%, adult heifers = 9.1%, cows 32.9%, castrated males 14.9% and entire males 13.1%.

The main use of the buffalo was in land preparation in agriculture (92%). They were also used in threshing paddy after the harvest. The mean age of utilisation was 3.1 yr. and both sexes were used. Time taken to plough 1 acre of land ranged for 4-7.8 buffalo days. Puddling required twice as much time taken for ploughing. The mean duration of utilisation for work was 52.3 days/year.

Only 14% of the farmers used the buffalo for milk production. Milk production was also confined to certain districts, e.g. Trincomalee, Batticaloa, Anuradhapura, Hambantota, Ratnapura, Matara and Kalutara. In these districts 60% of the animals were used for milk. The mean lactation length was 5-6 months. Age at 1st calving was 45.7 months, annual calving was 57.8% and the calving interval is 18.9 months. These variables varied significantly among districts and according to the management system and utilisation. Fertility was comparatively higher in milking, limited suckling and non working buffaloes. Major diseases were haemorrhagic septicaemia and gastrointestinal parasitism. Mortality in calves below 1 year was 25.4% and in adults it was 8%.

M-23 FERNANDO, SIR H. MARCUS **The need for the improvement of cattle in Ceylon.** *Tropical Agriculturist* (1926) **LXVI,** 297-303.

The Ceylon Blue Book for each year gives the cattle census of the island, by province. During the year 1924 the total number of black cattle were 941,828 and buffaloes 451,972 respectively. In addition to the animals mentioned above, Ceylon imported 5224 neat cattle for food 298 for milk and transport and 1857 buffaloes chiefly for milk.

Dealing with animals destined for agriculture, the most remarkable feature is that out of about one and a half million animals less than a third are buffaloes; and these are practically the only animals that are used for ploughing and puddling in the rice fields. Oxen are used for cart transport and buffaloes are seldom used as for this purpose. On the other hand, in India the practice is the opposite. Oxen are used in land preparation while the buffalo in used in road transport. On examining the census of cattle in Ceylon, it is evident that Kurunegala district has the highest population of cattle and buffaloes and an attempt in cattle improvement may best be started here. The following suggestions are made for the improvement of cattle used for transport and agricultural purposes, *viz.* (1) The establishment of a central cattle breeding station. (2) To educate the owners in dealing with their cattle, both in health and in disease, (3) Organisation of cattle fairs and markets at regular intervals, (4) The building and maintenance of cattle dips to exterminate ticks and (5) To control and maintain communal pastures.

M-24 FONSEKA, L.E.A. **Activities of the National Livestock Development Board in the field of buffalo development.** In: *Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka 7-10 March, 1989. Kandy, Sri Lanka.* National Livestock Development Board, Narahenpita, Colombo, SL.

Sri Lanka has a land area of 64,640 sq km with a human population of 17 million and 95% of the cattle and buffaloes are kept by small-farmers owning a farm size of less than one hectare and by landless labourers.

The main constraint for buffalo development is the high calf mortality. The buffalo cow produces 0.65 to 1.8 litres per day with a calving interval of about 15 to 16 months. The age at first calving is in the region of 40 to 46 months. Other constraints include the non-availability of quality stock, poor fodder and pasture supply, inadequate training and extension services, high cost of formula feeds and low farm-gate price of milk. The indigenous buffalo cow has a low genetic potential for milk production. The aim of the NLDB programme is therefore to produce an animal which will give a higher milk yield and is suitable for draught at the same time.

Of the 11 farms in the Coconut Triangle, five carry 1500 buffaloes, mainly of the Surti breed with a limited number of upgraded Surti crosses. The average Surti animal weighs around 350-450 kg and produce 1500 litres milk in a lactation of 305 days. The Board at present has the largest herd of Surti buffaloes in the island. Surplus quality bull calves are offered to farmers and development projects for breeding. The calf mortality in the farms is below 5%. Due attention had been given to proper feeding and management, with special emphasis on disease prevention. In 1981, buffalo stud bull services were commenced in night paddocks at Kurunegala, to upgrade indigenous buffalo to Surti or Murrah breeds. In 1984, a comprehensive programme was commenced to improve the local buffaloes in the district with the following objectives: Issue of animals for draught, salvaging of surplus buffaloes and organisation of Dairy Producers Associations (DPAs) and farmer training centres. Practical training in veterinary first aid, castration, conservation and management of pastures and other associated management activities were conducted for the benefit of the farmers.

M-25 GUNAWARDENA, INDRANI **Buffalo population trends in Sri Lanka.** *Ceylon Veterinary Journal* (1980) **28,** 64 [Abstract]. Sri Lanka School of

Animal Husbandry, Welisara, Ragama, SL

The buffalo is one of the best family assets in Sri Lanka. It is a renewable resource. There has been a dramatic reduction in the buffalo population since the mid 60's mainly due to the growing demand for meat by the human population expanding at a rate of over 2% per annum. Other contributory factors are the shrinking of the available grazing lands and the popularity of the tractor as a substitute rather than a supplement to buffalo draft power, in the dry zone. Due to the accelerated Mahaweli program, *villus* would disappear; and would affect one fourth of the total buffalo population of Sri Lanka. Recommendations for increased rearing of buffalo are presented.

M-26 HORADAGODA, A. **Studies on the composition of indigenous buffalo milk in Sri Lanka.** *M. Phil Thesis* (1990) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This study was undertaken to establish norms for chemical characteristics and physical properties of indigenous (Lanka) buffalo milk. A total of 566 samples of milk collected from buffaloes managed under both field conditions and at the university experimental farm were analysed using standard techniques in dairy chemistry.

The overall (mean±S.E.M., g/l) for constituents of indigenous buffalo milk, irrespective of the stage of lactation, the lactation number and age were fat 74.5±0.62; total proteins 51.6±0.15; casein 44.0±0.19; lactose 43.0±0.02; ash 7.2±0.02; solids-non-fat (SNF) 96.2±0.46 and total solids 174.0±0.57. The average values (mean ± S.E.M., mg/l) of the minor constituents studied under the same conditions were: sodium 456±99.6; potassium 1213±356; total phosphorus 1500±400; inorganic phosphate 1000±200; calcium 1555±350 and magnesium 325±96. The mean vitamin A content was 1.20±0.1 IU/ml. The results of the physical properties revealed that the specific gravity of indigenous buffalo milk was 1.033±0.003 while the surface tension, electrical conductivity and viscosity were 46.52±3.4 dynes/cm, $37.05 \times 10^{-4} \pm 5.00$ mhos and 1.9633±0.243 centipoises, respectively at 27°C. The average pH of milk at 27°C was 6.42 while the fat globular size varied between 5 and 10 _m at this temperature. The titrable acidity and ethanol stability were 0.202 and 50 per cent, respectively. All constituents of milk except for lactose and ash varied with the stage of lactation, lactation number and age. The average milk yield of indigenous buffalo cows was 3.58 litres per day when estimated by measuring water turn-over in their calves.

The composition of colostrum was markedly different from that of milk. The average values (g/l) for parameters examined were fat 63, total proteins 150, casein 80, lactose 30, ash 11.0; SNF 200, total solids 260 and vitamin A 3.30 IU/ml. At 27°C, the viscosity and surface tension of colostrum was 4.067±0.461 centipoises and 29.35±1.92 dynes/cm, respectively.

The result revealed that the fat percentage of the Lanka buffalo milk was similar to that of the Murrah buffalo while the protein content was high, and comparable to swamp buffaloes of the Philippines and China. The elevated protein concentration in the buffalo indicate that the alcohol test is not a suitable platform test for assessing the quality of milk from this breed.

M-27 HORADAGODA, A. **Milk and milk products.** In: *Water Buffalo-Improved Utilisation Through New Technologies.* [Edited by Subasinghe, D.H.A. *et al.*]. Colombo, SL, National Science Foundation Press, 1998. pp. 29-36. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A significant proportion of the milk in developing countries, particularly in South East Asia is produced from the buffalo. In Sri Lanka buffalo milk constitutes 25 per cent of the total milk produced. The milk yield of the buffalo varies with breed, lactation number, diet, management and environmental factors. Buffaloes of River type breeds such as Murrah, Surti and Nili Ravi are high milk producers yielding 1600 to 2000 kg of milk per lactation while Swamp breeds such as the Lanka buffalo are poor milk producers giving only around 350-390 kg per lactation. In comparison to cow and goat milk, buffalo milk is rich in fat (75g/l), proteins (52 g/l), calcium (1.56 g/l) and vitamins A and B. Buffalo milk is whiter than cow milk, which is slightly yellow, and this difference is because the buffalo is a more efficient converter of the yellow pigment, beta-carotene to vitamin A which is colourless. Buffalo milk is generally not consumed as fresh milk instead it is processed to prepare value added products such as curd, yoghurt, ghee, condense milk, cottage cheese, Mozzerella cheese and butter. At present curd and yoghurt are the most popular value added preparation made from buffalo milk, but Mozzarella cheese, an essential ingredient in "Pizza", a globally known Italian delicacy, offers great potential for buffalo milk utilisation in the future. This chapter on buffalo milk and milk products is intended for general reading but teachers, students and extension workers will find the information useful.

M-28 HULANGAMUWA, S. **Buffalo as a source of farm power.** In: *Water Buffalo - Improved Utilisation Through New Technologies.* [Edited by Subasinghe D.H.A. *et al.*]. Colombo, SL, National Science Foundation Press, 1998. pp. 23-28. Department of Agriculture, Peradeniya, SL.

This paper gives a brief description on the utilisation of the buffalo as a source of farm power in Sri Lankan agriculture. A national survey conducted

in 1987 has shown that Lankan farmers use animal power to cultivate 36% of the land area. This situation remain the same even today, where over 50% of the land preparation is done with hand tools and the buffalo. Hence the significance of the buffalo as a source of farm power in Sri Lanka agriculture.

The present day use of buffalo as a source of farm power is mainly for land preparation specially in rice cultivation, for ploughing, harrowing and levelling. The method of utilisation varies according to each location. In certain areas they use the animals for ploughing, while in other areas like the low country wet zone they tie few animal together in several groups and use them for puddling the land. When buffaloes are used for ploughing the land usually 2 animals are tied to each plough as a traditional practice. Both males and females are used on the plough and 95% of them are of the indigenous breed of buffalo. Most Sri Lankan farmers seem to adopt the same traditional farming practices used by their ancestors in the use of draught animal and implements in land preparation. Very little scientific effort has been made to study these traditional systems, implements and the techniques with a view to improve the efficiency of the system.

M-29 ILANGANTILEKE, S.G., JAYATISSA, D.N. and GUPTA, C.P. **The use and measurement of draught power in buffaloes**. In: *Proceeding of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November, Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC 1982. pp. 44-53. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL

The efficient use of animal power is one solution to the increased fuel and machinery rental prices for land preparation in agriculture. Rearing a few animals with high draught capabilities is necessary for maximum utilisation of animal power, especially in small farm holdings. Data on draught capabilities of buffalo breeds in Sri Lanka is seriously lacking. Measurement of draught in different breeds is therefore a necessary first step in planning breeding programmes, to select animals with high draught capabilities for animal power utilisation.

A device to measure the draught power of animals both bullocks and buffaloes, was designed and developed using a calibrated spring type dynamometer, attached to a single animal drawn plough. One end of the calibrated spring was directly connected to the yoke of the animal by means of a steel bar with chain. The other end was connected to the plough beam. A linear displacement of spring, proportional to the load on the plough was recorded by means of a pen indicator attached to the steel bar. The displacement of the indicator was recorded on a moving paper strip attached to a continuous recorder, driven by a lugged ground wheel.

The change in draught power with soil penetration resistance at different moisture contents and the relationship between draught capability and speed of the animal, was observed during the initial testing stage of the measuring device. The mechanism performed satisfactorily during preliminary testing at all soil moisture contents. Further development and testing of the draught measuring device is necessary to suit the varying draught capabilities of buffalo breeds.

M-30 JALATGE, E.F.A. **Production characteristics of buffaloes in Sri Lanka.** In: *Proceeding of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November, 1980, Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC 1982. pp. 96-102. Veterinary Research Institute, Peradeniya, SL

The paper presents data relating to the calving season, age at first calving, calving interval, sex ratio, gestation length and the draught value of buffaloes in Sri Lanka. Information has been obtained by analysis of data in two buffalo farms located in the Southern and North Central Provinces of Sri Lanka. Some information cited has also been obtained direct from farmers by administering a simple questionnaire. A definite seasonal pattern of calving has been observed. Bulk of the pregnancies took place when adequate grazing was available. It is concluded that other factors being the same, nutrition plays an important role in the breeding of buffaloes. The age at first calving (44 months) was similar to that reported from other countries of the region. However, significant differences in the age at first calving, has been observed among calves born during different periods of the year. It is concluded that the age at first calving is greatly influenced by the nutrition of the calf. The calving interval of the indigenous buffalo appeared to be less than that of Murrah buffaloes maintained in the farms. Therefore, under the general pattern of buffalo production in Sri Lanka indigenous buffaloes have a higher reproductive efficiency than the Murrah buffaloes.

The seasonal differences in calving have been explained on the hypothesis that the buffalo population has a minimum 'refractory period' of about 5-6 months duration following parturition, before receiving a fertile service. If the conditions after this period are favourable, animals return to heat without delay resulting in a shorter calving interval. A sex ratio of 51 male: 49 females and a gestation length of 308.7 ± 0.75 days for the Murrah buffalo has been observed. The milk yield of the indigenous buffalo averages 355 litres/ lactation. Upgrading to the Murrah which has a mean yield of 1317 litres/lactation, resulted in the following average milk yields ½ Murrah 956 litres/lactation; ¾ Murrah 1203 litres/lactation. The extent of land cultivated by a buffalo/day varied on the nature of the operation and on the district. The mean estimate of the area ploughed per day was 0.24 acres. Puddling required

approximately twice as many buffaloes as ploughing whilst 6.9 buffaloes were required to thresh the harvest from one acre of paddy land.

M-31 JALATGE, E.F.A., PARANAGAMA, D.M., SENEVIRATNE, de ALWIS, S. and JEYARUBAN, M.G. **A survey to ascertain the present status of indigenous buffaloes on small farms in Sri Lanka.** In: *Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka 7-10 March, 1989, Kandy, SL.* Veterinary Research Institute, Peradeniya, SL.

Randomly selected buffalo herds from four agro-climatic zones of Sri Lanka were monitored at regular intervals to ascertain the conditions that prevail on small farms. The herd composition varied in different zones depending on factors such as the length of the cultivation season, availability of feed and the mortality patterns.

The demand for draught power was acute in all the zones studied. The extent to which buffaloes were worked differed with local factors such as the duration of the cultivation season, number of buffaloes available and the feasibility of buffaloes to be driven as herds from place to place.

Farmers in all zones paid little attention to the nutritional requirements of buffaloes. Only 10% of the buffaloes were milked mainly due to the poor lactation yield of the Lanka buffalo.

Calf mortality was high (average 36%) in all zones, the main causes being roundworm infestation and contagious diseases such as haemorrhagic septicaemia and foot and mouth disease. Adult mortality was higher in the dry zone due to a heavy work load and the early impairment of food intake in adult animals due to the wasting of teeth.

M-32 JAYASEKARA, S., SILVA, K.F.S.T., THATTIL, R.O. and RAJAGURU, A.S.B. **Determination of body weight in Lanka buffaloes: Development of an empirical formula to be used under field conditions** *Sri Lanka Veterinary Journal* (1992) **39**, 39. [Abstract] Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The methods available to Sri Lankan stockmen for estimation of body weights of buffaloes, other than by the use of a weigh bridge, often provide higher values. Therefore an attempt was made to develop a practical and reliable, empirical method to estimate the body weights of buffaloes using measurements such as heart girth, height and body length as parameters. The correlation of the above parameters with the measured body weight of the animal, individually and when combined were statistically tested. The actual body weights of 95 randomly selected buffaloes were also determined.

As has been established for other species, a close relationship between the heart girth and body weight was observed with a correlation coefficient of (r^2) 0.96, which was highly significant ($P<0.0001$). The correlation between measured body weight with the height and length x heart girth^2 produced r^2 value of 0.94. The correlation of the body length with its body weight was found to be less when compared with that of girth *vs* body weight and height *vs* body weight. A formula was developed based on the results of the statistical analysis. When a validation test was performed on randomly selected buffaloes it yielded estimated body weights which were very close to the measured body weights. (C.V. = 10%).

M-33 KATADA, A., TILAKARATNE, N. and BUVANENDRAN, V. **Live weight gain and carcass composition of cattle and buffaloes slaughtered at different ages.** *Ceylon Veterinary Journal* (1980) **28,** 5-11. Veterinary Research Institute, Peradeniya, SL.

A comparative study of the growth rates and carcass characteristics of Lanka cattle, Sindhi cattle and Murrah buffaloes slaughtered at 3 different ages were conducted at the Polonnaruwa Livestock Farm from April 1975 to August 1976. Thirty four bull calves comprising 12 Lanka, 11 Sindhi and 11 Murrah were used in the experiment and the animals were 7 - 10 months old at the commencement of the trial. Rotational grazing was practised on *Brachiaria brizantha* pasture at a stocking rate of 9/ha, and supplementary feeding was not practised. They were taken to water about 1 km away from the paddocks. The animals were slaughtered in groups at 16, 22 or 26 months of age. Breed differences of various traits studied at each age were compared by analysis of variance. The daily weight gain of the three breeds ranged from 0.27 to 0.39 kg/head/day. Lanka cattle had the highest mean dressing percentage ($P<0.05$) of 51.4 compared to 46.2 and 45.1 for Sindhi and Murrah, respectively. A possible reason for the higher dressing percentage of Lanka cattle could be that they were physiologically more mature than the other two breeds at the time of slaughter. The percentage of muscle tissue showed a positive relationship to both carcass weight and muscle and bone weight in the cattle breeds, while in the buffalo the regression was not significant. The carcass weight of the buffalo at all slaughter ages were higher than those of cattle breeds but comparatively bone accounted for a greater proportion of the carcass weight. There was a significant difference in muscle to bone ratio among the breeds; Lanka being superior to Sindhi and Murrah.

M-34 KOMORI, M., PERERA, E.R.K., PERERA, A.N.F. and RAJAGURU, A.S.B. **Productive and reproductive performances of Nili-Ravi buffaloes in Sri Lanka.** *Journal of the National Science Council, Sri Lanka.* (1994) **22,** 201-211 Department of Veterinary Anatomy, Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Japan.

The productive and reproductive

performances of imported Nili-Ravi buffaloes were evaluated under Sri Lankan condition. The mean calving interval between the 1st and the 2nd calvings was 453.9 ± 56.1 (S.D) days. The mean interval between a calving and the 1st service was 134.2 ± 93.1 days. The mean birth weights for male and female were 30.5 ± 4.52 kg and 28.6 ± 4.58 kg, respectively. The average daily weight gains for male and female up to 1 year of age were 0.50 kg and 0.43 kg, respectively. The mean lactation yield after the 1st parturition was 1698.1 ± 451.3 kg and the mean length of the 1st lactation was 291.4 ± 75.2 days. The findings suggested that the interval between a calving and the 1st service and the birth weights were affected by environmental factors, particularly rainfall.

M-35 KUMARATILEKE, W.L.J.S. and BUVANENDRAN, V. **A survey of production characteristics of indigenous buffaloes in Sri Lanka.** *Ceylon Veterinary Journal* (1979) **27,** 10-13. Veterinary Research Institute, Peradeniya, SL.

The production characteristics of the indigenous buffaloes, and buffalo management practices were surveyed in five districts in the dry zone of Sri Lanka. Districts surveyed were Amparai, Anuradhapura, Hambantota, Kurunegala and Polonnaruwa. Three to five buffalo herds from 5-6 villages in each district were randomly selected. The survey involved 79 herds. The mean herd size was 37.7 of which 32 percent were adult females. The herd ranged from 6 to 205; larger herd were found in Amparai, Hambantota and Polonnaruwa districts where buffaloes were kept for draught and milk, while in Anuradhapura the herds were small and kept solely for draught. In all districts the proportion of bulls in a herd was in excess of that required for breeding. They were allowed to mate at random. Conception and calving showed a seasonal trend corresponding to the monsoon rains and availability of pasture. Majority of the cows conceived from December to March soon after the North – East monsoon rains when pasture growth was maximal and herds were in good nutritional status. These cows eventually calved from November to February. A minor calving season was observed in May – August corresponding to the light rains which fell during the South West monsoon (April – June).

The age at first calving and calving interval were 44 and 15.8 months, respectively. The daily milk production was 2.9 litres in a lactation of 160 days. Incidence of calf mortality was high and ranged from 10-38 percent while mean adult mortality was 10.9 percent. Draught performance varied with the type of soil and method of tilling; one buffalo could plough 0.25, and puddle only 0.12 acre per day. Twelve buffalo days, inclusive of rest days, were required to prepare an acre by ploughing and about twice that length by puddling.

M-36 PATHIRAJA, N. **Buffalo and its economic importance.** *Animal Production and Health Bulletin.* (1978) **11,** 34-37. Veterinary Research Institute, Peradeniya, SL

The buffalo is a triple purpose animal reared for milk, draught and meat. Because of their large feet, buffaloes are more suited than small footed cattle to work in muddy rice and submerged fields. It has a very poor heat tolerance ability. One of the early signs of heat stress is reduction in feed intake, with subsequent reduction in milk yield. This can be prevented by provision of shade, sprinkling or splashing of water, protecting from hot winds and providing wallowing facilities. The ruminal movements are slower than that of cattle and therefore the average retention is relatively longer. The feed consumed would have a longer time of exposure to microbial digestion. Buffalo can utilise roughages that are generally avoided by cattle. The reproductive efficiency of the buffalo is poor. Seasonal breeding, a long calving interval, completely absent or weak signs of heat in the cycling buffalo cow and late maturity are some of the "problems". Buffalo milk has a higher fat and higher solid-non-fat content when compared to cows milk. The milk potential of the indigenous buffalo is low, the average yield being only 800 lbs per lactation. Even with good husbandry practices and on a high plane of nutrition, the milk yield of the indigenous buffalo is lower than that of indigenous dairy cow. Lactation length varies from 90-213 days with a mean of 180 days. The daily milk yield ranges from 1.1-3.2 pints with a mean of 2.1. Buffalo is used for draught purposes such as ploughing, harrowing, treading of paddy fields and threshing and is also used to prepare the clay in making bricks and tiles.

The buffalo is a part of Sri Lankan rural farming economy. It brings an important supplementary income in the form of milk, draught and meat. There is thus an urgent need to improve and enhance the production level of the buffalo by selective breeding and use of artificial breeding techniques.

M-37 PATHIRANA, K.K., KODIKARA, C.P., DASSANAYAKE, D.K.M.P. and WIDANAPATHIRANA, S. **A field survey and microbiological studies on Ruhunu card.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, SL, NARESA Press, 1996. pp. 111-127. Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, SL.

Ruhunu curd although acclaimed as a quality product from ancient times, has not been the subject of any authentic study. Out of 609 Grama Niladari (GN) divisions in the entire Hambantota district and the Divisional Secretaries (DS) division of Tanamalwila in Moneragala district, 511 GN divisions (84%) were covered in the study. All curd producers were identified by GN division and a house to house survey was done on a 5% sample to obtain basic information

on curd production. Sixty samples of curd were subjected to microbiological studies. A total of 1,968 producers manufactured 19,015 pots of curd/day. The highest number of producers and the number of pots produced were from Ambalantota and Tissa DS divisions, respectively. The lowest in both the aforementioned categories were from Okewela DS division. Buffalo milk and the warm dry conditions of the area were largely responsible for the firm curd, since curdling was invariably poor on rainy days. Data on herd composition, health, breeding, feeding and management of herds owned by curd producers were also recorded. Microbiological study showed the presence of Coliforms in 31.25% and *E. coli* in 6.25% of the samples. Potentially pathogenic *Staphylococcus aureus* was present in 56.25% of the samples (10-13 x 10^{10}/g) indicating the need to improve the hygienic conditions. Yeast and moulds were present in all samples with very high counts (1-5 x 10^5/g) indicting a low keeping quality. *Aspergillus flavuas/parasiticus* was present in 31.25% of the samples. Twelve Aspergillus isolates were producers of aflatoxin in artificial media. The pH of curd ranged from 3.09 to 6.22 whereas the maximum recommended is 4.5. Lactic starter culture organisms isolated were *Lactobacillus fermentum, Lactobacillus cellobiosus, Streptococcus lactis and Streptococcus lactis* sub species *diacetylactis.* Acidity, pH and extent of curdling of buffalo milk by individual isolates after 6-8 hrs of inoculation were satisfactory. The minimum inoculum required for satisfactory curdling was 0.5 g of previously made curd or 34 x 10^6 colony forming units. Indications are that by introduction of low cost, simple scientific procedures, the quality and hygienic standards of the curd could be improved.

M-38 PERERA, B.M.A.O. and DE SILVA, L.N.A. **Small farm buffalo production in Sri Lanka.** In: *Proceedings of the Buffalo Seminar, 29 April – 2 May, 1985. Bangkok, Thailand.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL

A field survey was conducted to determine ownership and management patterns, reproductive performance, utilisation, production characteristics, disease and mortality in indigenous buffaloes of Sri Lanka. The sample comprised 11,863 buffaloes (approx. 2% of the national population) belonging to 528 holdings distributed among 16 of the 24 districts in the country. A questionnaire administered to each farmer that was visited and stock details physically verified. Rectal palpation was done in 1300 breedable females to determine the reproductive status.

Mean herd sizes ranged from 5.3 to 53.6 in different districts. None of the farmers depended solely on livestock for their livelihood, 87% of them being primarily crop producers. Buffaloes were kept solely for draft by 64%, solely for milk by 2% and for multiple purposes by 35%. Over 90% used them for land preparation in rice cultivation. Only 39% milked their buffaloes, one third of them routinely through the year and the remainder only for 2-3 months after the calving season. Mean age at first calving was 45.7 months. Overall calving rate was 61.4% with a calving interval of 18.9 months. Reproductive indices calculated from rectal palpation data (annual pregnancy rate, projected calving rate and calving to conception interval) were better in herds which were milked, than in those herds which were not milked, worked and with *ad lib* suckling. Annual mortality was 25% in calves less than one year old, 21% in those between 1-2 years and 8% in older stock. The major disease problems were worm infestation and haemorrhagic septicaemia.

M-39 PERERA, B.M.A.O., RANAWANA, S.S.E., FERNANDO, S.T., JALATGE, E., KURUWITA, V.Y., DE ALWIS, M.C.L. and WEILGAMA, D.J. (EDITORS). **The Sri Lanka Water Buffalo - Science Education Series No. 31.** Colombo, SL, NARESA Press. (1989) 74 pp. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This is a scientific publication (monograph) on the Sri Lankan water buffalo and has been written and edited by a group of scientists. The information contained in the book has been generated through research and field surveys conducted over several years, and has been drawn from the work of several researchers from both within and outside the editorial panel. The material is presented under seven chapters namely, (1) Introduction (2) General aspects (3) Physiology and Nutrition (4) Reproduction (5) Production of milk and meat (6) Parasitic diseases and (7) Bacterial and Viral diseases, and also a short bibliography at the end. The book is intended primarily for teachers of agriculture and animal science, students, farm managers, extension workers, undergraduates, veterinarians and scientists of allied fields. The general public may also find the book informative and useful.

M-40 PERERA, B.M.A.O., SIRIWARDENE, J.A.de S., HORADAGODA, N.U. and IBRAHIM, M.N.M. [EDITORS] **Role of the buffalo in rural development in Asia.** Colombo, Sri Lanka. NARESA Press, (1996). 522 pp. ISBN 955-590-007-8. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This publication consist of the proceedings of the SAREC/NARESA Regional symposium on the "Role of the Buffalo in Rural Development in Asia". It contains research papers presented by Sri Lankan scientists and invited foreign scientists from the Asian region on buffalo production with special reference to the Asian region. The papers are presented under five broad groupings, namely production systems and uses, genotypes and environment, nutrition and feeding, reproduction and health and diseases. The seven

papers presented under the production system broadly deals with crop-animal systems, the use of female buffaloes for on-farm work, transfer of technology, milk production and carcass quality. Breeding strategies and adaptation to environmental stress were the main topics presented under the heading genotype and environment while the eight papers on nutrition and feeding covered aspects of utilization of forage resources and supplementary feeding systems. Under reproduction, papers dealt with, reproductive characteristics, reproductive efficiency, hormonal effects and the influence of suckling on fertility Ten papers on aspects of health covered a variety of bacterial, viral and parasitic conditions of topical interest to the Asia region.

M-41 PERERA, B.M.A.O., KENDARAGAMA, K.M.T., LIYANAGAMAGE, A., SIRIWARDENE, J.A.DE S., SUBASINGHE, D.H.A. and PERERA, A.N.F. **Use of participatory appraisal for identifying training needs of smallholder dairy farmers and extension personnel in three different regions of Sri Lanka.** In: *Proceedings of the Annual Scientific Sessions of the Sri Lanka Veterinary Association, 8 March, 1997. Colombo, SL.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A technology transfer programme is being implemented under the framework of the SAREC/NARESA Buffalo Information Dissemination Programme, to assist smallholder dairy farmers in three selected regions (Coconut Triangle, Mahaweli system H and Mahaweli system C), to adopt improved methods of rearing buffaloes for optimum economic benefits. Two important components of this are (a) training and motivating farmers to use improved methods of management, nutrition, breeding, reproduction and disease control, which are appropriate for each location and also economically viable, and (b) providing information and training to Livestock Development Instructors (LDIs) and Veterinary Surgeons (VSs) who advice these farmers.

To identify the training and information needs of each category, a farmer participatory appraisal (FPA) approach was used, initially in the Coconut Triangle with 11 farmers, 9 LDIs and 4 VSs from Kuliyapitiya, Pannala and Bingiriya ranges. Brainstorming sessions and small group discussions were used to elicit responses from each category of participants on their perceptions of the major constraints to buffalo production and to determine the gaps in knowledge which prevented adoption of improved methods to overcome these constraints. Subsequently, a list of common training needs was arrived at by large group discussions and consensus. This comprised, in order of priority: intensive rearing methods; low cost feeding; disease control and prevention, developing a system for sale and exchange of animals; value addition of milk products, heat detection and timely breeding, growing drought resistant fodder, and the use of draught power. Other suggestions made by farmers were: to restrict the duration of training to one day, to provide on-farm practical training within the region, and to organise these activities through farmer organisations wherever possible.

Subsequently, FPA was conducted at two other locations (Nirawiya in Mahaweli system H and Girandurukotte in Mahaweli system C) with groups of farmers, and their priority training needs were determined. Based on these findings and recommendations, training modules have been designed and are being used for training in the three project regions. The feedback from farmers on the impact of these activities indicate that FPA is a very appropriate approach for identifying their actual training and information needs.

M-42 PERERA, B.M.A.O., KENDARAGAMA, K.M.T., LIYANAGAMAGE, A., SIRIWARDENE, J.A.de S., SUBASINGHE, D.H.A., PERERA, A.N.F. and ABEYGUNAWARDENA, H. **Identifying the information and training needs of smallholder buffalo farmers and extension personnel through participatory appraisal.** In: *Proceedings of the 5th World Buffalo Congress, 13-16 October, 1997. Caserte, Italy.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Smallholder buffalo farmers in three selected regions in Sri Lanka are being assisted to adopt improved methods of rearing buffaloes for optimum economic benefits. Two important components of this area (a) training and motivating farmers to use improved methods of management, nutrition, breeding, reproduction and disease control which are appropriate for each location and also economically viable, and (b) providing information and training to Livestock Development Instructors and Veterinary Surgeons who provide extension services. To identify the needs of each category, a farmer participatory appraisal (EPA) approach was used. Brainstorming and small-group discussion were used to elicit response from each category of participants on their perceptions of the major constraints in buffalo production and to determine the gaps in knowledge which prevented adoption of improved methods for overcoming these constraints. Subsequently, a list of common training needs was arrived at, by large-group discussions and consensus. This comprised, in order of priority: intensive rearing methods; disease control and prevention; developing a system for sale and exchange of animals; value addition through milk products; heat detection and timely breeding; growing drought resistant fodder; and use of draught power. Other suggestions made by farmers were to restrict the duration of courses to one day, to provide on-farm practical training within the region and to organise

these activities through farmer organisations whenever possible. In a subsequent workshop conducted along similar lines, in a different location, the identification of broad subject areas was followed by further discussions to determine specific topics under each area. Based on these findings, training modules were designed and training programmes are being conducted in the three project regions. The feedback from farmers on the impact of these training activities, and observations on the adoption rate of improved technologies, indicate that FPA is a very appropriate approach for identifying the actual information and training needs of farmers.

M-43 PERERA, B.M.A.O., ABEYGUNAWARDENA, H. and SIRIWARDENE, J.A.de S. **Body condition scoring system for assessing the nutritional status of buffaloes and cattle.** In: SAREC/NARESA Buffalo Research and Development Programme Information leaflet No. 3, Publication No. 7. Colombo, SL, NARESA Press, (1998). 5 pp. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The leaflet introduces a body condition scoring system as a means of assessing the nutritional state of dairy animals. Productively of buffaloes and cattle is primarily influenced by the nutritional status of the animal in different physiological states. Farmers thus far did not have a simple and practical method to assess of nutritional status of dairy animals . The body condition scoring system is simple and can be used by stockmen by usual observation and palpation of points on the body of the animal. These observations are given a score on a numerical scale ranging from 1 to 5. The procedure is described and the method of assessment is illustrated in the leaflet.

M-44 PERERA, A.N.F., PERERA, E.R.K., ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A. and PREMALAL, G.G.C. **Use of tree fodders in ruminant feeding.** SAREC/NARESA Buffalo Research and Development Programme Information Leaflet No: 7, Publication No. 11. Colombo, SL. National Science Foundation Press, (1998). 7 pp. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL

This is a farmers' guide to the use of tree fodder as a feed supplement for ruminants. The paper has discussed the value of tree fodder varieties abundantly available in the environment and some introduced species, methods of establishment, management and utilization. The paper has also pointed out its usefulness as a feed supplement for cattle and buffaloes both in routine feeding as well as in times of forage scarcity during drought.

M-45 RANAWANA, S.S.E., KURUWITA, V.Y., EKANAYAKE, E.M.C., HORADAGODA, N.U., VAN AKEN, D. and PERERA, B.M.A.O. **A preliminary evaluation of the nutritional and disease status of cattle in system 'C' of the Mahaweli settlement areas.** In: *Proceedings of the Sri Lanka Veterinary Association 40th Annual Convention, 5-6 December, 1986. Kandy, SL.* Veterinary Research Institute, Peradeniya, SL.

System 'C' which is one of the newer settlement areas under the Mahaweli programme, covers an area of 64,000 ha and extends north from Mahiyanganaya on the right bank of Mahaweli river. At present 12,800 settlers have between them 10,000 cattle (mainly local) and 2,650 buffaloes. Milk is being collected at present from 500 suppliers. A cross-breeding programme, using mainly the Tharpakar breed, is being carried out to improve milk production. Animals are grazed communally on natural pastures in vacant lots and in fallow paddy fields. Breeding is uncontrolled, most cows and heifers being served by companion bulls in the field. This paper records preliminary results from an on-going study to determine the reproductive, nutritional and disease status of female cattle in this system.

Over a period of one year 345 cows and heifers in field units, were examined rectally; several other particulars were recorded. Blood and dung samples were obtained from 46 cows (36 in milk) and 20 heifers. Blood was analysed for standard haematological parameters and for minerals. Blood smears were examined for haemoparasites and dung samples for the presence of helminth eggs. The body condition of the animals ranged from average to good; mean value of 2.9 on an arbitrary scale of 1 to 4. Farmers figures for milk production averaged 2.2 ± 1.2 l/d for 120 cows. Blood parasites (Rickettsia) were seen in only 4 smears (6%). Nematode eggs (scanty) were found in 10 (25%) of the dung samples. Haematocrit values were below 25% in four animals but haemoglobin and plasma proteins were normal. Over 40% of the cattle had subnormal plasma calcium and phosphorus; P was particularly low in milking cows, sixty percent being below 4.5 mg/dl. Copper was subnormal in 12% of the animals but Zinc and Iron were normal. Blood selenium values were marginal in a fourth of the cattle and 17% had deficient levels.

Despite the minimal inputs given by farmers to these animals, they are in reasonable condition and parasites do not appear to be a serious problem in adult cattle. Foot and mouth disease is endemic and outbreaks occur regularly. Other epizootic diseases such as HS, BQ, brucellosis and leptospirosis have not been studied. Deficits of P, Se and Cu (and possibly others not studied) are evident particularly among the milking animals. These may effect growth, production and reproduction in heifers and cows. With the proposed breed improvement and increased milk yields, further deficits of nutrients including energy and protein and possibly disease problems may be expected unless appropriate measures are taken.

M-46 RANAWANA, S.S.E. **Water buffaloes in Sri Lanka.** In: *Proceedings of the Symposium on Buffalo Genotypes for Small Farms in Asia, 15-19 May, 1989. Kuala Lumpur, Malaysia.* Veterinary Research Institute, Peradeniya, SL.

Buffaloes have played an essential role in the cultivation of the staple rice in Sri Lanka from ancient times. During the last 10 years, several studies have been carried out which included surveys of small-buffalo farms, as well as technical studies on physiology, nutrition, reproduction and disease in this species.

This report carries a brief summary of the finding of history, population and distribution, herd size and composition, general management, breeding, milk and meat production of buffaloes.

M-47 RANAWANA, S.S.E., CHANDRASIRI, A.D.N., CHANDRASENA, M.G. and HERATH, M.B. **The performance of crossbred buffaloes on an upcountry farm.** *Sri Lanka Veterinary Journal* (1992) **39,** 40. [Abstract] Veterinary Research Institute, Peradeniya, SL.

In August 1989, twenty eight buffaloes were taken to the upcountry cattle farm at Ambewela. This herd consisted of 27 cows, 17 heifers (9 over 12 months of age), 2 bulls and 11 bull calves. Concentrates were fed daily at the rate of 2 kg per cow and 1 kg per calf and the calves were allowed to suckle before milking. Average values for some herd productive parameters were; male and female birth weights - 26.7 kg and 27.1 kg, respectively, daily weight gain - 0.325 kg (range 0.197 - 0.577), calving interval - 487.1 days, age at first calving - 1816 days, daily production excluding calf consumption - 4.4 litres (range 0.4 - 10.1), 305 day milk production - 1063.8 litres and lactation length - 8.8 months.

Apart from regular worming, buffaloes needed little attention and were less susceptible to common cattle disease problems such as mastitis, calf mortality, tick fever or tick infestation. The main problems encountered with buffaloes were the difficulty in handling and poor milk "let down" in the absence of suckling by calves. The level of production was satisfactory compared to the Ayrshire cows, that produced an average of 6.5 litres daily with more than double the intake of concentrates. Moreover, due to the high sale value of curd the buffalo unit was maintained at a profit. It is clear that the performance of buffalo at high altitudes with high rainfall is promising. They appear to utilise the kikuyu grass better than cattle, possibly due to the higher intake and turnover of water. Further studies to determine the reasons for this better performance are warranted.

M-48 RAJAMAHENDRAN, R., RAVINDRAN, V. and KUMARAGUNARATNAM, S. **A study on the performance of Murrah buffaloes at Polonnaruwa in Sri Lanka.** *Journal of the National Agricultural Society of Ceylon* (1980-81) **17-18,** 123-128. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Murrah buffaloes, have been imported to Sri Lanka since 1937 to improve the genetic potential of the indigenous swamp-type buffaloes. The objective of the present investigation was to study some of the productive and reproductive traits of imported and locally bred Murrah buffaloes under the conditions in Sri Lanka. The data used in this study were collected from a herd maintained at the Polonnaruwa Livestock Farm and were collected only from animals that had at least two calvings.

The mean lactation yield of locally bred Murrahs (1308 kg) was comparable to that of imported Murrahs (1359 kg). Highest yield was obtained in the first lactation, when both imported and locally bred buffaloes yielded around 1500 kg milk and thereafter showed a decreasing trend. This can be partly attributed to mastitis and improper milking techniques adopted in the farm. The mean lactation length of imported Murrah was shorter than that of locally bred Murrahs. The estimates for Murrah brought from India and locally bred Murrahs were 295 and 315 days, respectively. A decreasing trend in the length of lactation was observed with the increase in age of animals. The mean length of dry period of Murrahs imported from India was 254 days, while the estimate for locally bred Murrahs was 31 days shorter. Mean calving interval of the Murrahs imported from India was found to be 518 days varying from 418 to 1129 days. The corresponding value for locally bred Murrah was 521 days ranging from 425-1366 days. The main reason for the higher value reported in this study was the longer dry periods which may be due to the seasonal calving pattern observed in this herd. Total number of calvings recorded among the imported and locally bred Murrahs, during 1968-1977 were 733 and 850 respectively. The calving patterns of the two groups were almost identical.

Since birth dates were not available for imported Murrahs, the mean age at first calving was calculated only for locally bred Murrahs. The values based on 126 observations, ranged from 34.5 to 74.7 months with a mean of 50.42 ± 0.75 and a coefficient of variation of 16.86 percent. This higher value is probably due to the poor nutrition in this herd.

M-49 RICHARDS, E.M. and AGALAWATTA, M. **An inter agro-ecological zone survey of cattle and buffalo management practices in Sri Lanka.** *Food and Agricultural Organisation of the United Nations, Field Document No. CCP/SRL/30 (SWE), (1). Dairy Production Improvement, Peradeniya Sri Lanka, 1981* Department of Animal Production and Health, Peradeniya, SL.

The Livestock Economics Unit of the Department of Animal Production and Health undertook in 1980 a single visit random sample survey

of cattle and buffalo farmers in ten different agro-ecological zones. The main purpose of this survey was to generate baseline planning data and extension recommendations, in accordance with project objectives. In this report the herds recorded were split into four breed types, and for each breed type an analysis of herd management practices, herd productivity parameters and herd profitability was undertaken.

Recommendations and findings included: (a) Discrepancies with official cattle and buffalo population estimates, and recommendations for further surveys, (b) Long calving intervals for all breed types in the wet and intermediate zone, and high calf mortality rates of buffaloes and European upgraded cattle, (c) The economic superiority of indigenous buffaloes over Sinhala cattle, and of upgraded cattle over Sinhala cattle, in all areas, (d) The need for a more frequent assessment of milk prices and for a revision in the method of milk pricing to incorporate the solids-non-fat percentage, in view of the dangerously low levels of dairy profitability of European upgraded cattle recorded in the wet mid and up country, (e) The need for further research into the constraints to the milking of she-buffaloes, (f) The need to encourage low cost milk production among upgraded cattle, in view of the high price of concentrates, (g) The need to grasp current opportunities in the accelerated Mahaweli programme, by identifying optimal dual purpose (draught and milk) breeds and management practices, (h) The need to strengthen the existing animal husbandry extension services in Sri Lanka.

M-50 RICHARDS, E.M., and AGALAWATTE, M. **A sample survey of buffalo management practices and herd profitability in the different agro-ecological zones of Sri Lanka.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November, 1980 Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982. pp. 31-43. Department of Animal Production and Health, Peradeniya, SL

The data in this paper was recorded from a strictly supervised single visit random sample survey of cattle and buffalo herds, conducted in the different agro-ecological zones, for the purpose of generating base line planning data and extension recommendations. Areas considered representative of these zones were purposely selected and, in each area a group of 3 randomly selected survey clusters sampled from a sample frame of farmers collected by the Department of Agriculture, Peradeniya. A two stage sample was used to select livestock farmers in each cluster.

A comparison of recorded herd size with 1973 census cast considerable doubt on the latter's accuracy. Management systems in each area were fairly homogeneous, and of a low cost/input nature. In most areas buffaloes were kept solely for draught, but in Ampara and Galle Districts dairying was more important. It was only in Anuradhapura that the genuinely dual purpose draught/milk she buffalo was commonly found. Statistical tests showed that there were no significant differences in draught output between males, milk buffaloes and unmilked females. A herd parameter study showed a shorter calving interval among milk buffaloes, considerable variation in output levels between areas, and a very high mortality rate. The herd profitability analysis highlighted the economic advantage of dual purpose herds, labour economics of scale in large herds, and the importance of imputed family labour costs in determining real profitability.

Research implications/significance of findings: (a) Socio-economic research into the constraints to milking of she buffaloes. (b) Research into output response to improved grazing systems, straw feeding and locally available/agricultural by-product concentrates, e.g. rice bran. (c) The importance of adequate milk price/market incentives, without which the indigenous buffalo seems destined to continue to fill an almost purely subsistence role, well below its genetic potential. This is probably a precondition for the adoption of improved management practices.

M-51 RYAN, M., ABEYRATNE, F. and FARRINGTON, J. **Animal draught - The economics of revival.** *Joint ARTI/Reading University Farm Power Study Team Report. Occasional Publication No. 23 (1981).* Agrarian Research and Training Institute, Colombo, SL

The traditional role of draught buffaloes in paddy cultivation has been eroded by tractor power in the last thirty years. Only about one third of the *asweddumised* acreage in Sri Lanka is currently ploughed by animals, although animal draught continues to play an important role in secondary tillage and levelling, even where mechanised power is most widely represented. With major land development programmes, the demand for draught power is increasing at a time when adverse terms of trade and balance of payments deficits make it difficult to support the present tractor-based strategy. It is against this background that the role of buffaloes in small scale farming is receiving renewed interest. This paper draws on data collected by the current ARTI/Reading University Study on farm Power and water Use in the Dry Zone. Farm Management data were collected from a total sample of 443 farmers and power owners (including 88 buffalo owners) at three major colonisation scheme in 1980. Preliminary analysis of part of the data is examined in this paper.

A comparison of tractor and buffalo operating costs provides strong economic justification for expanding the role of animal power in cultivation.

However, imperfections in the farm power hire market prevent such real discrepancies in operating costs from being translated into hire-charge differences at the farm gate which, in turn, leaves the demand for tractor custom services high. The thrust of our paper is that this imbalance cannot be rectified by intervention in the farm power hire market. What is necessary is a concerted effort to broaden the base of ownership of power, especially that of draught animals. A range of issues relevant to policy of ownership, poor quality of statistical information on the national herd, the patterns of distribution and use of animal draught at three major irrigation schemes, consideration of the options in animal husbandry systems, and an overview of the profitability of each system are discussed. It is suggested that, whilst the role of buffaloes could be expanded in the short to medium term by wider use of ploughs instead of trampling, and by transfer of adult and juvenile animals from areas of low (e.g. Hambantota) to areas of high use-intensity, policy for the long term must concentrate on widespread individual ownership of a pair of animals for draught and milk production. Currently, tethering and stall-feeding, grazing systems can be regarded as moribund. For the future, tethering and stall-feeding, possibly using improved feedstuffs, will have to be introduced.

M-52 RYAN, M.J., ABEYRATNE, F. and FARRINGTON, J. **The utilization of buffalo for farm power in Sri Lanka.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka 24-28 November, 1980 Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC 1982. pp. 20-30. Agrarian Research and Training Institute, Colombo SL.

The traditional role of draught buffaloes in paddy cultivation has been eroded by tractor power in the last thirty years. Only about one third of *asweddumized* acreage is currently ploughed by animals. With major land development programmes, the demands for draught power are increasing at a time when adverse terms of trade and balance of payments deficits make it difficult to support the present tractor-based strategy. It is against this background that the role of buffaloes in small scale farming is receiving renewed interest. A comparison of tractor and buffalo operating costs provide economic justification for the role of animal power. Attention is drawn to the inadequacy of current statistical information on buffalo populations. Careful interpretation suggests only a slow decline since the mid-1960s. Buffalo use-levels are found to be low in a current ARTI/Reading University study, even during peak periods, when they average only some 17-22 hours per pair per week.

It is suggested that the role of buffaloes could be expanded even in the short/medium term by wider use of ploughs instead of trampling, and by transfer of adult and juvenile animals from areas of low to areas of high use-intensity. In the longer term, promotion of a stall feeding system such as that observed in parts of Polonnaruwa is essential. Even with a diet of cut grass only, the size and condition of animals is not inferior to that found under open grazing. The system has potential for intensification through higher quality feeds, and permits easy use of by-products. it also seems to reduce the incidence of disease, and by keeping average herd sizes small organisational problems in hiring out are removed. Intensification should be introduced where grazing land is unavailable and policies to promote its adoption are essential. They include extension services, subsidised breeding, purchase and feeding schemes, the organisation of markets for working animals, and possibly the reduction of subsidies on tractor purchase and use.

M-53 SANTIAPILLAI, CHARLES and CHAMBERS, M.R. **The social organization and calving patterns of the water buffalo *(Bubalus bubalis)* in the Ruhuna National Park.** In: *Proceeding of the Workshop on Water Buffalo Research in Sri Lanka 24-28, November 1980.Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982. pp. 59-67. University of Peradeniya, Peradeniya, SL.

Ecological studies on the population structure, social organization and birth periodicity in the water buffalo *(Bubalus bubalis)* were carried out seasonally in the Ruhuna National Park, Sri Lanka from May 1978 to November 1979. Water buffalo is a social animal, which moves about in large groups. The most frequently observed category was that of the solitary animals of which over 90% were bulls. The adult sex ratio in the groups was always in favour of the cows. The adult bulls seem to suffer heavier mortalities than the cows. In the park it was found that the smaller groups of about five animals were characteristic of the forested areas, while larger groups of more than twenty animals were typical of the grasslands. Water buffalo was found to be a seasonal breeder. But considered with the onset of the drought, while parturition was associated with the duration of the rainy season. Thus there were two clearly defined peaks in breeding activity and calving in the case of the water buffalo in the Ruhuna National Park. The period of lactation and weaning coincided with the availability of a high plane of nutrition in the Park.

M-54 SENEVIRATNE, S.K. and JAYASEKARA, S. **Studies on work performance of Sri Lankan water buffaloes.** *Buffalo Journal (1993)* **2,** 99-105 Faculty of Engineering, University of Peradeniya, Peradeniya, SL.

The work performance of Lanka buffaloes was investigated using a loading cart fitted with a load cell and signal integrator. Animals were made to pull the loading cart on a test track with a hard flat surface. Five draught levels were selected to cover the range of

forces encountered by the animals under normal field conditions. The power output increased with increasing draught levels up to 18 percent of average body weight. The maximum value of average power recorded was 528 watts and the corresponding total work done during a 20 minute period was 519 x 10^3 J. As the draught level was further increased, the power output showed a significant decline. However, the total work done did not change noticeably. These results combined with the changes of physiological parameters observed during the trials, suggest that the animals reach the point of exertion at a draught level of around 18 percent of body weight. These results indicate that a better power and work output from the animals could be obtained at draught level of around 14 percent of body weight.

M-55 SILVA, I.D, DANGOLLA, A and SILVA, K.F.S.T. **Preliminary analytical observations on persistency of milk yield in buffalo in Sri Lanka.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by Perera, B.M.A.O. *et al.*] Colombo, SL, NARESA Press, 1996. pp.129-136. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The daily milk yield in buffalo cows had been observed to fluctuate substantially after day 75 of the lactation period when compared to cattle. This fluctuation may vary from hypogalactia to even a temporary cessation of lactation (agalactia). This communication examines the persistency of milk yield in the first lactation milk records of 23 Murrah, Surti and their crosses from 3 farms in the dry, wet and intermediate zones. All observations were made over the period between day 75 up to at least day 178 of the lactation curve. The longest lactation period included was 368 days. The median, minimum and maximum of 10 day moving averages of the milk yield were 3.4, 0.33 and 10.40 litres respectively. The median reduction in milk yield in any given month was 10% of the previous month's yield. However, the monthly milk yield increased by approximately 110% of that of the previous month in 14 cows, at least once during the observation period. The variation in milk yield, in relation to the average yield, for 10 day periods was examined by calculating the weighted milk production (WMP). The WMP was calculated by dividing (or weighting) the difference between the maximum and minimum daily yield by the average yield for that period. The WMP was less than 1.5 in 10 cows. However, in 9 cows the WMP increased, at least twice, to over 1.5 indicating a substantially large variation in the milk yield of these cows.

An interesting finding was that, at least once during the study period, 13 cows showed an increase of 10% of their peak yield of the entire lactation during a 15 day period. Such unusual patterns have not been reported in cattle. Future studies on subsequent lactations of these buffaloes may provide information on factors leading to such variations in daily milk yield.

M-56 SIRIWEERA, W.I. and JAYASEKERA, P.V.J. **Trends in the utilisation of animal draught in Mahaweli System 'C'.** In: *Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka 7-10 March, 1989. Kandy, SL.* Faculty of Arts, University of Peradeniya, Peradeniya.

Three settlements Hebarawa, Viranagama and Galporuyaya in Mahaweli System C and a traditional village (Udattawa) outside the Mahaweli system were selected for a field study. For quantitative data, questionnaires were administered at different stages of the cultivation cycle both in Maha and Yala 1986/87. Qualitative data such as the attitude of settlers towards different modes of farm power were obtained through informal interviews, free inter-communication and participant observation methods.

The use of neat cattle in field preparation activities is predominant in the area, because the settler could own and rear a small herd of neat cattle in the home-stead of half an acre of land allocated to him whereas buffalo herding requires more extensive grazing and wallowing facilities. Neat cattle could be managed easily in paddy fields and the labour requirements is relatively less. As there is no prohibition on slaughter for meat there is also a ready market for neat cattle. The incentives and advice provided to farmers to keep neat cattle, are greater than those given for buffalo keeping. These practical considerations have given rise to a situation where neat cattle has become the farmers predominant choice in field preparation in the System C. The findings of the study highlights the following points: a) In dry-zone small farms, utilisation of animal draught (both buffaloes and neat cattle) could be encouraged, for agriculture to be economically viable, b) In future settlement planning, adequate provision should be made for grazing and wallowing of animals, c) Experiments on supplementary animal feed should be continued with much greater vigour, d) Support for tractorisation in colonisation schemes under facilities for credit purchase should be gradually discontinued. e) Farmers should be induced to build up their own herds through low interest credit facilities, f) More government support should be given to both buffalo and neat cattle dairy industry by providing necessary infrastructural facilities, g) Simple and inexpensive technologies should be introduced for cultivation operations other than ploughing, in order to minimise costs.

M-57 SIRIWARDENE, J.A.de S., WICKRAMSURIYA, U.G.J.L. and BALACHANDRAN, S.S. **Management practices of the buffalo in small farms.** In: *Proceeding of the Workshop on Water Buffalo Research in Sri Lanka, 24-28, November, 1980 Peradeniya, Sri Lanka.* SAREC Report R3:

Stockholm, Sweden. SAREC 1982. pp. 13-19. Veterinary Research Institute, Peradeniya, SL.

A survey was carried out on the management practices of the water buffalo in small holdings in the Polonnaruwa and Matara Districts. Sixty seven small farmers were interviewed on the basis of a questionnaire for the purpose. The average size of each farm holding is 0.57 ha (1.4 ac) of highland and 1 ha (2.5 ac) of paddy land. Each unit has on an average 4 head of cattle and 20 head of buffaloes. The buffaloes are maintained mainly for milk production and draught power.

None of the farmers had any cultivated pasture. The stock are almost entirely of the indigenous type. The buffaloes are allowed free grazing during the day on natural pasture available in paddy fields, jungle land, waste land and on road sides. Most of the animals are moved seasonally from the holdings to jungle land or waste land during times of floods and poor feed availability. Almost all the farmers (92%) milk the buffalo cows. The daily average milk yield per cow is about 1 litre. The milk is mostly sold as liquid milk or curd, very little being consumed by the family.

Calf mortality due to parasitism and haemorrhagic septicaemia appear to be the major disease problem. The percentage of farmers who reported deaths and the average percentage mortality of calves among this group of farmers is 20% and 30% for the Matara District and 32% and 41% for the Polonnaruwa District, respectively. Few deaths were reported among adult buffaloes. Nearly 70% of farmers have their animals vaccinated against haemorrhagic septicaemia but none against foot and mouth disease.

All farmers use buffalo bulls for ploughing but when numbers are inadequate, non-pregnant cows and those not in milk are also used for this purpose. Although 52% of the farmers use both bulls and cows for ploughing, their preference is for bulls for both ploughing and puddling operations. Farmers estimate that a pair of buffaloes can generally plough 0.20 ha (0.5 ac) and puddle 0.05 to 0.1 ha (1/8 to ¼ ac) per day.

M-58 SIRIWARDENE J.A.de S. **SAREC/NARESA project on dissemination of information on improved buffalo production systems to small farmers**. In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press, 1996. pp. 19-25. Buffalo Research and Development programme, Peradeniya, SL.

The SAREC/NARESA Buffalo Research and Development Programme was initiated in 1983 and concluded the research phase in 1994. The Information Dissemination programme which was the final phase of the programme continued for 1995 to the 1998. Phase III had three major activities which were (1) The establishment of the buffalo information centre (2) The dissemination of the research information generated in phases I and II to rural farmers and (3) popularisation of intensive buffalo farming. Activities related to dissemination of information included the publication of a compendium of research information, a book on buffalo production, a handbook on buffalo husbandry practices, a training manual and information leaflets for farmers. The popularisation of intensive buffalo farming was achieved by creating greater public awareness on the benefits of intensive buffalo farming particularly in rural farms where limitation of land and other resources have made the traditional extensive buffalo management systems unworkable. The program popularised the model "Smallholder Intensively Managed Buffalo Farm Unit" which was based on the introduction of a combination of management practices applicable from a basket of technologies developed by the Buffalo Research and Development Programme.

M-59 SUBASINGHE, D.H.A. **Calf Mortality** *Ceylon Veterinary Journal* (1981) **29,** 26. [Abstract] Department of Animal Production and Health, Peradeniya

Five-thousand four-hundred and forty-nine pregnancies in the hill country cattle farms and 4408 pregnancies in two dry zone buffalo farms during 1970-74 were analysed in this study.

These pregnancies resulted in 399 and 344 prenatal deaths (abortions and still births), and 5050 and 4118 live births in cows and buffalo cows respectively. Calves that died before they reached 6 months of age only were taken to consideration for calf mortality data. The overall calf mortality rates in the cattle and buffalo farms were 17.8 and 22.2%, respectively; the prenatal mortality rates in them were 7.3 and 11.3% respectively. Comparison of the same parameters in the cattle and buffalo farms taken individually showed a similar trend. The ratio of post-natal deaths: live births had a significant effect attributable to the year of birth (P=0.005): similarly, the age had a significant effect on post-natal mortality (P=0.001). Deaths in buffalo calves were higher at 0-1 month and at 4-6 months, whereas in cattle, mortality was higher in the 0-3 month age group. The month of post-natal deaths had no effect on the total number of deaths. Thus, apart from disease, management obviously played an important role in post-natal deaths.

M-60 SUBASINGHE, D.H.A. **Calf mortality in buffaloes on major state farms of Sri Lanka (1970-74)** In: *Proceedings of the 5th Conference of the Institute of Tropical Veterinary Medicine, 18-22 August, 1986. Kuala Lumpur, Malaysia.* 111-112 Department of Animal Production and Health, Peradeniya, SL.

Calf mortality is an important indicator of the state of management on a livestock farm. The current investigation was designed to study the pattern of buffalo calf mortality and its causes under intensive management, with a view to assess the magnitude of the problem of mortality and to identify the types of calfhood diseases that caused death. Data on births, abortions, still births and deaths in calves dying up to the age of six months, were recorded from three major state buffalo farms for the period of 1970-74.

Examinations of the information relating to six thousand five hundred and sixty (6560) pregnancies in buffalo cows included in this study showed that there were 390 prenatal deaths and 6170 live births and 1224 postnatal calf deaths. Differences in prenatal, postnatal and overall calf mortality rates between farms were not significant. The mean values taken together were 6.0%, 19.8% and 24.6%, respectively. The age of the calf at death had a significant effect on postnatal mortality rate. The deaths were higher below one month age and between 4-6 months. Sex had no significant effect on the death rate. No significant seasonal effect was observed on the postnatal mortality of calves in this study. There was a seasonal effect on births showing a high birth rate in months of May, June, July and again in November, December and January, but the month of the year did not show a significant effect on the number of live birth. Data from only two of the farms were available for the study of the causes of calf mortality. Among the causes of calf mortality, alimentary disorders, debility, respiratory infections and undiagnosed conditions were among the highest. Calf wastage in the current study was rather high, as one in every four pregnancies did not survive up to 6 months of age. The major cause of calf mortality is identified as poor calf management.

M-61 SUBASINGHE, D.H.A., PERERA, B.M.A.O., ABEYGUNAWARDENA, H., RANAWANA, S.S.E., KURUWITA, V.Y. and DE ALWIS, M.C.L. **Development of the SAREC/NARESA Buffalo Research Farm, Narangalla.** In: *Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka. 7-10 March, 1989. Kandy, Sri Lanka.* pp. 56-59. Department of Animal Production and Health, Peradeniya, SL.

At the inception of the SAREC/NARESA Co-ordinated Buffalo Research Project, a decision was taken to establish a central facility for research on indigenous buffaloes under small farm holdings. A coconut estate located in the intermediate zone of Sri Lanka about 60 miles from Kandy was selected for this purpose. This property is owned and managed by the National Livestock Development Board (NLDB) and consists of 200 acres of coconut, a limited acreage of improved pasture and a small reservoir. A memorandum of understanding (MOU) to establish and maintain a research facility on this property was signed by the Director General NARESA and the Chairman NLDB, which became effective on September 30, 1985.

The planned research facility at its completion will consist of 200 acres of improved pasture, a circuit bungalow *cum* research laboratory, cattle shed, calving pens, cattle yard, crush and hay barn. The construction work on the circuit bungalow *cum* research laboratory has been completed. We are grateful to the Australian Centre for International Agricultural Research (ACIAR) for the generous donation of the furniture and other equipment for this unit. A 'worm free' cattle shed was also constructed through ACIAR funding. The farm now has 200 buffaloes (mature cows 80, stud bulls 2, bull calves 30, heifers 35, male calves 30 and female calves 30). It has so far provided facilities for 10 research projects. (reproduction 6, nutrition 3 and parasitology 1) The research facility is managed by a resident manager, assisted by a technical assistant. The conditions of the agreement are as follow: 1). The agreement was to be valid for 5 years from 1985 in the first instance. 2) NLDB will allow NARESA to develop and maintain the pasture lands exclusively for research animals, use of all facilities to research scientist. authorised by NARESA and instruct the managerial staff to assist in management and development of the facility. 3) NARESA will disburse funds for capital development and improvement of the research facilities and also reimburse the NLDB the expenses incurred in connection with its maintenance. 4) At the conclusion of the Project, NARESA will hand over the assets to the NLDB who will consider the maintenance of this facility as a model research farm for use of the scientists.

M-62 SUBASINGHE, D.H.A. **Activities of the Department of Animal Production and Health in the field of buffalo development.** In: *Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka. 7-10 March, 1989. Kandy, Sri Lanka.* Department of Animal Production and Health, Peradeniya, SL.

This paper is a brief review of the buffalo development programme of the Department of Animal Production and Health (DAPH) which is implemented through six technical divisions, each headed by a Deputy Director. For planning and monitoring of the activities of the technical divisions, a planning cell was established under the purview of the Director.

In recognition of the need to upgrade the Lanka buffalo, the DAPH imported several consignments of Murrah and Surti buffaloes in the nineteen thirties and sixties and established state farms in several districts. Producing superior quality buffaloes of high milk production potential, multiplying and issuing selected males to AI stations, stud centres and to farmers, supplying surplus females to breeders and conducting and facilitating research in

animal production and health were some of the main aims in the establishment of the above farms. The male progeny born were reared under special care. The best animals were kept on the farm or transferred to semen collecting stations, while the rest were issued to stud centres or farmers.

The DAPH conducts research on production and health of buffaloes. In addition, it maintains bulls at Polonnaruwa and Kundasale for collection and processing of semen for AI that is distributed throughout the country through range veterinarians. Natural breeding is preferred to AI in breeding programmes where the importance of increasing the productivity of the Lanka buffalo by crossbreeding them to dairy types, is emphasised. Establishment of night paddocks in estates in the Kurunegala district where local buffalo cows and Murrah bulls were herded together resulted in the production of good quality crossbred calves. The contract breeding and heifer rearing scheme was implemented to meet the demand for heifers where the sale of the heifers was mediated by the DAPH. A special health care scheme for calves was introduced in order to reduce the mortality.

The DAPH also assists the farmers to market their products through the formation of Dairy Producers' Associations. The pasture subsidy scheme was implemented in 1972 to encourage the farmers to produce good quality fodder on their own. A livestock insurance scheme which was established in 1990 provides insurance cover for valuable animals.

The DAPH carries out disease control and preventive measures through 118 veterinarians and their support staff. It is also responsible for the task of imparting and improving the knowledge and skills of the officers and farmers. This is achieved through in service training programmes or through the schools of animal husbandry situated at Welisara and Anuradhapura.

The future plans of the DAPH include the strengthening of selected livestock farms with foreign assistance, importation of high quality female buffaloes, bulls and semen to further improve the stocks in the livestock farms.

The shortage of good quality breeding stock, nutrition and the inadequacy of credit and animal health in rural areas are some of the major constraints to the development of buffalo farming in the island. These problems may be overcome through creating national awareness, identifying suitable farming systems and a national commitment to support a dairy/draught programme.

M-63 SUBASINGHE, D.H.A., ABEYGUNAWARDENA, H., PERERA, B.M.A.O., PERERA, A.N.F., JAYATILAKE, M.W.A.P., DAYANANDA, W.K.R. and WEERATHUNGE, P.H.G. **The use of sample survey (SS) and rapid rural appraisal (RRA) as tools for identification of the needs of smallholder dairy farmers for technology transfer.** In: *Proceedings of the 49th Annual Scientific Sessions of the Sri Lanka Veterinary Association on, 8 March, 1997. Colombo, SL.* SAREC/NARESA Buffalo Research and Development Programme, Peradeniya, SL.

The failure of past livestock development activities based on conventional surveys and centrally planned strategies prompted us to adopt a new approach to technology transfer for improving smallholder buffalo production. Under the SAREC/NARESA buffalo information Dissemination project, we initially conducted sample surveys (SS) of farmers belonging to milk producer co-operative societies (MPCS) in two target areas, Mahaweli system C (MSC) and Mahaweli system H (MSH). This was followed by Rapid Rural Appraisal (RRA) done through several visits to selected farmers. Characteristics of farming systems, resources and their utilization, farmers needs, attitudes, perceptions and constraints were determined through observations and discussions with the farmers. Results from the SS in MSC (211 farmers in 7 MPCS) and MSH (28 farmers in 6 MPCS) respectively, showed that average land holding was 2.5 and 3.7 acres, average herd size of large ruminants was 7 and 16, and the average milk production per day was 2.7 and 4.2 litres for cattle and 3.7 and 2.7 litres for buffaloes. While the primary occupation of all sampled farmers was crop production, livestock made an important contribution to regular family incomes of a majority. The RRA revealed that farmers are very heterogeneous in their resource base, attitudes, perceptions and expectations. However, they all agreed that income from livestock, compared with that from crops, was steady and less prone to fluctuations of climate and market factors. Diminishing grazing lands, restrictions on animal movements and crop damages made extensive rearing increasingly difficult. Although farmers were conscious of the need to change their management practices, such transition was slow due to their conservative nature, poor resource management, lack of technical knowledge and absence of appropriate guidance.

Based on these findings we have designed a programme for providing limited material inputs, training, demonstration and extension, catering to specific needs of selected individual farmers aimed at promoting intensive integrated management practices. These farmers are intended to serve as "models" acting as catalytic agents for dissemination of appropriate technologies to other farmers enabling them to overcome their specific constraints.

M-64 SUBASINGHE, D.H.A., ABEYGUNAWARDENA, H. and PREMALAL, G.G.C. **Crop-Livestock integration for maximising smallholder farm income.** SAREC/NARESA Buffalo Research and Development Programme Information Leaflet No.10, Publication No. 14. Colombo, SL, National Science

Foundation, Press (1998). 17 pp. SAREC/NARESA Buffalo Research and Development Programme, Peradeniya, SL.

This is a farmers' guide for optimum utilisation of farm resources for increase in productivity, through crop-livestock integration. The paper has outlined the value of integration and provided some specific guidelines on relevant subjects such as a) the establishment and management of the forage base in a smallholder farm, b) construction of a low-cost cattle shed, c) management of the dairy stock and (d) recycling of crop residues, agro-industrial by-products and animal waste, and many other useful practical guide lines including a preventive health care package, to achieve optimal productivity.

M-65 SUBASINGHE, D.H.A., ABEYGUNAWARDENA, H., PERERA, E.R.K. and PERERA A.N.F. **Management of buffaloes and dairy cattle.** SAREC/NARESA Buffalo Research and Development Programme Information Leaflet No: 8, Publication No. 12. Colombo, SL, National Science Foundation Press. (1998). 8 pp. SAREC/NARESA Buffalo Research and Development Project, Peradeniya, SL.

This publication is a farmers' guide to efficient management of cattle and buffaloes. Practical requirements for efficient management of a smallholder dairy/buffalo farm have been described. The authors have discussed vital management practices necessary from birth of the calf to adults covering different age groups. Management of new born calves, weaners, growers (from weaning to puberty); management of adults including pregnant heifers, lactating cows and post-partum cows etc. are discussed. For practical guidance a programme of routine de-worming and vaccination has been recommended as a preventive health care package.

M-66 SUBASINGHE, D.H.A., HORADAGODA, N.U., ABEYGUNAWARDENA, H. and SIRIWARDENE, J.A.de S. [EDITORS]. **Water.Buffalo - Improved utilization through new technologies**. Colombo, SL, National Science Foundation Press (1998). 94 pp. D.H.A. Subasinghe, SAREC/NARESA Buffalo Research. and Development Project, Peradeniya.

This is a NSF publication on the Water Buffalo. It is a multi - author publication edited by a panel of scientists from the SAREC/NARESA Buffalo Research and Development Project and University of Peradeniya.

The book contains up to date information on various aspects of the water buffalo. It is an attempt to provide authentic information on the water buffalo to scientists in the relevant fields, teachers and students extension workers, farming community and the reading public, to popularise buffalo farming and stimulate better utilisation of this animal for economic gain.

The book contains 11 chapters. The first two chapters provide a historical background and an analysis of the buffalo farming systems in Sri Lanka. The three subsequent chapters discuss the utilisation of the buffalo as a source of farm power together with remarks on potentials and constraints. Chapter 6 deals with physiology and reproduction together with improvement of reproductive performance, while chapters 7 and 8 have focused on feeds and feed utilisation including appropriate feeding system to optimise production. Chapter 9 and 10 described the common diseases of the buffalo and their prevention and the health care management at different ages. Chapter 11 gives a resume of the new technologies that could help improve the utilization of the buffalo as a multipurpose animal under an intensive production system and also the experience gained during the stage of dissemination and transfer of new technologies.

M-67 SUBASINGHE, D.H.A. and HORADAGODA, N.U. **Health care management in the buffalo.** In: *Water Buffalo - Improved Utilization Through New Technologies* [Edited by Subasinghe, D.H.A. *et al.*] Colombo, SL, National Science Foundation Press. 1998. pp. 77-82. SAREC/NARESA Buffalo Research and Development Project, Peradeniya, SL.

This paper describe the management and health care practices in buffaloes with special reference to disease prevention in young stock and adults reared under intensive system of management. In most instances the principles and procedures apply to other farming systems as well. The management and healthcare of the new-born calf to the parturient cow have been described under six sub headings. 1). management of the neonatal calf, 2). management of calf from first week to weaning, 3). management and healthcare of buffaloes after weaning, 4). management of animals from one year to puberty, 5). management of adult heifer and cows, 6). management and healthcare of the parturient cow.

M-68 THAMOTHARM, M. **Preliminary study on the performance of Surti buffaloes in Sri Lanka.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November, 1980 Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC 1982. pp. 54-58. National Livestock Development Board, Melsiripura, SL.

Under the Indo - Sri Lanka animal husbandry programme 200 pregnant Surti buffalo cows and 11 studs were imported into this country in two consignments in June, 1976 and in July 1977. They are being maintained as a pure herd, for the purpose of multiplication and distribution to villagers and private breeders for draught and breeding purposes. Up to date the farm has distributed 211 buffaloes.

A detailed study was conducted on these imported buffaloes and this paper illustrates their management at Melsiripura Farm with respect to rearing of calves, breeding of both heifers and adults, feeding, grazing, milking and wallowing. It gives also a detailed analysis on the production parameters such as birth weight, weight at different ages, milk yield, lactation length, dry period, calving interval, seasonality of calving, disease problems and solutions, and a brief illustration on the economic viability of the farm. The average birth weight of the calves in both males and females was 20.5 kg. While the average growth rate was around 0.35 kg per day. Milk production varied between 4.5 - 5.7 litres per day. Mortality in calves from all causes was 8%. The adult deaths were mostly due to haemorrhagic septicaemia. There is no seasonal calving pattern in the farm. Calving percentage was 65% with a mean calving interval of 510 days. Lactation length ranged from 150-424 days with a mean of 286 days.

The main source of income in this dairy unit was from curd and sale of animals. In general the farm has maintained itself as a viable economic unit.

M-69 TILAKARATNE, N. and BUVANENDRAN, V. **A study of growth rates of Murrah and cross-bred buffalo calves.** *Ceylon Veterinary Journal* (1972) **20,** 92-95. Veterinary Research Institute, Peradeniya, SL.

A program of upgrading the local buffalo with the Indian Murrah to improve the milk production potential of the local buffalo, has been in existence in this country for many years. It is therefore, opportune to examine the growth rates of Murrah and local crossbred calves in experimental herds, to obtain data in terms of the meat potential of the improved animals. The objective of this paper was to report on the weight and growth rates of cross-bred (Murrah x local) buffalo male calves from data collected from the Government Livestock Farm, Ridiyagama. All animals sampled in this study were either second or third generation progeny and thus had 75 percent (3/4) or 87.5 (7/8) percent Murrah blood. Pure bred Murrah calves were also included in the study. The growth rates during the early period (8 - 18 months) were very similar in the three breeds, while the adjusted mean weight at 14 months of age was approximately to 410 lbs (186.4 kg). The growth rates beyond 18 months of age were different, Murrah being the most superior followed by the 7/8 Murrah cross-breds.

M-70 TILAKARATNE, N. **Meat production from the domestic buffalo.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28. November, 1980 Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC 1982. pp. 91-95. Department of Animal production and Health, Peradeniya, SL.

In most countries where buffaloes are domesticated they are being used as a triple purpose animal-for work, milk and meat. In Sri Lanka, however, the buffalo has never been raised for meat production. This is due to the ban on slaughter of this animal in order to conserve it for draught purposes, and also because people generally dislike buffalo meat. Experimental evidence, has generally substantiated the claim that buffaloes could be used more economically for the production of quality meat which is in no way inferior to cattle meat.Studies conducted under conditions typical of the dry zone of Sri Lanka have shown that the growth rate up to two years of age of the indigenous buffalo (0.45 kg/day) and the Murrah buffalo (0.39 kg/day) were superior to those of Friesian (0.15 kg), Sindhi (0.33 kg) and Lanka (0.30 kg) breeds of cattle. The two breeds of buffalo were also superior to cattle in the total yield of lean meat (live weight x dressing percentage x lean percentage) at comparable ages.

Similar results were also obtained from experiments carried out in the mid country where both climatic and nutritional conditions are comparatively better. The mean daily live weight gains were 0.51, 0.38, and 0.24 kg for Murrah, Sindhi and Friesian steers, respectively. Buffaloes were significantly more efficient converters of feed to body tissue requiring only 11.0 kg dry matter per kg gain whereas the corresponding values for Sindhi and Friesian were 12.2 and 22.2 kg respectively. Buffaloes had the highest dressing percentage of 50.9 compared to 46.3 and 42.8 for Sindhi and Friesian, respectively. Mechanical tests for tenderness and taste panel scores for palatability revealed that buffalo meat compared favourably with cattle meat with regard to eating quality.

M-71 ULLUWISHEWA, R. **A comparison of tethering and free grazing buffalo management systems in Sri Lanka.** *Buffalo Journal* (1989) **2,** 121-129. Department of Geography, University of Sri Jayawardenapura, SL.

This study compares the major characteristics of free grazing and tethering systems which are practised in the dry zone and the wet zone, respectively. The objectives of this study are to identify the major characteristics of the free grazing system and the tethering system, to comparatively analyse the economic aspects of buffalo management and to identify the limitations of buffalo husbandry in these two systems and to provide some guidelines for an appropriate buffalo management system.

The results indicate that the herd quality in terms of health and nutrition is better in the tethering system. The calving rate was higher (86%) in the free grazing system than in the tethering system (57%). On the other hand, calf mortality was substantially high (35%) in the former system in comparison of the latter (12%). Profitability was higher in the free grazing system, because of the lower costs and labour

requirement per animal compared to the tethering system. In both systems buffalo management is becoming less practical and economically less viable, because the uncultivated lands used for grazing animals are becoming scarce. Therefore, stall-feeding using crop residues, tree fodder and cut-grasses may be a better alternative system.

M-72 WIDANAPATHIRANA, A.S. **Some issues concerning buffalo statistics in Sri Lanka.** In: *Proceedings of the First World Buffalo Congress, 27-31, December 1985, Cairo, Egypt.* pp. 921-922 Agrarian Research and Training Institute, Colombo SL.

Buffalo statistics such as population data, age composition, classification by purpose, levels of production etc are vital for planning purposes. There are four main sources of buffalo statistics in Sri Lanka namely, (a) registers complied by the veterinary surgeons serving in the various parts of the country, (b) cultivation officers who are placed in villages at a rate of one for each 150-200 farm families, (c) field level officers of the department of agriculture and (d) sample surveys including census undertaken by the government department of census and statistics. Of these four sources, information collected by the veterinary surgeons do not provide the correct population figures since they are based only on the number of vaccinations carried by them. With regard to the population figures there is apparently a large discrepancy in available statistics not only between the three sources but also within each source for different years. The discrepancies may pose serious constraints to effective planing exercises.

The errors in buffalo statistics are possibly due to two main reasons namely: (a) the manner in which data are collected and (b) lack of cross checking of information at the time of collection and later on. In order to avoid the above complications, it would be better to take a head count of buffaloes, though practical difficulties exist in locating animals.

M-73 WIJERATNE, W.V.S. **Some of the production statistics of the Ceylon buffalo** *Ceylon Veterinary Journal* (1962) **10,** 48-49 Department of Agriculture, Peradeniya, SL.

The study is confined to the domestic variety of Ceylon buffalo, *Bubalus bubalis migona*, (Deraniyagala 1951). It is apparently smaller in size than other buffaloes in the region, horns are usually cresentic in shape and body colour leaden grey. The conformation and colour of the breed is fairly uniform. One hundred indigenous buffalo cows were purchased from rural farmers and maintained on a state farm at Ridiyagama in the Southern Province, as here the temperate was 81_F, rain fall 43 inches and humidity was 74%. The animals were on the farm from 1950-54, and only 36 records of the buffalo cows milked on this farm were available for the present study.

The length of gestation was 301 ± 2 days. A seasonal trend was observed in calving. Fifty six percent of calvings occurred in the months of January, May and June, while 2 percent of the calvings were in September, October and November. It is presumed that oestrous period would have been in the months of March, July and August. The herd average for all lactations was 79 ± 4 gal, with the calf being allowed to suckle during milking. The lactation length was 248±10 days with a coefficient of variation of 33%. The dry periods (184±12 days) and calving intervals (432 day) are very long. The milk production of the Ceylon buffalo is extremely low and the economics of milk production do not warrant selection within the breed as a means of improvement. An alternative method with greater promise would be cross breeding with a dairy breed of buffalo and upgrading the progeny to the exotic breed to improve the milk yield.

Part III - Nutrition and Physiology

N-01 ABEYGUNAWARDENA, H., SIRIWARDENE, J.A. de S. and PERERA, B.M.A.O. **Urea-molasses-mineral (UMM) multinutrient feed supplement.** SAREC/NARESA Buffalo Research and Development Programme, Information leaflet No. 2, Publication No. 6. Colombo, Sri Lanka, NARESA Press, (1998) 5 pp. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The publication is a farmers' guide to supplementation of roughage feeds in ruminants with Urea- molasses -mineral (UMM) supplements as a means of overcoming the nutrient deficiencies encountered in feeding under traditional feeding systems. The paper describes the process of rumen fermentation of fibrous feeds and the manner in which UMM feeding helps to improve the efficiency of fermentation of fibrous feeds in the rumen. It provides information on the composition, the method of production and recommendation on feeding of UMM.

N-02 ARIYARATNE, H.B.S., JAYASEKARA, S., DE SILVA, D.D.N., ABEYGUNAWARDENA, I.S. and WIJETUNGA, K. **Electrocardiographic studies in water buffaloes with standardised body and limb positions.** *Sri Lanka Veterinary Journal* (1992) **39,** 40-41 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Several authors have reported on the electrocardiographic findings of the different phases of the cardiac cycle of cattle and river buffaloes. However, there is no information available on the electrophysiology of the heart of the indigenous buffalo. Therefore, electrocardiographic records were obtained from healthy, adult indigenous Lanka buffaloes, of about 2 - 3 years of age, using standard unipolar limb and exploratory chest leads. The findings revealed that the P-wave appeared positive in leads I, II, aV_F and the chest lead C_R and negative in lead aV_R where it appeared labile in leads III and aV_L. The QRS complex emerged as a negative deflection in all leads studied except in lead aV_R. The T-wave was negative in leads I, II, III, aV_F and C_R whereas labile in leads I, aV_R and aV_L. The magnitude of each wave varied in different leads. The time intervals of various electrocardiographic complexes of the electrocardiogram and the coefficient of arrhythmicity were also calculated and compared with values reported for cattle. A high degree of arrhythmicity was noted in the Lanka buffalo, compared to values reported for the bison and deer.

N-03 HORADAGODA, A. **Studies on the composition of indigenous buffalo milk in Sri Lanka.** *M.Phil. Thesis* (1990) Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The chemical composition and physical properties of milk of indigenous (Lanka) buffalo were studied using standard techniques in dairy chemistry. A total of 566 samples of milk collected from buffaloes managed under field conditions, as well as those maintained in the university experimental farm were analysed. The overall values (mean ± S.E.M.; g/l) of the major constituents of buffalo milk, irrespective of the stage of lactation, lactation number and age, were: fat, 74.5 ± 0.61; total proteins 51.6 ± 0.15; casein, 44.0 ± 0.19; lactose 43.0 ± 0.02; ash 7.2 ± 0.02; solids-not-fat (SNF) 96.2 ± 0.46; and total solids 174.0 ± 0.57. The average values (mean ± S.E.M.; mg/l) of the minor constituents studied under the same conditions were: Na, 456 ± 99.6; K, 1213 ± 356; total phosphorus, 1500 ± 400; inorganic phosphate, 1000 ± 200; Ca, 1555 ± 350 and Mg, 325 ± 96. The mean vitamin A content was 1.20 ± 0.1 IU/ml. The average pH at 27^0 C, titrable acidity and ethanol stability were 6.42, 0.202 and 50% respectively. The mean values of the physical properties examined were: specific gravity 1.033 ± 0.003; surface tension 46.52 ± 3.46 dynes/cm at 27^0 C; electrical conductivity, 37.05×10^{-4} ± 5.00 at 27^0 C, viscosity, 1.9633 ± 0.243 centipoises at 27^0 C and fat globule size, 5.10 mm.

The composition of the colostrum was markedly different from that of milk. The average value (g/l) for parameters examined were: fat, 63; SNF, 200; total solids, 260; vitamin A, 3.30 IU/ml, while the viscosity was 4.067 ± 0.461 centipoises at 27^0 C and surface tension was 29.35 ± 1.92 dynes/cm at 27^0 C. The average daily milk yield of indigenous buffalo cows estimated by measuring water turn-over in their calves was 3.58 litres. The effect of the stage of lactation, lactation number and age, on the composition of milk was examined in 74 animals. All constituents were found to vary in composition with the aforementioned factors except lactose and ash. This study which is the first comprehensive analysis of indigenous buffalo milk

in Sri Lanka, attempted to establish norms for the breed. The results also revealed that the fat percentage of the Lanka buffalo was similar to that of the Indian Murrah buffalo while the protein content was higher, and comparable to that of the Philippine carabao and the Chinese swamp buffalo. The elevated protein concentration in the Lanka buffalo demonstrated that the alcohol test was not a suitable platform evaluation for this breed.

N-04 HORADAGODA, A. KODIKARA, C.P. and RANAWANA, S.S.E. **Studies on the vitamin A content of Sri Lankan indigenous buffalo milk.** In: *Proceedings of meeting of the Association for Veterinary Teachers and Research Workers, April, 1991 Scarborough, United Kingdom.* pp. 40. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Vitamin A is one of the essential dietary components obtained from milk but its concentration in indigenous (Lanka) buffalo milk in Sri Lanka is not known. A modified Carr-Price method was used to estimate vitamin A and β-carotenoid content in milk samples obtained daily from 74 buffaloes for one week from first lactation, and thereafter once every two weeks up to the end of lactation. Vitamin A content ranged from 0.9 - 2,2 IU/l with a mean of 1.21 ± 0.1 (mean ± SEM) while the carotenoid concentration was negligible. The vitamin A content was lower than that in Indian buffalo milk but higher than in Egyptian buffalo milk. As carotenoids were absent from buffalo milk it is apparent that buffaloes are efficient converters of β-carotenoid to vitamin A. When compared to milk, colostral vitamin A concentration was high, ranging from 4.78 - 6.24 IU/l with a mean of 5.52 ± 0.15 (mean ± SEM) and the levels steeply declined with advancing lactation.

N-05 HORADAGODA, A., KODIKARA, C.P., RANAWANA, S.S.E., KURUWITA, V.Y., PERERA, B.M.A.O. and GUNARATNE, KUMARI. J. **A preliminary report on the composition of indigenous buffalo milk.** *Sri Lanka Veterinary Journal* (1988-89) **36,** 51 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

In several districts (Batticaloa, Trincomalee, Anuradhapura, Hambantota, Matara and Kalutara), 75-100 per cent of the buffalo herds are milked. Buffalo milk is mainly used in the preparation of curd, a popular dessert in Sri Lanka, while a proportion is supplied to milk collecting centres as whole milk. Although indigenous buffalo milk has been consumed as curd and milk for many years, there is little information on its composition. In the present study, therefore, the composition and some of the physical properties of indigenous buffalo milk were investigated.

Milk samples from 32 indigenous buffaloes in the Puttalam district were collected fortnightly, over an entire lactation period. Fat and protein were assayed by Gerber and Kjeldhal methods respectively. Lactose and minerals were measured by spectrophotometric techniques. Results for each constituent, expressed as mean and standard deviation, were fat, 7.32 ± 2.4 g/l; lactose, 4.2 ± 0.41 g/l; protein, 4.1 ± 0.9 g/l; total solids, 16.62 ± 2.9 g/l; P, 824.9 ± 157.6 mg/l; Na, 534 ± 137 mg/l; K, 712.6 ± 108 mg/l; pH 6.3 ± 0.73; specific gravity 1.0238 ± 0.0003; percentage acidity 0.222 ± 0.039. There was a tendency for the fat percentage to increase with advancing stage of lactation.

N-06 HORADAGODA, A., RANAWANA, S.S.E. and KODIKARA, C.P. **Estimation of the milk yield of Lanka buffalo *(Bubalus bubalis).*** In: *Proceedings of the Annual Research Sessions of the Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, 3, December 1994, Peradeniya, SL.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The milk yield of Lanka buffalo is often underestimated, as milk let down is achieved only following an initial suckling stimulus by the calf. Results from a questionnaire based survey and previous studies on the milk yield through emptying of the udder by stripping, have estimated that the milk yield of the Lanka buffalo is between 1 to 2 litres/day. These investigations however have not accounted for milk consumed by the calf. In the present study, this limitation has been overcome by measuring the body water turn-over of calves given access to milk only. Two millilitres of carrier-free tritiated water (200 mCi/ml) were injected intramuscularly into 12 buffalo calves (age; 30 ± 11.8 days). The body weights of all animals were recorded prior to inoculation, and at each collection of blood (10 ml in heparin) on day 1, 2, 4, 7, and 14, after inoculation. The tritium concentrations in plasma were assayed and the regression of tritium was correlated with time.

The daily milk intake of the 12 calves was approximately 11.9 per cent of the body weight. Based on the water turn-over studies, the estimated average milk yield of the Lanka buffalo is 3.58 ± 0.82 litres/day. The intake of milk solids (45.4g/kg B.W.) was somewhat lower than that reported for dairy calves. Since buffalo milk is richer in energy, the energy intake (296 kcal/kg B.W.) was similar to that of dairy calves. A good relationship ($r = 0.8466$, $p<0.01$) was evident between the intake of milk solids and the growth rate of calves.

N-07 HORADAGODA, A., RANAWANA, S.S.E., KODIKARA, C, PERERA, B.M.A.O. and KURUWITA, V.Y. **The milk yield of suckled indigenous buffaloes.** *Sri Lanka Veterinary Journal* (1988-89) **36,** (2) 52, [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The daily milk yield of the indigenous Sri Lanka buffalo has been reported to range from 1.5 to 2.5 litres. These estimates, made on large farms and in the course of field surveys, have not included the quantity of milk consumed by the calf. This paper records an assessment of the total milk produced by suckled buffalo cows in early lactation, estimated by measuring the daily turnover of body water in calves. Tritiated water (200 mCi) was administered intra-muscularly to 12 calves with a mean age of 30 ± 11.8 days and mean weight of 30.5 ± 5.0 kg and whose mothers were not milked. Five blood samples taken over a period of 14 days were processed and counted. Measured activity of body water in the samples was regressed against time; total body water (TBW) was calculated from activity at time zero and the water turnover (WTO) from the TBW and the fractional rate of daily turnover. Mean (± SD) values of 21.1 (± 3.3) l for TBW (70.3% of body weight), 0.153 (± 0.0201) per day for k and 3239 (± 712.1) ml/day for WTO were obtained. The metabolic water produced was subtracted from the WTO to calculate the proportion of the WTO arising from milk. The amount of milk drunk by the calves, calculated using a value of 16.3% for milk solids, averaged 3580 ± 824.6 g per day with a range of 2425 to 5025 g.

The daily milk intake of the 12 calves amounted to 11.9% of the body weight. The intake of milk solids (45.4 g/kg $^{0.75}$ body weight) was somewhat lower than the value of 55 reported for dairy calves. However, since buffalo milk is richer in energy, the energy intake (296 kcal/kg $^{0.75}$ body weight) was similar to that of dairy calves. A good relationship (r^2 = 0.8466, $p < 0.01$) was evident between the intake of milk solids and growth rate in these calves. It was concluded that the values for milk production of indigenous buffaloes in early lactation obtained in this study were more reliable than those hitherto reported.

N-08 HORADAGODA, N.U., GUNAWARDENA, I.S., AMBAGALA, A.P.N. and MUNASINGHE, D.M.S. **Haematological and biochemical profiles of adult female Lanka buffaloes (*Bubalus bubalis)*** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 439-450. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The objective of this study was to establish reference values for haematological parameters and serum biochemical constituents of the Lanka buffalo in order to interpret results from experimental and clinical investigations. Jugular blood collected from 80 apparently healthy female buffaloes (2-7 years) at the Narangalla buffalo research farm were used to determine the haematological parameters whilst serum biochemical constituents were assayed in 120 animals from both Narangalla and Mawela buffalo research farms. The haematological parameters were measured using standard methods while serum analytes were assayed using biochemical kits (Randox Laboratories, UK). Irrespective of age, the reference values (mean±one standard deviation) for haematological parameters were: red blood cells, 5.34±1.23 (10^{12}/l); haemoglobin, 11.88±1.69 (g/dl); packed cell volume, 0.31±0.05 (1/1); erythrocyte sedimentation rate, 31.17±22.2 (mm/hr); plasma protein, 76±11.5 (g/l); Fibrinogen, 6.8±2.7 (g/l); icterus index, 5.66±2.23; white blood cells, 11,642±3991/µl; lymphocytes, 54.05±11.31(%) or 6171±3540//µl; neutrophils, 36.23±11.04 (%) or 3797±1928//µl; monocytes 3.48±2.26 (%) or 682±580//µl; eosinophils, 6.79±5.51 (%) or 388±357//µl and basophils 0.38±0.3 (%) or 39±24//µl. The reference values (mean±one standard deviation) for biochemical constituents were: albumin, 31.64±4.54 g/l; aspartate aminotransferase (AST), 105±36.56 U/l; alanine aminotransferase (ALT), 36.2±11.8 U/l; creatine phosphokinase, 66.75±35.5 U/l; alkaline phosphate (ALP), 118.5±64.3 U/l; gamma glutamyl transferase, 18.8±16.03 U/l; glucose, 3.22±0.87 mmol/l; urea, 4.82±1.62 mmol/l; creatinine, 130.27±27.25 mmol/l and bilirubin 4.9±4.4 (total), 2.05 ± 1.7 (direct) µlmol/l. The results of this study indicate that the haematological parameters of the Lanka buffalo are comparable to those reported for both swamp and river type buffaloes in Asia, characterised by a low icterus index, a high ESR and a predominance of lymphocytes over neutrophils. The biochemical values, in general, corresponded to values reported for the swamp buffalo in Australia and are similar to the values described in cattle, except for AST, ALP and ALT which are higher in the buffalo. In contrast to other domesticated ruminants, the serum ALT concentration in the buffalo is high, and may reflect a species characteristic.

N-09 HORADAGODA, N.U., MULLERIYAWA, I.S., AMBAGALA, A.P.N. and MUNASINGHE, D.M.S.

Biochemical values for normal female swamp buffaloes (*Bubalus bubalis*) in Sri Lanka. *Proceedings of the 5th Congress of International Society of Animal Clinical Biochemistry, 2-6 September, 1992. Parma, Italy.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This study was undertaken to establish reference values for interpretation of results from experimental and clinical investigations of the buffalo. Jugular blood samples from 120 clinically healthy, indigenous swamp buffaloes (age 2-7 years) reared in two research farms were analysed using reagent kits (Randox Laboratories, United Kingdom). The reference values (mean ± standard deviation) for parameters examined were; total protein, 90.69 ± 11.8 g/l; albumin, 31.64 ± 4.54 g/l; aspartate aminotransaminase (AST), 105 ± 36.56 U/l; alanine aminotransaminase (ALT), 36.2 ± 11.87 U/l; creatine phosphokinase, 66.75 ± 35.47 U/l; alkaline phosphatase (ALP), 118.56 ± 64.29 U/l, gamma glutamyltransferase 18.77 ± 16.03 U/l, glucose 3.22 ± 0.87 mmol/l, urea, 4.82 ± 1.62 mmol/l; creatinine, 130.27 ± 27.25 mmol/l; bilirubin, 4.93 ± 4.4. (total); 2.05 ± 1.71 (direct) mmol/l. The biochemical values obtained in this study were in general, similar to the values recorded in the only other parallel study on the swamp buffalo conducted in Australia. The results closely correspond to values in cattle except for AST, ALP and ALT which were higher in the buffalo. The findings of this study also indicated that the ALT values in the buffalo were higher than levels reported for other domesticated ruminants and may reflect a species characteristic.

N-10 IBRAHIM, M.N.M. **Feeds and feeding of buffaloes.** In: *Water Buffalo - Improved Utilisation Through New Technologies.* [Edited by Subasinghe, D.H.A. *et al.*] Colombo, Sri Lanka, National Science Foundation Press. 1998 pp. 52-59. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The article gives a brief description of the nutritive values of feedstuffs, the supplementation of diets deficient in essential nutrients and data on the nutritive value of feeds in terms of TDN and DCP. The author discusses briefly the approach to feed formulation and gives an example of the procedure to be adopted in feed formulation. Information on the daily nutrient requirements of lactation cows are also provided to illustrate how one could determine the nutrient requirements of lactating buffalo cows.

N-11 IBRAHIM, M.N.M., ABEYGUNAWARDENA, H. and SUBASINGHE, D.H.A. **Feed formulation for cattle and buffaloes.** SAREC/NARESA Buffalo Research and Development Programme, Information leaflet No. 09 Publication No. 13. Colombo, SL National Science Foundation Press (1988). 9 pp. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The publication is a farmers' guide to the rational and economic feeding of forage and concentrates to dairy animals. It emphasises the need to match the feed offered to the requirements of dairy animals, taking into consideration the physiological status of animals. Instructions on how to determine the nutritional requirements of animals and how to formulate rations to meet these requirements are provided.

N-12 JAYASEKARA, S., ARIYARATNE, H.B.S. and ABEYGUNAWARDENA, I.S. **Electrocardiographic studies in Lankan water buffaloes.** *Sri Lanka Veterinary Journal* (1987) **39,** 1-6. Faculty of Veterinary Medicine and Animals Science, University of Peradeniya, Peradeniya, SL.

Electrocardiographic recordings are widely used to study the different phases of the cardiac cycle and in the diagnosis of heart diseases in man and animals. Three healthy Lanka buffalo heifers of 2 to 3 years of age were used as experimental animals. The heart of each animal was auscultated using a clinical stethoscope to detect any deviations from normal heart sounds or irregularities of the rhythm before making the recordings. All recordings were obtained while the animals were standing at rest and no pharmacological preparations were used to restrain them. Electrocardiographic recordings were obtained using standard unipolar and bipolar limb and exploratory chest leads. To compare the values obtained from buffaloes, electrocardiograms were also recorded in dairy cattle. The coefficient of arrhythmicity (K_a) was calculated according to the method of Jankus and Good (1970).

Results indicate that, the ECG of Lanka buffalo is similar in most parts to those recordings of American bison and Indian river buffaloes. A striking feature noticed in the ECG of Lanka buffalo was a "M" shape complex appearing within the QRS complex in lead II in all three test animals. Lank and Kingsberry (1959) reported a "M" shape complex in lead III in dairy cattle. A physiological significance of this complex has not yet been explained. The ECGs obtained are characterised by low voltage and amplitudes. The low amplitude may be due to the relative thickness and poor electrical conductivity of the skin of this species compared to those in man. Lead I of the ECG consistently produced records of high quality with relatively low voltages suggesting that this lead can also be used to determine the durations of different cardiac intervals. Compared to dairy cattle, a higher coefficient of arrthmicity (K_a) was noted in Lanka buffaloes.

N-13 JAYASURIYA, M.C.N. **The utilisation of agro-industrial by-products by growing buffalo calves.** In: *Proceedings of Workshop on Water Buffalo Research in Sri Lanka, 24-28 November, 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982. pp 71-77. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The concept of recycling agro-industrial by-products has received wide publicity in recent years because of the growing belief that future ruminant production will increasingly depend upon the use of these 'wastes' in view of the possible limitations in the world food supply with expanding population. Rice straw, which is one of the largest agricultural by-product resources, is however little used as an animal feed in Sri Lanka, because of its poor nutritive value arising from low digestibility and low intake. Treatment with sodium hydroxide improves its feeding value but for economic reasons the technique is not feasible under local farm conditions. In an attempt to identify a cheaper system of treatment, the influence of urea solution on rice straw was investigated using growing buffalo calves. Rice straw treated with 4% urea solution and ensiled for 4 weeks was compared with untreated straw. Spent tea leaf (STL), a residue from the manufacture of instant tea, having 30% crude protein in dry matter, constituted 20% of the concentrate supplement. Urea treatment increased digestibility of straw organic matter by 30 percentage units, making it equivalent in feeding value to a medium quality hay. This treatment also increased the voluntary dry matter consumption by 40%. Ensiling straw wit' urea solution appears to be feasible in small-farm situations. Field scale testing is however necessary before the technique could be recommended to farmers.

N-14 JAYASURIYA, M.C.N. **Effect of urea-ensiling of rice straw on digestibility, voluntary intake and VFA production in growing buffalo calves.** In: *Proceedings of the 2nd Co-operative Agreement on the Use of Nuclear Techniques to Improve Domestic Buffalo Production in Asia,* (1981) pp. 46-54. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Treatment of rice straw with NaOH can improve its feeding value to a level equivalent to that of medium quality hay. In an effort to develop a cheaper system of treatment, the influence of urea-ammonia on rice straw was investigated using growing buffalo calves. Rice straw treated with 4% urea solution and ensiled for 4 weeks was compared with untreated straw. Straw was fed *ad libitum* with a concentrate mixture (2.4 kg/animal/day) containing 20% spent tea leaf. Urea treatment increased digestibility of straw OM by 3% units and voluntary DM intake by 40% compared to untreated control. The urea treatment, however, depressed the total VFA and rumen ammonia concentration, but had no significant effect on the VFA production rate. Urea ensiling of straw appears to be feasible under small farm situations. However, further research is necessary before it is extended to the farmer.

N-15 JAYASURIYA, M.C.N. **The utilisation of alkali treated roughages supplemented with cheap NPN in buffalo production in Sri Lanka.** In: *Proceedings of the Third Meeting of the Co-ordinated Research Programme on the Use of the Nuclear Techniques to Improve Domestic Buffalo Production in Asia, 19-23 April, 1982. Serdang, Selangor, Malaysia* pp. 46-52. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Studies were conducted to upgrade the feeding value of rice straw for cattle and buffaloes by chemical treatment and suitable supplementation. Rice straw treated with a 4% urea solution and ensiled for 21 days, increased OM straw digestibility by 30% units (32-62%), increased the estimated straw ME value from 4 to 8 MJ/kg DM, increased straw DM intake by 40% when fed *ad libitum*, decreased total VFA concentration from 101.6 to 70.6 moles/litre decreased acetate production rate from 13.83 to 7.72 moles/24 hours, total VFA from 27.9 to 15.6 moles and reduced rumen ammonia concentration from 31.5 to 15.4 mg N/100ml of rumen fluid. The significantly low total VFA and ammonia contents in the rumen of buffalo calves fed urea ensiled straw may be due to increased rumen volume resulting from the greater feed intake. The VFA production rate was not significantly different between the two groups.

N-16 JAYASURIYA, M.C.N. and KARUNARATNE, M. **The utilisation of alkali-treated rice straw supplemented with cheap non-protein nitrogen in buffalo production in Sri Lanka.** In: *Proceedings of the Final Research Co-ordination Meeting on the Use of Nuclear Techniques to Improve Domestic Buffalo Production in Asia, 30 January - 3 February 1984. Manila, Philippines.* Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Two experiments were undertaken to evaluate the feeding value of rice straw, with special emphasis on rumen function in swamp buffalo in Sri Lanka. In Experiment 1, three rumen-fistulated buffaloes with an average liveweight of 240kg were used to compare three rations containing straw supplemented with 4% urea, straw 'ensiled' for 21 days with a solution of 4% urea (urea/ammonia

treatment) and straw treated with a 4% solution of sodium hydroxide. The urea-ammonia and sodium hydroxide treatments were superior to urea supplementation in increasing apparent digestibility of the diet, total volatile fatty acid concentration and acetate production rate in the rumen. In Experiment 2, three treatments were compared using the same three fistulated buffaloes. Treatment 1 and 2 were as in Experiment 1, except that in treatment 3, the ration contained straw mixed with 4% urea and 5% by weight of finely chopped, fresh glyricidia leaves prior to ensiling, to supply urease for enhancing ammonia production from urea. The digestibility of the glyricidia-containing ration was similar to that of the ration with straw treated for 21 days. Acetate production and total volatile fatty acid concentration were also similar for the two treatments. The increased digestibility of the diet and the apparent increased volatile fatty acid production in the rumen accounts for the increases in live weight gain and milk production in cattle and buffalo fed urea-ammonia treated straw. The addition of glyricidia at the commencement of ensiling can be recommended as a means of reducing the ensiling time of treated straw.

N-17 KUMARASWAMY, S. and PADIWITA, S.H. **The importance of wallowing to buffalo calves.** *Sri Lanka Veterinary Journal* (1982) **30,** (2) 38-39; [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Alopecia, emaciation and increased mortality were encountered among Murrah buffalo calves in some farms of the Department of Animal Production and Health. An experiment was carried out to determine whether this clinical picture was due to calves being deprived of wallowing, which is allowed daily to adult animals as a routine practice. Suckling calves, 67 in number of varying ages, available at the time of the experiment were divided into two groups. Two thirds of the number are allowed to wallow daily for 2 to 3 hr from 10 a.m. to 1 p.m., and the balance served as controls. There was an equitable distribution of calves with alopecia in both groups at the commencement of the experiment. The experiment lasted three months and during this period, thirty seven new born calves were also drawn into experiment. Every alternate calf born was allocated to the group allowed to wallow. Calves in both groups were subjected to study of the following parameters: body temperature, respiratory rate, body weight gain, incidence or persistence of alopecia and mortality.

The body temperature and respiratory rate were higher in the group deprived wallowing compared to those allowed wallowing. Body weight gains were lower in the group not allowed to wallow. This group recorded a higher percentage of mortality during the experimental period and shortly afterwards. In most of the calves that were allowed to wallow, alopecia disappeared within 3 weeks and the calves which were allowed to wallow from birth did not develop alopecia. The experiment provided conclusive evidence that alopecia, chronic emaciation and death were due to deprivation of wallowing.

N-18 OKADA, M., OZAWA, S., THANGARAJA, P. and GAMINI, S.L. **Comparison of meat productivity of cattle and buffaloes at two levels of nutrition.** *Ceylon Veterinary Journal* (1978) **26,** 52 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Live weight gains and carcass characteristics were compared between Murrah Buffalo, Red Sindhi, Sinhala Ayrshire, and Friesian steers, fed at two planes of nutrition. The average body weights at slaughter ranged from 130.9 kg to 181.3 kg: Murrah was the heaviest and local Sinhala cattle, the lightest. Daily body weight gains ranged from 0.17 to 0.24 kg. Murrah and Sindhi showed higher daily body weight gains than the other breeds. The dressing percentages and muscle to bone ratios of Sindhi and Sinhala cattle were higher than those of Murrah, Ayrshire and Jersey. The two former breeds, therefore, showed promise as meat breeds. Animals on a higher plane of nutrition were heavier at slaughter, had higher daily weight gains, dressing percentages and muscle to bone ratios than those on a lower plane of nutrition. These results indicate that a high plane of nutrition is desirable for meat production. The cost of concentrate feeds, however, need to be taken into consideration.

N-19 PATHIRANA, K.K. and SIRIWARDENE, J.A. de S. **Fertiliser nitrogen and seasonal effects on pasture and buffalo calf production in the dry zone.** *Ceylon Veterinary Journal* (1979) **27,** 31 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Buffalo heifers; 15.7 ± 3.1 months old, weighing 279.4 ± 21.8 lb. were continuously grazed on *Brachiaria mutica* pasture for one year using a split plot in time in a randomised complete block design with two replicates. Groups of animals were assigned to each of 3.5 ac. paddocks, fertilised with the following treatments (25, 50 or 100 lb. N/ac/yr applied as one application or in four equal parts in each of the four seasons), four 'testers' animals per paddock remained through the entire period of experimentation and the 'put and take system' of grazers was adopted depending on pasture availability. No concentrates were fed, but water and minerals were available *ad libitum*.

The parameters studied were: average daily gain (ADG), grazing days/ac., live weight gain

(LWG)/ac, stocking rate/ac, the dry matter production (DMP) and the proximate composition of pasture. Only the DMP (lb/ac/yr) was significantly ($P<0.01$) affected due to N levels; being higher at 100 N (11,889 lb) than at 25 N (7,662 lb) or 50 N (8,895 lb). Seasons affected ($P<0.01$) all parameters. The October - January season produced the highest ($P<01$) response. LWG during the four consecutive seasons were 90.0 ± 8.7 SEM; 61.8 ± 4.6; 73.7 ± 7.5 and 148.6 ± 7.9 lb/ac and with 25, 50 and 100 N were 228.2 ± 146.7; 210.7 ± 111.4 and 243.3 ± 142.1 lb./ac/yr respectively. The response to N levels were similar ($P<0.5$) between seasons for all parameters. It was concluded that under the conditions that prevailed during the experimental period the seasonal effect was more important than the increase in N fertiliser levels for pasture and animal production.

N-20 PATHIRANA, K.K. and SIRIWARDENE, J.A. de S. **Seasonal and fertiliser nitrogen effects on the utilisation of *Brachiaria mutica* pastures by buffalo calves in the dry zone of Sri Lanka.** In: *Proceedings of Workshop on Water Buffalo Research in Sri Lanka, 24-28 November 1980, Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC 1982. pp. 78-82. Veterinary Research Institute, Peradeniya, SL.

Buffalo heifers of mean age 16 ± 3 months (x ± SD) and weighing 127 ± 10 kg were continuously grazed on *Brachiaria mutica* pasture for one year in the dry zone of Sri Lanka. The experimental design was a split-plot in time in a randomised complete block with two replicates. Six paddocks, each 1.42 ha in extent were used. The main treatment of N fertiliser applications (26, 52 or 112 kg N/ha/year and the sub-units or the season or the quarters of the year as subunits). The stocking rates were adjusted depending on the availability of pasture, using the "put and take system" of "grazers", while four "testers" per paddock remained throughout the experimental period. Except for water and minerals given *ad libitum*, no feed supplements were offered.

Seasons effected ($P<0.01$) all parameters studied. The seasons in a descending order of precipitation (mm) were: October to January, 1049; January to April, 170; April to July, 107 and July to October 104. The ranking tended to be the same when arranged in descending order, of the seasonal dry matter production of grass (7207, 2658, 409, 347 kg/ha), percentage crude fibre (32.7, 32.2, 29.6, 24.7), percentage weeds (39, 19, 15, 19), grazing days (489, 413, 385, 390) and liveweight gain (166.5, 101.8, 69.2, -82.6 kg/ha or 0.34, 0.25, 0.18, -0.21 kg/head/day) respectively. The effect of application ($P<0.01$) of 26, 52 or 112 kg N/ha year was only on the total dry matter production per year which was 8580, 9963, or 13316 kg/ha/year respectively. The same treatments gave the following results in term of annual percentages: crude protein, 8.0, 8.4, 9.5; crude fibre, 30.1, 30.5, 28.9; weeds, 29, 26, 14, and also animal grazing days, 1621, 1650, 1768 per ha; live weight gains, 255.6, 235.9, 273.5 kg/ha/day or 0.14, 0.13, 0.15 kg/head/day and stocking rates of 4.5, 4.5, 4.9 respectively.

Irrespective of treatment, the sub-optimal weight gains together with a significant ($P<0.01$) decline in dry matter production and live weight gain with decreasing rainfall emphasises the need for supplementary feeding and/or irrigation of pasture, at least to prevent weight loss as the dry spell advances. It is concluded that the adoption of seasonal feeding and management practices rather than the application of higher levels of fertiliser N would help to improve buffalo calf production on grazed pasture.

N-21 PATHIRANA, K.K. and WICKRAMATILAKE, N. **A rice straw and urea based ration for milk production.** *Sri Lanka Veterinary Journal* (1982) **30,** 33 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

A cheap ration to sustain locally acceptable levels of milk production, with minimum dependence on forages, was tested during a period of drought. Using a simple change-over design, milking Murrah buffaloes (409 ± 45 kg) were fed on fresh forage during first two months of the dry season (period one) and fed on unprocessed rice straw, during two months of advanced drought period (period two). Feed supplements provided/head/day during period one were: 2 kg compounded concentrates and during period two 2 kg rice bran, 1 kg *fresh Brachiaria brizantha* grass and 0.5 kg fresh Ipil-Ipil leaves. Rice straw sprinkled with urea solution containing 18g urea in 1 litre of water per kg of rice straw, and 50g of a complete mineral mixture were offered *ad libitum* during both periods. During periods one and two (X ± S.E.M.) milk yields and composition of fat and SNF were 3.7 ± 0.2 *vs* 3.4 ± 0.1 l/head/day, 7.4 ± 0.1 *vs* 7.5 ± 0.1% and 9.3 ± 0.1 vs 9.1 ± 0.1% respectively while the average live weight changes were -105 ± 135 *vs* -115 ± 120 g/head/day. There was no difference ($P>0.05$) between periods in each of the parameters. The straw intake was 10.2 ± 0.5 kg/head/day, or in terms of dry matter, 2.30 ± 0.02% of live weight, equivalent to 80% total of dry matter in the ration. The estimated urea intake was 184 ± 9 g/head/day, which was 47% of the total ration protein. The cost of total non-forage supplements/head/day during period two was half that in period one. The test ration appeared to be a feasible substitute for the conventional feeding

practices under drought situations, at least during short periods when forage availability is minimal.

N-22 PEIRIS, H. and PERERA, A. **Study of the grazing behaviour and forage utilisation of free range buffalo herds.** In: *The Role of the Buffalo in Rural Development Asia* [Edited by Perera B.M.A.O. *et al.*] Colombo, Sri Lanka. NARESA Press. 1996 pp. 273-279. Veterinary Research Institute, Peradeniya, SL.

A study was conducted to investigate the grazing behaviour of free range buffalo herds in relation to the forage quality. Four experiments were conducted under field conditions using twenty four buffaloes, covering both dry and wet seasons of the year. Their behaviour in relation to the forage quality was monitored over a twenty four hour period in each study. Results revealed that animals grazing natural forages under coconut spent significantly (P£ 0.01) more time on grazing, selecting feed and ruminating, when compared with those grazing *B. milliformis* pasture, which had a comparatively higher nutritive value than the natural herbage. Regression analyses indicated that there was a high correlation between the grazing time and the nitrogen content of forages (r=0.96) and also between the resting time of the animals and the lignin content of the forage (r=0.92).

N-23 PERERA, A.N.F. **How buffaloes utilise fibrous feed.** In: *Water Buffalo - Improved Utilisation Through New Technologies.* [Edited by Subasinghe, D.H.A. *et al.*] Colombo, Sri Lanka, National Science Foundation press. 1998. pp 60-66. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The paper describes the anatomy of the digestive system of the buffalo, the rumen environment and the process of digestion of feed in the rumen. Particular reference is made to the microbial fermentation of structural carbohydrates to volatile fatty acids which are utilised by rumen microbes as energy sources and the utilisation of non-protein nitrogen for the synthesis of microbial protein.

N-24 PERERA, A.N.F. and PERERA, E.R.K. **Effect of different nitrogen sources on dry matter intake rumen kinetics, rumen and blood parameters of buffaloes fed rice straw-based diets.** In: *Proceedings of the 2nd Asian Buffalo Association Congress, 9-12 October, 1996. Manila, Philippines.* pp 484-491. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

This study was conducted to evaluate the effect of different dietary nitrogen (N) sources on rice straw utilisation by buffaloes. The sources of dietary nitrogen used were; Gliricidia spp., 2% urea-supplemented rice straw (USRS), coconut oil meal (COM) and urea molasses mineral block (UMMB) with or without fish meal or flavomycin. Four ruminally cannulated male buffaloes were used. Rice straw was used as the basal diet. Total dry matter intake (DMI), dry matter degradation in the rumen, and rumen and blood parameters were measured during the study period with each source of dietary nitrogen. Dry matter intake ranged from 0.027 to 0.020 kg/kg BW (mean: 0.022 ± 0.002). The intake as a percent body weight above was 2.0% for all dietary nitrogen sources (mean: 2.3 ± 0.24). Rumen pH were at neutral levels and rumen ammonia nitrogen (ammonia-N) ranged from 13.1 to 17.6 mg/100 ml (mean: 15.4 ± 2.23). In rumen degradation characteristics of dry matter, readily soluble fraction (a), was similar irrespective of the source of nitrogen, but the highest potentially degradable fraction (b) was highest when gliricidia was used as a N source (71.0%).

N-25 PERERA, A.N.F. and PERERA, E.R.K. **Composition of natural herbage and improvement of quality of some alternate feed sources for buffalo feeding.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by Perera B.M.A.O. *et al.*]. Colombo Sri Lanka. NARESA Press. 1996. pp. 227-237. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The total buffalo population in Sri Lanka is 0.85 million, and more than 75% of the population is reared under free grazing conditions in grazing lands under natural pasture or on other herbage. An experiment was conducted to evaluate the botanical composition and feeding value of natural forages. A series of experiments were conducted to evaluate the methods available to upgrade the feeding value of crop residues when fed to buffaloes as a supplementary feed. In natural forages, the highest grass component (72%) was observed in roadside forage and the highest legume component in forage from scrub jungles (30%). Crude protein (CP) ranged from 8-16% and the *in vitro* dry matter digestibility (IVDMD) was 45-64%. Rice straw was ensiled with biogas slurry liquid (BSL) up to 14 days and CP improved from 4 to 7% and IVDMD and *in vitro* organic matter digestibility (IVOMD) from 29 to 41% and 25 to 39% respectively. The effect of different levels of urea treatment (0-6% urea) and ensiling duration (0-21 days) on bagasse were evaluated. Urea treatment improved CP from 1% to 9% and IVDMD and IVOMD from 29 to 34% and 28 to 33% respectively. Duration of ensiling had no effect. Treatment of palm press fibre (PPF) with urea (0-8%) was studied. The IVDMD and IVOMD of PPF were improved from 22 to 32% and 17-24% respectively. Urea treated PPF had a higher CP content (33% *vs* 5%) due to urea nitrogen. These

results suggest the possibility of using different treatments on available crop residues to improve their utilisation as supplementary feeds in buffalo production.

N-26 PERERA, A.N.F., SIRIWARDENE. J.A. de S. and ABEYGUNAWARDANA, H. **Fibrous feeds and their utilisation.** SAREC/NARESA Buffalo Research and Development Programme, Information leaflet No. 1 Publication No. 5. Colombo SL, NARESA Press (1998). 7 pp. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The publication is a farmers guide to utilisation of fibrous feeds in buffalo and cattle feeding. It gives a brief description of the seasonal availability and the use of fibrous crop residues, as a means of overcoming the shortfall of forage feed during dry seasons. The composition of some of the fibrous feeds available in the country and methods to overcome the limitation in the use of these materials are presented. Special emphasis is given to supplementation of feed by the use of urea, urea-molasses-mineral multinutrient mixtures and concentrates to improve the utilisation of diets which contain fibrous crop residues.

N-27 PERERA, B.M.A.O. **Health aspects of feeding (UN)treated straw.** In: *Proceedings of International Workshop on Rice Straw and Related Feeds in Ruminant Rations, 24-28 March 1986, Kandy, Sri Lanka.* pp. 350-355. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

In Sri Lanka, many small farmers use straw as feed for cattle and buffaloes, particularly during periods of drought when fresh fodder is scarce. Feeding untreated (US) or treated straw (TS) to ruminants is a relatively safe and acceptable procedure, provided a few simple precautions are taken to prevent undesirable or injurious effects on the health of animals. Adverse effects could occur due to factors associated with urea and straw separately, or in combination. Straw is deficient in many minerals and carotene (vitamin A), which may be manifested clinically and therefore require supplementation with an appropriate mineral mixture and some green fodder. Although health hazards could occur due to mycotoxins produced by moulds and through residues of agrochemicals used during the growing period of the rice plant, these do not appear to be major problems in practice.

Urea is highly toxic if ingested in large doses over a short period of time. Clinical signs develop rapidly and the condition could terminate in tetany and death. Treatment can be attempted with acetic acid or household vinegar given orally, but is often too late and unsuccessful. A long term effect of urea feeding could be mild hypomagnesaemia due to impaired absorption of magnesium. It is concluded that feeding US or TS, if adequately controlled and judiciously supplemented, can be a useful method of providing nutrients when fresh grass and fodder are scarce.

N-28 PERERA, E.R.K., KULASEKARA, R. and PERERA, A.N.F. **Diurnal variation in thermo-regulatory responses in water buffalo and cattle.** In: *Proceedings of the 49th Annual Session of the Sri Lanka Association for the Advancement of Science 6-7 December. (1993)* pp. 55. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The study examined the diurnal variation in thermoregulatory responses of water buffaloes and cattle. Three Surti buffalo heifers and 3 Friesian heifers of similar age (2.5 ± 0.5 years) and body weight (342.5 ± 18.2 kg) were used. Both groups of animals were housed indoors and managed under identical conditions. Data on skin temperature (ST), rectal temperature (RT), respiration rate (RR), heart rate (HR), and cutaneous evaporation rate (CER) were obtained from individual animals at hourly intervals during 24 h periods (n=10). Data on ambient temperature (AT) and relative humidity (RH) were recorded simultaneously. Ambient temperature and RH fluctuated from 71 to 90°F and 60 to 88%, respectively. Buffaloes had a lower (p£0.05) mean ST (89.0 *vs* 93.7°F), RT (100.7° *vs* 101.5°F), RR (19.2 *vs* 29.6 breaths/min.), HR (52 *vs* 74 beats/min.) and CER (0.15 *vs* 0.17 g/cm/h) compared to cattle. All the physiological parameters exhibited diurnal fluctuations associated with AT. Skin temperature of buffalo increased linearly with the elevation of AT (71 to 90°F), while ST of cattle increased in a curvilinear manner. Respiration rate and HR of both species increased (p£0.05) linearly with the elevation of AT, but at different magnitudes. Rectal temperature of cattle increased in a curvilinear manner with increasing AT, while RT of buffaloes increased more rapidly to reach 101.5°F and ambient temperature of 80°F. These results indicate that conditions even in open houses can be stressful to Friesian and Surti buffaloes, when the day temperature exceeds 80°F.

N-29 PERERA, E.R.K., MAITHRIPALA, K.G.R.P. and PERERA, A.N.F. **Physiological responses to different sprinkler treatments in water buffalo *(Bubalus bubalis).*** In: *Proceedings of the 49th Annual Session of the Sri Lanka Association for the Advancement of Science.6 -7 December, 1993* pp. 54. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL

This study examined the effect of different sprinkler treatments on thermoregulatory responses of the water buffalo. Six different sprinkler

treatments, using combinations of 30, 60 and 90 sec. unit wetting periods and 3 or 6 repeated wetting cycles were applied to 3 buffalo heifers, while 3 other heifers of similar age (1.60 ± 0.06 year) and body weight (121.20 ± 4.90 kg) were used as controls. Data on skin temperature (ST), respiration rate (RR), heart rate (HR) and the rectal temperature (RT) were obtained from all the animals simultaneously at -10.0, +15 +30, +45 and +60 min after each sprinkler treatment. Treatments were repeated for 5 alternate days and ambient temperatures were recorded at the same time intervals during the study periods. Skin temperature was reduced (p£0.01) in response to all 6 treatments. Three repeated cycles of 30 or 60 sec. did not influence RR or HR. However, 6 repeated cycles of the above wetting periods, and both 3 and 6 repeated cycles of 90 sec. sprinkling reduced (P£0.01) RR and HR. Following withdrawal of sprinkling, ST, RR and HR increased (p£ 0.01) with time. The results suggest that, 3 or 6 repeated cycles of 90 sec. wetting periods were more effective in cooling animals than 3 repeated cycles of 30 or 60 sec. wetting durations.

N-30 PERERA, E.R.K. and PERERA, A.N.F. **Effect of different sprinkler treatments on thermoregulatory responses in water buffalo.** In: *Proceedings of the Annual Research Sessions of the Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, 3, December 1994, Peradeniya, SL.* pp. 21. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

A study was conducted to examine the changes in thermoregulatory responses in water buffaloes following application of different sprinkler treatments. Six different sprinkler treatments using combinations of 30, 60 and 90 sec. unit sprinkling durations and 3 or 6 repeated sprinkling cycles were applied to 3 buffalo heifers, while 3 other heifers of similar age (1.7 ± 0.06 years) and body weight (125.0 ± 5.0 Kg) were used as controls. Data on skin temperature (ST), respiration rate (RR), heart rate (HR) and rectal temperature (RT) were obtained from all the animals simultaneously at -10, 0, +15, +30, +45 and +60 minutes of application and withdrawal of each sprinkler treatment. Ambient temperature was recorded at the same time intervals. Treatments were repeated for 5 days. Mean ambient temperature during the study period was 82.4 ± 1.6° F. The skin temperature declined (P£0.05) in response to all 6 treatments. Three repeated cycles of 30 or 60 sec. sprinklings were not effective in reducing HR, RR or RT significantly. However, 6 repeated cycles of 30 and 60 sec. sprinklings and both 3 and 6 repeated cycles of 90 sec. sprinklings reduced (P£0.05) HR, RR, and RT. Following withdrawal of the sprinkler treatment, ST, RR, HR and RT increased with time to reach the pre-sprinkling values at different rates. The results suggest that of the tested sprinkling treatments, 3 or 6 repeated cycles of 90 sec. sprinkling durations were most effective in cooling the buffalo.

N-31 PERERA, E.R.K. and PERERA, A.N.F. **Effectiveness of different cooling treatments in alleviating heat load in water buffalo (*Bubalus bubalis*): A suitable cooling method.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka. NARESA Press, 1996. pp. 183-193. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

An experiment was conducted to determine a suitable duration and frequency of cooling treatments that would effectively alleviate the heat load in water buffaloes. Thermoregulatory responses of buffaloes to the application of the following eight different cooling treatments were compared with no cooling (control), using a minimum of 3 heifers/treatment. Covering with wet gunny bags (T_1), six sprinkler applications (T_2 - T_7) using different combinations of 30, 60 or 90 sec (unit) durations and 3 or 6 repeated sprinkling cycles and 540 sec. continuous sprinkling (T_8). Among the treatment groups, the heifers were balanced by age (2.0 ± 0.6 yr) and body weight (155.5 ± 10.0 kg). Data on skin temperature (ST), respiration rate (RR), heart rate (HR) and rectal temperature (RT) were obtained from all animals at - 10,+15,+30,+45 and +60 min of application and withdrawal of each treatment. Data on the ambient temperature and relative humidity were recorded at the same time intervals. Each treatment was repeated on 5 days. The temperature humidity index (THI) remained ^{3} 81 during all treatments. Skin temperature was reduced (p£ 0.05) in response to all sprinkler treatments. Increasing the frequency and duration of sprinkling increased the effectiveness of cooling. Three repeated cycles of 30 or 60 sec sprinkling were not effective in lowering HR, RR, or RT significantly. However, 6 repeated cycles of 60 and 90 sec sprinkling and 540 sec, continuous sprinkling decreased (p£ 0.05) HR and RR. Rectal temperature was reduced (p £ 0.05) by 6 repeated cycles of 90 sec, sprinkling and 540 sec sprinkling only. Following the withdrawal of the cooling treatments, ST, RR, HR and RT increased over time at different rates to reach the pre-cooling values. Hourly application of either 6 repeated cycles of 90 sec, sprinkling or 540 sec continuous sprinkling is recommended for effective dissipation of heat and reduction of the heat load in buffalo, at ambient temperature humidity index conditions ^{3} 81 THI.

N-32 PERERA, E.R.K. and PERERA, A.N.F. **Changes in growth, rumen characteristics and blood metabolites of indigenous buffalo heifers in response to supplementary feeding of urea-treated *versus* untreated rice straw.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by B.M.A.O. Perera *et al.*] Colombo, Sri Lanka. NARESA Press. 1996. pp. 251-259. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

An experiment was conducted to examine the changes in feed intake, rumen parameters, blood metabolites and body weight gain of indigenous buffalo heifers, in response to supplementary feeding of urea treated *versus* untreated rice straw. Twelve indigenous buffalo heifers were allotted to two groups (n=6/group) balanced by body weight (89.0 ± 8.9 kg) and age (12.0 ± 0.5 months). During day time, all the heifers were offered "Guinea A" grass (*Panicum maximum*) *ad libitum*. At night, 4% urea-treated straw and untreated straw were offered to the treatment group and the control group, respectively. The group feed intakes of Guinea grass and straw were recorded monthly. Rumen samples were obtained every 4th week to determine rumen pH and rumen ammonia-N (NH_3-N). Blood urea nitrogen (BUN) and beta hydroxybutyrate (BHB) were determined on the blood samples obtained on the same day. Urea treatment improved (p£ 0.01) crude protein content of rice straw. The heifers in the treatment group had greater intake of straw dry matter (P£0.01), total dry matter (P£0.01), dietary nitrogen, (P£0.01) and dietary energy (P£0.01) compared to the control group. Rumen ammonia content was higher (P£0.05) in animals in the treatment group. Rumen pH, circulating BHB and BUN were not different between the groups. But trends in rumen NH_3-N and BUN of the two groups suggested better utilisation of available dietary protein by the treatment group, which resulted in higher (P£0.05) body weight gain compared to the control group. The results suggest that supplementary feeding of urea-treated straw instead of untreated straw improved the intake of feed, protein nutrition and also nitrogen utilisation and growth performance in local buffalo heifers.

N-33 PERERA, E.R.K. and PERERA, A.N.F **Effect of intermittent sprinkling on physiological parameters, feed intake, body weight and milk yield of water buffalo *(Bubalus bubalis)*** In: *Proceedings of the 2nd Asian Buffalo Association Congress, 9-12 October 1996, Manila, Philippines.* pp. 473-483. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

A study was conducted to examine the response of physiological parameters; supplementary feed intake, body weight and milk yield of buffalo cows maintained under grazing management in the dry zone climatic conditions of Sri Lanka, to intermittent sprinkler cooling. Ten (10) Surti x Indigenous crossbred buffalo cows were divided into two groups balanced by body weight (245.8±22.8 kg), lactation number (1), length of lactation (88.9±13.2 d) and milk yield (0.7±0.2 l/d). All the management conditions were maintained identical between the two groups except for the treatments. One group (n=5) was sprinkled with water for 10 min at 1.5 hour intervals between 900 and 1700hr daily. The other group (n=5) served as the control. Animals of both groups were offered straw at 1800hr daily. Data on respiration rate (RR), heart rate (HR) and rectal temperature (RT) were obtained from individual animals at - 15, 0, 15, 30, 45, 60 and 75 minutes post sprinkler application at every three weeks. Hourly ambient temperature (AT) and relative humidity (RH) during the experimental period were recorded. Body weight (BW) of the cows and calves were measured once every three weeks. Individual straw intake and milk yield were measured daily. Composition of straw and milk were analysed.

Mean day time AT (32.1±2.8°C) and RH (65.2±11.9%) resulted in a mean temperature humidity index (THI) of 83.5±2.6. Sprinkling of water significantly ($P<0.05$) lowered day time RR, HR and RT by 6.1±0.4 breaths/min, 6.5±0.5 beats/min and 1.1±0.7°C, respectively. Straw dry matter intake increased ($P<0.05$) by 10% (0.12 kg/100 kg BW) in response to sprinkler cooling. Sprinkler treated cows experienced less ($P<0.05$) reduction in body weight (-13kg *vs* - 50kg; $P<0.05$), while their calves gained more (50.1 *vs* 40.4 kg; $P<0.05$) weight. Milk yield and persistency of lactation improved ($P<0.05$) in response to sprinkling. Milk composition was not altered significantly.

The results suggest that intermittent sprinkling of water for 10 minutes every 1.5 hours during day time is effective in dissipating thermal load, alleviating heat stress, improving supplementary feed intake, lowering body weight loss and improving milk yield of lactating buffalo cows kept under grazing management conditions system in the dry zone (THI>83) of Sri Lanka.

N-34 PREMARATNE, SUJATHA **Effect of non-protein nitrogen, by-pass protein and fodder legumes on intake, digestibility and growth parameters of buffaloes fed urea treated rice straw.** In: *Proceedings of Second Research Co-ordination Meeting on the Use of Nuclear Techniques to Improve Domestic Buffalo Production*

in Asia. 24-28 August, 1987. Penang, Malaysia. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The role of supplementation of feed with tree legumes on rumen function has been studied. Four rumen fistulated buffaloes averaging 200kg were used. The buffaloes were allotted at random to diets (4x4 Latin Square Design) (a) *Ad lib.* straw (plus 2% urea), Erythrina leaves equivalent to 15% of straw dry matter and mineral mixture, (b) *Ad lib.* straw (plus 2% urea) and mineral mixture, (c) *Ad lib.* urea ensiled straw (4% urea), Erythrina leaves equal to 15% of straw dry matter and mineral mixture, (d) *Ad lib.* urea ensiled straw (4% urea) and mineral mixture

A 10-day transition period was followed by a 45-d preliminary period and a 10-day collection period during which faeces, feed and refusals were collected, weighed and sub-sampled for dry matter determination and chemical analysis. Rumen fluid was collected for the determination of ammonia nitrogen. In conjunction with digestibility studies, dry matter and nitrogen disappearance of substrates: Erythrina, untreated straw and treated straw were evaluated using nylon bags with mesh size of 40 microns. The results showed that dry matter digestibility was markedly increased by the application of urea. Inclusion of tree fodder legumes in the diet increased the *in vivo* dry matter digestibility of either straw or treated straw. However, the increment was much higher for untreated straw compared to treated straw.

N-35 PREMARATNE, SUJATHA **Effect of non-protein nitrogen and fodder legumes on the intake, digestibility and growth parameters of buffaloes.** In: *Domestic Buffalo Production in Asia.* International Atomic Energy Agency, IAEA/RC/325,3/4 Vienna. 1990 pp. 53-61. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Rice straw has become a major source of roughage for cattle and buffalo in Sri Lanka. Most often, rice straw is supplemented with concentrates such as coconut meal and rice bran, as straw alone may support only maintenance. Due to the high cost of concentrates, the use of rice straw in roughage based diets is limited. The objectives of the study was (i) to measure the by-pass nature of protein of some tree fodder legumes when fed with rice straw (ii) to measure the effect of supplementation with tree fodder legumes on rumen function in buffaloes and (iii) to study the effect of feeding tree legumes on weight gain in buffalo calves. Four rumen fistulated male buffaloes were used in the study. Straw dry matter (DM) intake and digestibility were increased by urea treatment compared with urea supplementation. Inclusion of legume tree leaves in the diet increased *in vivo* DM digestibility of both untreated straw and treated straw.

Supplementation of legumes also increased the *in vivo* nitrogen (N) digestibility of the diet of buffaloes. A trend towards an increase in straw intake with legume supplementation was also observed. Of the tree fodder legumes tested, *Erythrina lithosperma* had the highest potential for providing protein. Inclusion of legumes in the diet increased the DM and N degradation rates of feedstuff. In a growth trial with grazing female buffalo calves, the inclusion of fodder legumes increased weight gain.

N-36 PREMARATNE, S. and SIVARAM, A. **Development of systems of supplementary feeding for buffaloes in Sri Lanka.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by Perera B.M.A.O. *et al.*] Colombo, Sri Lanka. NARESA Press. 1996. pp. 219-225. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Improving the productivity of the domestic buffalo is an urgent necessity for the Sri Lankan economy. Productivity of these animals mainly depend on the availability of quality feed throughout the year. Therefore, the objective of this study was to develop systems of supplementary feeding for buffaloes in Sri Lanka.

Experiments were conducted with four rumen fistulated male buffaloes to study the intake, digestibility and growth response of buffaloes fed rice *(Oryza sativa)* straw, supplemented with non-protein nitrogen and energy. Treatments consisted of 2% of urea supplemented straw or plain straw with or without Jak *(Artocarpus heterophyllous)* seeds. Feed offered, refused and faeces excreted were measured and the dry matter intake and digestibility were calculated. Urine was collected to measure the nitrogen balance in animals. Animals were weighed before and after the experiment. The effect of these treatments on volatile fatty acid production, rumen ammonia and pH were also measured. Experiments were also conducted to study the effect of different fodders on dry matter intake of straw by milking buffaloes. Dry matter intake of urea supplemented straw with Jak seeds was higher compared to that with plain straw (102 *vs* 87 g/kg $w^{0.75}$), whereas dry matter digestibility of plain straw with jak needs was higher compared to plain straw (56% *vs* 48%). Inclusion of Jak seeds improved weight gain in buffaloes. Inclusion of fodders increased the straw dry matter intake by milking animals and the effect was prominent with glyricidia. In conclusion, it is evident that supplementation of straw based diets with urea and glyricidia improved the intake, digestibility and growth of buffaloes.

N-37 RAJARATNE, A.A.J. and RANAWANA, S.S.E. **Effects of the season on the mineral concentration in cattle and buffaloes.** *Sri Lanka Veterinary Journal* (1982) **30,** 34, [Abstract]. Veterinary Research Institute, Peradeniya, SL.

An experiment was carried out to determine the differences in plasma concentrations of minerals in cattle and buffaloes. Since rainfall is known to effect the availability of minerals both to plants and animals, this study was carried out both during the dry period and during the South-west monsoon. Five each of *Bos taurus*, *Bos indices* and Murrah buffaloes were grazed on *Brachiaria brizantha* pasture during both periods. Blood samples were obtained three times from each animal during each season. Plasma was analysed for Ca, Mg, Fe. Cu, Zn and cyanocobalamin. During the dry period, plasma levels of Mg and cyanocobalamin were higher in buffaloes than in cattle. During the monsoon period, higher levels of Ca, Mg and cyanocobalamin and lower levels of Cu were seen in buffaloes. Levels of Mg, Cu and cyanocobalamin were lower in buffaloes during the monsoon period when compared those during the dry period. In cattle, plasma levels of Ca, Cu and cyanocobalamin were lower during the monsoon season. During the monsoon, subnormal levels of plasma Ca and Mg were observed in zebu and temperate cattle respectively. These results indicate that there are differences in the plasma levels of minerals between buffaloes and cattle even when they are similarly managed. Supplementation of feed with Ca, Mg and Co appears to be necessary particularly in the wet season. Further studies need to be carried out to elucidate the reasons for these differences.

N-38 RAJARATNE, A.A.J. and RANAWANA, S.S.E. **Physiological responses of Lankan buffaloes to stress at work.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera B.M.A.O. *et al.*] Colombo, Sri Lanka. NARESA Press, 1996 pp. 175-182. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

A series of experiments were carried out to investigate the degree of stress that buffaloes undergo during performance of different types of work in the field. Physiological parameters such as heart rate, respiration rate and rectal temperature were measured in Lankan buffaloes engaged in threshing paddy, ploughing muddy fields and ploughing dry lands before and at 30 minutes intervals of working. Mean rectal temperature increased from 38.1^{0}C to 39.2^{0}C, mean respiration rate from 21 to 45 per minute and mean pulse rate from 63.3 to 84.5 per minutes during a 1.5 h period of ploughing muddy fields. Mean rectal temperature increased from 37.4^0 C to 39.7^0 C, mean respiration rate from 20.3 to 75.5 per minute and mean pulse rate from 66.5 to 82 per minute, when animals ploughed dry land for a period of 1.5 h. When the animals were used for threshing paddy for a period of 2 hrs, mean rectal temperature from 38.5°C to 40.5°C, mean respiration rate from 34.5 to 112 per minute and mean pulse rate from 68.9 to 107.3 per minute. The results indicate that threshing paddy although not a very strenuous exercise, caused significantly higher stress in buffaloes compared to ploughing muddy fields. When water was poured on animals as a method of alleviating stress in working buffaloes, there was a significant reduction in the pulse rate and respiration rate but there was no significant effect on rectal temperature. The results point to heat stress as the main stress factor in working buffaloes but the work load itself does not seem to cause a significant effect. Therefore, it is important to separate these two effects when studies are conducted on stress in buffaloes at work.

N-39 RAJARATNE, A.A.J. and RANAWANA, S.S.E. **Physiological responses of Lankan buffaloes to dehydration.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera B.M.A.O. *et al.*] Colombo, Sri Lanka. NARESA Press, 1996. pp. 195 [Abstract]. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

Buffaloes are widely known to be shade and water loving animals. However, they also possess a remarkable ability to thrive under dry conditions. The main objective of this study was to investigate responses of buffaloes to dehydration. Water balance was studied in four, one year old female Sri Lankan buffaloes (mean body weight = 142.8 kg), by measuring water intake and water output. Total mean water intake, output and balance in the normal hydration was 21.8 l/day, 19.4 l/day and 2.32 l/day respectively. The figure for water balance (2.32 l/day) represents water loss by cutaneous and respiratory evaporation.

When the animals were dehydrated by withholding water until they lost 7% of their body weights, the urine output was 595 ml/day. This value could be considered as the obligatory urine volume for Lankan buffaloes. Faecal water output during dehydration was 1.2 l/day. These results show the ability of buffaloes to conserve water both by urinary and faecal routes as a response to dehydration.

N-40 RAJARATNA, A.A.J., RANAWANA, S.S.E., TILAKARATNE, N. and SRIKANDAKUMAR, A. **A study of the adaptability of cattle and buffalo to a hot humid environment.** *Ceylon Veterinary Journal* (1981) **29,** 29 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Five each of temperate, zebu and buffalo heifers were grazed (with access to water) from 06.00 to 18.00 h during the monsoonal (M), intermonsoonal (IM) and dry (D) periods at the Undugoda Livestock Farm. The grazing and watering behaviour were observed and measurements were made of the physiological indices of environmental stress, water content and daily water turnover. The maximum temperature (^{0}C) and the maximum RH (%) during the periods were M=26.8 and 74.6, IM=30.0 and 66.5 and D=33.8 and 41.2, respectively. All animals grazed continuously during the monsoon period, and from 06.00 to 09.00 h during other periods. The grazing time (as a percentage of available time) was 88.6, 66.7 and 76.8 for the M, IM and D periods, respectively. Overall grazing times were 74, 70 and 57% in the IM period and 71, 85 and 74% in the dry period for buffalo, zebu and temperate animals, respectively. Animals were inclined to go to water only during the hot seasons and that too only between 09.00 and 15.00 h. The percentage of the time spent in water was 3.2, 7.4 and 9.3 for zebu, temperate and buffalo breeds during the IM period. The corresponding figures for the dry season were 3.1, 4.3 and 4.0 respectively.

Measurements of rectal temperature and respiration rates, among others indicated that temperate animals were severely stressed under the prevailing conditions whilst the zebu breeds were the least effected. In general, the animals were more stressed by a combination of moderate temperature and high humidity (IM period) than during the dry period characterised by high temperature and low humidity. Water content and turnover were significantly less in the zebu when compared with the other two groups. In all animals, the water content and turnover tended to be lower during the dry period than during the other periods.

The results of the study indicated that the temperate breeds, despite their extravagant use of water, were unable to adapt satisfactorily to prevailing conditions. Buffalo and zebu animals were better adapted, but the latter used less water. These differences were also reflected in the gains in body solids during the period of the study.

N-41 RAJARATNE, A.A.J., RANAWANA, S.S.E., TILAKARATNE, N. and SRIKANDAKUMAR, A. **Comparative tolerance of hot - humid climatic conditions by three species. (*Bos taurus, Bos indicus* and *Bubalus bubalis*).** *Sri Lanka Veterinary Journal* (1983) **31,** 21-26. Veterinary Research Institute, Peradeniya, SL.

Four heifers (aged = 23 to 40 mo) each of temperate and zebu cattle and river - type buffaloes were used to compare the ability of the three species to tolerate hot and humid climatic conditions. Experimental animals were grazed in an open paddock of *Brachiaria brizantha* grass during the day and housed at night. Rectal and skin temperature, rate of respiration, pulse and cutaneous evaporation were measured in each animal at 0770, 1200 and 1500 h on a number of days during each of the seasons, wet (June - July), dry (February - March) and intermonsoonal (September -October).

Based on the magnitude of deviations from the respective basal (at 0770 h) heat reading of rectal, skin temperature, respiration and pulse rate, it was found that temperate cattle suffered the greatest from heat stress. Buffaloes were affected to a lesser extent while zebu cattle did not show any signs of heat stress. In general, the intermonsoonal season, the high air temperatures and humidity, conditions caused the most amount of stress in animals. Differences in susceptibility to climatic stress were reflected also in the growth rates of the three species. Zebu cattle showed uniform growth, buffaloes grew during the dry and the wet seasons but suffered a set back during the intermonsoonal period, while temperate cattle hardly recorded any increase in body weight during the nine - month period of study.

N-42 RANAWANA, S.S.E. **The nutritional status with respect to essential mineral elements of cattle and buffaloes in Sri Lanka.** In: *Proceedings of the Annual Session of the Sri Lanka Association for the Advancement of Science.* (1988) pp. 79-88. Veterinary Research Institute, Peradeniya, SL.

This paper records the results of a series of studies designed to determine the prevalence of deficiencies and imbalances of essential mineral elements in domestic ruminants. Chemical analysis of 59 grass samples from different areas and of 50 miscellaneous forages revealed that their content of Na, Cu, P and Zn were inadequate. Levels of calcium were marginal but K, Mg, Fe and Mn were adequate or even excessive. Area differences in mineral content were evident. A significant proportion of cattle at the Kandy abattoir had inadequate levels of Mg, Cu, Zn and Co. A survey of 223 cattle in small dairy farms in the mid country area showed that P and Na deficiencies were major problems among these animals. Significant numbers had low contents in Cu, Zn and Se. Indigenous buffaloes, surveyed at 10 locations mainly in the dry zone, were low in P, Cu and Zn while inadequacies of Ca and Se were also found. Two, year-long studies revealed that both in the wet and dry zones, the status with regard to several minerals varied considerably with season (rainfall). The results of these studies indicate that the nutritional status of ruminants with respect to Na, P, Cu, Zn, Co and Se was unsatisfactory, whereas Ca and often Mg were marginal. In contrast, K, Fe and Mn are adequate or

even excessive. There is good agreement between plant contents and the animal status for most minerals. It is also clear that there is considerable variation between seasons and regions.

N-43 RANAWANA, S.S.E., DHARMAWARDENE, J., ABEYSEKARA, A.W.A.S., RAJARATNE, A.A.J., GUNARATNE, G.D.J.K. and EKANAYAKE, E.M.C. **The nutritional status of indigenous buffaloes with respect to selected micronutrients.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera. B.M.A.O. *et al.*] Colombo, Sri Lanka. NARESA Press. 1996 pp. 281-282. Veterinary Research Institute, Peradeniya, SL.

An earlier survey of the mineral status of buffaloes on smallholdings in Sri Lanka based on analysis of blood taken during a single visit revealed inadequacies of several essential minerals. This investigation was designed to study these minerals in more depth. Ancillary information was also collected so as to relate the status of indices of production and health. Five locations representative of the main buffalo production systems, namely Rambukkana, Kuliyapitiya/Pannala, Mihintale, Tissamaharama and Thanamalwila were visited and up to 10 farms were selected from each area. From each herd, one cow and its calf were chosen for the study. The visits were planned to coincide with a major change in the annual calendar of buffalo management; for example, in Rambukkana, the visits were made just after paddy was planted, after harvest and just before the cultivation season so as to complete an annual cycle. Apart from taking blood samples, observations were made at intervals on other ancillary information, particularly in relation to feed availability. Altogether 33 field visits were made over a period of 24 months of which 18 were in dry seasons and 15 during wet season. Feed availability was found to be limited on 7 occasions but adequate at other times. A total of 365 blood samples were collected, of which 186 were from calves and the balance from cows. Most of the blood samples have been analysed for PCV, haemoglobin and the selenium enzyme, glutathione peroxidase.

N-44 RANAWANA, S.S.E., RAJARATNE, A.A.J. and EKANAYAKE, E.M.C. **Studies on the selenium status of ruminants in Sri Lanka.** *Sri Lanka Veterinary Journal* (1986) **34,** 72 [Abstract]. Veterinary Research Institute, Peradeniya, SL

Selenium and vitamin A are known to act together in preventing oxidative damage to tissues. Deficiencies of these nutrients have been associated with myopathies in young ruminants. Several conditions in adults that respond to selenium and vitamin A have also been described. At present, there is no information regarding the selenium status of soils, plants or animals in Sri Lanka. Several studies in which the selenium status of ruminants was assessed, by measuring the activity of the enzyme glutathione peroxidase in blood, are described in this paper. In a survey of 137 cattle in small-farm dairies in the Mid-country, 31.4% were found to have inadequate selenium; of these, 15.3% were marginally deficient. Differences between sampling areas were statistically significant but those between calves and adults were not. In a similar study of 161 buffaloes in private herds, chiefly in the dry-zone, 26% were low in selenium and of these, 9% were marginally deficient. Again, differences between age groups were not significant but those between areas were significant. In a separate study, no differences were evident between Lanka, Murrah and Surti buffaloes grazed together for 12 months. The selenium status was highest in the rainy season, lowest during the dry season but was in general, satisfactory. These results indicate that selenium inadequacy may pose a significant problem among ruminants in Sri Lanka and that the severity can vary with season and location. Direct measurements of the selenium contents in soils, plants and in blood are needed in order to define the problem more clearly.

N-45 RANAWANA, S.S.E., RAJARATNA, A.A.J., GUNARATNE, K.J. and EKANAYAKE, E.M.C. **A study of the mineral nutritional status of indigenous Sri Lanka buffaloes** In: *Proceedings of the 4th Australasian Association of Animal Production Congress, Hamilton, New Zealand.* 1987 pp. 184-185. Veterinary Research Institute, Peradeniya, SL.

This paper records the results of a study in which 265 buffaloes owned by rice farmers were surveyed to determine the mineral status, which was assessed by analysis of the levels in blood. At 11 locations, 265 animals from 33 herds which included 173 adults, 43 juveniles and 46 calves, were sampled. Blood drawn into heparinised tubes, were analysed immediately for the enzyme glutathione peroxidase; blood selenium was estimated from enzyme activity. Plasma was separated and analysed later for Ca, Mg, Cu, Zn and Fe by atomic absorption spectrometry and inorganic P by colorimetry. Values obtained were compared with published norms for cattle. Differences between age groups and sampling sites were examined statistically. The results indicate that the status of these animals with regard to P, Cu and Zn was unsatisfactory. In contrast, most animals had inadequate levels of Mg and Fe. The results also indicate that the inadequacy of Se can be significant. The proportion of adults with subnormal values for P, Cu and Zn were greater than in calves. These findings could reflect physiological variations with age of these minerals. Values for Mg were higher in

adults but there was no age difference in contents of other mineral elements. Differences in the status of P, Se and Cu were significant for buffaloes from different locations and may reflect variations in soil and forage mineral concentration between regions. In the mid country area of Sri Lanka, dairy cattle showed the same range of mineral inadequacies but buffaloes in the present study were less affected. Neither of these studies examined the status of I or Co. Based on the findings of this study, it may be concluded that inadequacies and even clinical deficiencies of minerals may be common among the indigenous buffalo population in Sri Lanka.

N-46 RANAWANA, S.S.E., RAJARATNE, A.A.J., GUNARATNE, K.J. and EKANAYAKE, E.M.C. **Some blood values of the indigenous Sri Lanka buffalo.** In: *Proceedings of the Symposium on Buffalo Genotypes for Small Farms in Asia. 15-19 May, 1989, Kuala Lumpur, Malaysia.* pp. 219-223. Veterinary Research Institute, Peradeniya, SL.

Blood samples drawn from 338 indigenous buffaloes of all ages owned by paddy farmers in different parts of Sri Lanka were analysed for the following constituents; haemoglobin, haematocrit, erythrocytes, plasma proteins, Ca, Mg, P, Na, K, Cu, Zn and Fe. The range of values obtained for these parameters are presented in this paper as a contribution towards the establishment of norms for this breed in particular and for buffaloes in general. Values for haemoglobin, haematocrit and plasma protein obtained in this study were generally higher than those reported as normal values for cattle. Buffaloes also seem to have larger red cells with a higher haemoglobin content. Plasma mineral concentrations in buffaloes in this study were similar to those reported for cattle, with the exception that the concentration of sodium was considerably lower. Buffalo calves had significantly less haemoglobin, haematocrit and total plasma protein and more sodium, phosphorus and copper when compared to those of adult buffaloes.

N-47 RANAWANA, S.S.E., RAJARATNE, A.A. and TILAKARATNE, N. **Heat dissipation by buffalo during wallowing.** *Sri Lanka Veterinary Journal* (1983) **31,** 48 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

In an experiment conducted in Polonnaruwa in the dry zone of Sri Lanka, an attempt was made to estimate the quantity of heat dissipated by buffaloes whilst wallowing during the warmest period of the year, when the maximum temperature in shade was 32.2°C and minimum relative humidity was 57%. Five each of Lanka, Murrah and Surti buffaloes were allowed to graze or wallow during daytime at will. The time spent on these activities were recorded over several days. On three separate days, rectal temperature was measured in each animal immediately before and after wallowing. The total body water was measured by isotope dilution using tritiated water and the total heat dissipated by wallowing was computed. On an average (mean ± SD), buffaloes wallowed 7.5 ± 0.7 times daily for a period of 15.3 ± 2.1 min each time. The reduction in rectal temperature during one wallowing period was 1.80 ± 0.20° C, and the daily heat loss due to wallowing was 1676 ± 270 kcal. When the heat dissipated was expressed in terms of metabolic body size, i.e in kcal/$kg^{0.75}$ body weight, the Surti breed (29.4) lost significantly less heat than Lanka (33.1) and Murrah (35.6). Heat loss by wallowing was estimated to be 40-55% of the basal heat production (70 kcal per $kg^{0.75}$ body weight) and 12-16% of the calculated intake of metabolizable energy. Although the methods used may have somewhat overestimated the actual heat loss by wallowing, these results serve to show that wallowing is a major route of heat loss in buffaloes under the climatic conditions prevailing in the dry zone. In order to ensure that buffaloes use this adaptation to the best advantage, animals should be grazed close to water and allowed to wallow whenever needed.

N-48 RANAWANA, S.S.E., RAJARATNE, A.A.J. and TILAKARATNE, N. **Dissipation of body heat by buffaloes during wallowing.** In: *Proceedings of 3rd AAAP Animal Science Congress, 6-10 May 1985, Seoul, Korea,* pp. 894-896. Veterinary Research Institute, Peradeniya SL.

In the 'dry-zone' of Sri Lanka, the quantity of heat dissipated by buffaloes during wallowing was estimated during the hottest times of the year. Two-year old Lanka (indigenous) swamp buffalo, Murrah and Surti (Indian) river buffaloes breeds were allowed to graze in the sun and wallowing whenever needed. The times spent in these activities were observed over several days. On three separate days, the rectal temperature of each animal was measured just before and immediately following wallowing. Tritiated water was used as a marker to determine total body water. The heat lost during wallowing was calculated from the decrease in the rectal temperature and total body water content. On average, buffaloes wallowed 7.5 times a day for a period of 12.9 minutes each time. Rectal temperature decreased on average by 1.8°C and the animals lost 1.18 kcal/kg body weight at each wallow. It was calculated that they could lose about 40% of their basal heat production daily in this manner. It was concluded that wallowing is a major route of heat loss in buffaloes grazing in the sun in the dry zone of Sri Lanka.

N-49 RANAWANA, S.S.E., RAJARATNE, A.A.J. and TILAKARATNE, N. **A comparative study of the turnover of body water and responses to heat stress in grazing river and swamp type buffaloes.** *Asian-Australasian Journal of Animal Sciences* (1989) **2**, S4-12 pp. 281-283. Veterinary Research Institute, Peradeniya, SL

The objective of the present study was to compare the adaptability of Murrah and Surti with the Lanka buffalo under typical small farm conditions in the dry-zone in Sri Lanka.

Five each of two-year old heifers of the Lanka, Murrah and Surti breeds were grazed together on natural pasture close to water during daylight hours and paddocked in the night. No supplements were fed but buffaloes were free to graze and wallow. The daily turnover of body water was measured in each animal over a period of two weeks in May. One mCi of titrated water was injected intramuscularly and the specific activity of body water was measured in 6 blood samples drawn at intervals during the two weeks. Total body water (TBW) was calculated from the activity at zero time and the turnover from the fractional rate of decrease of activity. Respiration, pulse rates and skin and rectal temperatures together with the cutaneous evaporation rate were measured in each animal at different times of the day on several days. Five sets of measurements were made early morning to obtain basal values for these parameters. A further seven sets measurements were made at midday when the animals had been grazing for 3 to 4 hours in the sun. Differences between breeds and the times of day were tested by analysis of variance. The turnover of body water (WTO) when adjusted for differences in body weight and body water (ml/ $l^{0.82}$ day) was significantly lower in the Lanka buffalo. However, the main observation from the present study is that the water turnover in river buffaloes was more than in the Lankan animals. Values for respiration and pulse rates and for skin and rectal temperatures were not significantly different between breeds within each time period of the day. The early morning values may be considered as basal or resting values. It can be seen that there were large increases in all the parameters measured, from resting values to those at midday. The increases were, however, similar in all three breeds indicating that there is no difference between Lanka and the river breeds. The rate of water loss from the skin is greater in the river breeds than that in Lanka buffaloes. The only differences seen in this study between Lanka and river buffaloes such as Murrah and Surti were in their rates of water turnover and cutaneous evaporation. It was concluded that river type breeds are able to withstand the hot and humid conditions in Sri Lanka provided water is available freely for drinking and wallowing. They are, however, more likely to be affected by water shortages than Lanka swamp buffaloes.

N-50 RANAWANA, S.S.E., TILAKARATNE, N., RAJARATNE, A.A.J. and SRIKANDAKUMAR, A. **Water metabolism in the Asiatic buffalo.** In: *Proceedings of 3rd meeting of the Coordinated Research Programme on the Use of Nuclear Techniques to Improve Domestic Buffalo Production in Asia. 19-23 April 1982, Serdang, Selangor, Malaysia.* Veterinary Research Institute, Peradeniya, SL.

Utilisation of water by the Asiatic buffalo was studied in two experiments in which body water content and turnover were measured using tritiated water. In the first experiment, conducted in the dry zone of Sri Lanka, measurements were made in growing, pregnant and lactating buffaloes subjected to denial of wallowing and restriction of drinking water. When wallowing was denied, the animals increased their water turnover and when in addition, drinking water was restricted, water turnover declined to levels somewhat less than those on normal management. During the latter treatment, body water content increased, milk yields declined and it is likely that feed intake was affected.

In the second study carried out in the wet zone of Sri Lanka, Murrah buffaloes were compared with Indian and European cattle over a period of one year. Body water content was less in the dry period in the buffalo and less during the monsoon season in cattle. Indian cattle turned over less water than the other two groups in all periods. The buffalo turned over more water during the monsoon season whereas season had little effect on water turnover in cattle. The results confirmed that the buffalo requires more water than other domestic ruminants and that, conversely, they are more affected by the lack of water. The physiological reasons underlying this extravagant use of water by the buffalo await investigation.

N-51 RANAWANA, S.S.E., TILAKARATNE, N. and SRIKANDAKUMAR, A. **Daily turnover of body water in growing, pregnant and lactating buffaloes subjected to restriction of water for drinking and wallowing.** *Journal of Agricultural Science (Cambridge)* (1983) **100**, 741-743. Veterinary Research Institute, Peradeniya, SL.

Buffaloes need to wallow in water or in mud during the day and in general show a greater affinity for water than other domestic ruminants. This experiment was carried out to compare the effects on the daily turnover of body water in growing, pregnant and lactating buffaloes, under normal management conditions when denied wallowing and when drinking water is restricted. This study was made over a period of 2 1/2 months

during the dry period, in a buffalo farm in Sri Lanka. Five each of growing, lactating and pregnant Surti buffaloes were used in this study. Buffaloes were continuously grazed on improved pasture under young coconut trees which provided considerable shade. Drinking water was made available in a trough and the buffaloes wallowed for a period of 1.5h daily usually between 13.30 and 15.00 h. After allowing a period of seven days to adjust to the routine, body water content and turnover were measured over the next 14 days. Thereafter wallowing was denied for a period of 21 days and another set of measurements were made during the latter 2 weeks. During the final period, in addition to denial of wallowing, drinking water was restricted by allowing the buffaloes to drink only every other day at 10.00 h. A third set of measurement was made during the latter two weeks of this period. Water content and turnover were measured in each animal in each period using tritiated water. Differences between groups within each period were determined by ANOVA analysis of variance. The water content, however, was higher in all groups in period three when compared with that in other periods. Adults being larger in body size turned over more water than calves. The lactating group used more water than others, particularly in the second period.

When wallowing was denied, the turnover increased possibly as a result of the animals drinking more water, in order to compensate for lack of wallowing, by increased evaporative cooling. The conditions imposed in period 3 resulted in the buffaloes exhibiting signs of severe stress. The higher metabolic rate in the lactating cows would explain the greater turnover in this group. Milk production was reduced from 5.2/l day under normal management to 3.7 and 2.4/l day in latter periods respective. Wallowing therefore, apart from its cooling effect seems also necessary for the general maintenance of the integrity of the skin of the buffalo. The results of this study confirm that buffaloes have a high rate of water use and that they are very susceptible to restriction of drinking water even for short periods of time.

N-52 RANAWANA, S.S.E., TILAKARATNE, N. and SRIKANDAKUMAR, A. **Utilisation of water by buffaloes in adapting to a wet-tropical environment.** In: *Proceedings of the Final Research Coodinating Meeting on the Use of Nuclear Techniques to Improve Domestic Buffalo Production in Asia. 30 January-3 February, 1984. Manila, Philippines.* pp. 171-187. Veterinary Research Institute, Peradeniya, SL.

In a series of experiments, some characteristics that may influence adaptation to hot and humid environments by water buffaloes were investigated. The total body water and water turnover were related to measurements of respiratory and cutaneous evaporation rates and to rectal temperature. These measurements were made during different seasons, in animals from several agro-ecological zones. Water turnover was measured in unweaned Murrah buffalo calves and in growing, pregnant and lactating Surti buffaloes grazed under coconut with wallowing denied and drinking water was restricted; in Murrah buffaloes, zebu and European cattle during different seasons in the 'wet-zone', and in Murrah, Surti and Lanka buffaloes under 'dry-zone' conditions. Rates of water turnover in milk-fed buffalo calves were low but were higher in adult buffaloes than in other domestic ruminants. Water turnover was higher at higher air temperatures and during the monsoon when forage contained more water. Lactation and grazing in the sun also increased water turnover. A high rate of cutaneous water loss in buffaloes, apparently due to passive diffusion rather than to true sweating may have contributed to the high water turnover in this species. A relatively labile body temperature enabled buffaloes to 'store' body heat which was dissipated quickly by wallowing, which was shown to be a major route of heat loss and which also helps in the maintenance of the skin condition. If allowed adequate water for drinking and wallowing, buffaloes appear to be able to withstand hot humid environments but, in contrast to camels, sheep and goats, they seem unable to conserve water. Productivity in buffalo is affected by restriction of water.

N-53 RANAWANA, S.S.E., TILAKARATNE, N., SRIKANDAKUMAR, A. and RAJARATNA, A.A.J. **Water metabolism and mineral nutrition in the water buffalo.** In: *Proceedings of Workshop on Water Buffalo Research in Sri Lanka, 24-28 November 1980, Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. SAREC. 1982. pp. 83-90 Veterinary Research Institute, Peradeniya, SL.

The Asiatic buffalo is commonly known as the 'Water Buffalo' due to its affinity for water. This relationship was investigated in two experiments by measuring kinetics in buffaloes and relating these measurements to indices of heat stress. Tritiated water was used in the two studies to determine the water content of the animals and the daily turnover of water.

In the first study, conducted in the dry zone of Sri Lanka, lactating and late-pregnant Surti cows and growing Surti calves were subjected to three treatments as follows: normal management, no wallowing and no wallowing plus restricted drinking water. When animals were not allowed to wallow, their daily turnover increased by 25% but could not

compensate for wallowing, in terms of their ability to lose heat. When animals were further stressed by restricting drinking water, the daily turnover of water was reduced. The content of body solids was also decreased probably due to a lowered dry matter intake and a subsequent mobilisation of body reserves, especially fat. These changes were most marked in lactating animals which, despite the imposed stress, maintained their levels of milk production.

In the second study carried out in the wet zone, Murrah buffalo heifers were compared with *Bos indicus* and *Bos taurus* heifers under conditions of high temperature and humidity. Water turnover was highest in the buffalo and least in *B. indicus* whilst there was no difference between the groups in their body water content. It appears that the buffalo turns over more water than other domestic ruminants (k>0.2/day) and that wallowing plays a crucial role in their ability to lose heat. Buffaloes are more adversely affected than other domestic ruminants by any restriction of their water supply. The reasons for these differences need further investigation. In a separate experiment, the mineral status of buffalo calves in the dry zone of Sri Lanka was investigated. Murrah buffalo calves were supplemented with Cu, Zn, Mn, Fe, P and S for a period of 8 weeks and their body weights and concentrations of serum minerals were measured at intervals. The treated calves showed a highly significant increase in their rates of growth (0.39 kg/d) when compared to untreated controls (0.194 kg/d). Serum concentrations of those minerals that were measured gave no indication as to which of these were responsible for this response. Further investigations are required to determine which of the minerals need closer examination.

N-54 SAHAMA, T.M.I.R., PERERA, E.R.K. AND PERERA, A.N.F. **Effect of urea nitrogen treatment on growth performance and rumen parameters of indigenous buffalo *(Bubalus bubalis)* heifers.** *Tropical Agricultural Research* (1993) **5**, 327-335. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

Experiments were conducted to investigate the growth performance and rumen parameters of local buffalo heifers in response to urea nitrogen in treated straw. Ten buffalo heifers were allotted to two groups balanced by body weight (89.0 kg) and age (12 months). All the animals were offered "Guinea A" grass (*Panicum maximum*) *ad libitum* during daytime. At night, the treatment group (n=5) was given 4% urea treated straw, while the control group (n=5) was given untreated straw. Daily group feed intake of Guinea grass and straw was recorded. Individual body weights were obtained monthly. Representative samples of Guinea grass, straw and refusals were obtained periodically, for proximate analysis. Rumen samples were obtained to determine rumen pH, and rumen NH_3-N. Urea treated rice straw had a higher (P£0.05) crude protein content than untreated straw. Straw dry matter intake (P£0.01), total dry matter intake (P£0.01), nitrogen intake (P£0.01) and rumen NH_4-N (P£0.05), were greater in the treatment group. This group achieved a higher final body weight due to the greater body weight gain, suggesting long-term beneficial effects of urea nitrogen used in treated straw.

N-55 SAHAMA, T.M.I.R., PERERA, E.R.K. and PERERA, A.N.F. **Effect of improved protein nutrition on rumen parameters and blood metabolites of water buffalo *(Bubalus bubalis)* heifers.** In: *Proceedings 6th Annual Congress* of the *Postgraduate Institute of Agriculture, University of Peradeniya. 29-30 November, 1994.* [Abstract]. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

An experiment was conducted to examine the response of rumen parameters and blood metabolites in local buffalo heifers to improved protein nutrition. Twelve buffalo heifers were allotted to two groups balanced by body weight (89 kg) and age (12 months). All animals were offered "Guinea A" grass *(Panicum maximum) ad libitum* during day time. At night, the treatment group (n=6) was given 4% urea treated straw, while the control group (n=6) was given untreated straw. The daily group feed intake of Guinea grass and straw was recorded. Representative samples of Guinea grass, straw and refusals were obtained periodically, for proximate analysis. Rumen samples were obtained every 4th week to determine rumen pH and rumen ammonia (NH_3-N). Blood samples were obtained at the same time to determine circulating blood urea nitrogen (BUN), beta hydroxy butryrate (BHB), serum albumin (AL) and total protein (TP) contents. Urea treated straw had a higher (P<0.01) crude protein content than untreated straw. The treatment group of animals had a greater straw dry matter intake (P<0.01), total dry matter intake (P<0.01), nitrogen intake (P<0.01) and energy intake (P<0.01). Rumen ammonia content was higher (P<0.05) in animals of the treatment group. Rumen pH, circulating BHB, BUN, AL and TP were not different (P>0.05) between the groups. But, trends in rumen pH and BUN in two groups were indicative of better utilisation of available dietary protein by animals in the treatment group.

N-56 SIRIWARDENE, J.A. de S. **Relevance of crop residues and non - conventional feeds in overcoming feed shortages.** In: *Potential of Rice Straw in Ruminant Feeding* [Edited by Ibrahim M.N.M *et al.*] Peradeniya, Sri Lanka. Straw

Utilisation Project Publication No 1. 1985 pp. 35-54. Veterinary Research Institute, Peradeniya SL.

The dairy industry in Sri Lanka is beset with many problems. Perhaps the most important of these is the difficulty farmers face in ensuring an adequate year round supply of moderately good quality roughage. The seasonality of the weather pattern results in an abundance of roughage during part of the year and deficiencies at other times. Conservation of grass and fodder as a management practice has not found acceptance by local farmers. This is partly because of the lack of technical know-how, capital and storage facilities. The uncertainty of weather conditions also contributes to the lack of interest in conservation by farmers. At the same time, the traditional feed resources are grossly inadequate to support the supplementary feed requirements of the population of livestock and poultry. The only means available to increase the feed resources is to utilise the non-conventional feed resources and crop residues in feeding systems. Against this background, the use of crop residues and non-conventional feedstuffs should be encouraged so as to fill the deficiency of traditional and conventional in feed resources. The potential availability of crop residues is estimated to be over 2 million tons per annum. Much of this constitutes rice straw. While it is true that there are other uses for straw, this resource is still large enough to satisfy the greater part of the deficit in roughage for feeding of ruminants. This paper presents some statistics on the potential availability of crop residues and non-conventional feed resources and also suggestions for their effective utilisation in feeding systems for ruminants.

N-57 SIRIWARDENE, J.A. de S. **SAREC/ NARESA Project on dissemination of information on improved production systems to small farmers.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera, B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press 1996. pp. 19-25. SAREC/NARESA Buffalo Project office, DAPH Building, Peradeniya, SL.

The SAREC/NARESA Buffalo Research and Development Programme was initiated in 1983 and commenced on the research phase in 1984. The Information Dissemination Programme which is the third and final phase of the programme was started in January 1995. Phase III had three major activities which were (i) the establishment of Buffalo Information Centre (ii) the dissemination of the research information generated in phases I and II to rural farmers and (iii) the popularisation of intensive buffalo farming. Activities relating to dissemination of information included the publication of a compendium of research information, a book on buffalo production, a handbook on buffalo husbandry practices, a training manual and information leaflets for farmers. The popularisation of intensive buffalo rearing was achieved by creating greater public awareness on the benefits of intensive buffalo farming, particularly in rural farms where limitations of land and other resources have made the traditional extensive buffalo management systems unworkable. The programme popularised a model Smallholder Intensively Managed Buffalo Farm Unit which was based on the application of a combination of management practices applicable from a basket of technologies developed by the Buffalo Research and Development Programme.

N-58 SIVAKANESAN, R., RANASINGHE, J.G.S., MARIATHASAN, C. and ABEYGUNAWARDENA, H. **Serum concentration of progesterone and its precursor cholesterol in buffaloes.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera B.M.A.O. *et al.*], Colombo, Sri Lanka. NARESA Press. 1996. pp. 239-250. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

The dependence of steroidogenesis in mammalian ovary on high density lipoprotein cholesterol (HDL-C) prompted a study on the relationship between serum progesterone and HDL-C concentration in buffaloes. All pregnant animals at the Narangalla buffalo farm were divided into two groups and the feed of one group was supplemented with urea treated straw. All the animals were allowed to graze freely. Blood samples were collected at fortnightly intervals and progesterone, total cholesterol (TC) and HDL-C concentrations were measured.

Pearson correlation analysis gave coefficient values of 0.083 (progesterone and TC all animals, n=124); - 0.037 (progesterone and HDL-C all animals, n =128); 0.061 (progesterone and TC, control group, n=62); 0.112 (progesterone and TC, supplemented group, n=63), - 0.082 (progesterone and HDL-C, supplemented group, n=65) indicating very poor correlation. The TC concentration was lowest during the first two weeks postpartum in both control [1.22 ± 0.082 (SEM) mmol/l] and supplemented [1.42 ± 0.061 (SEM) mmol/l] groups and increased significantly up to 10 weeks (control, 1.68 ± 0.094; supplemented, 1.70 ± 0.089). Thereafter in the control group, the levels fluctuated between 1.51 to 1.86 mmol/l. whereas in the supplemented group it remained very close to 1.76 mmol/l. The wide fluctuations seen in the control group may be due to the availability of food. The TC concentration in the supplemented group did not differ significantly from that of the control group at the any stage of the experiment. HDL-C was lowest during the first two weeks after parturition; the values being 1.00 ± 0.068 (SEM) mmol/l and 1.10 ±

0.044 (SEM) mmol/l respectively for the control and supplemented groups. HDL-C gradually increased over a period of 8 weeks after which it remained around 1.22 mmol/l in both groups. The differences between the control and supplemented groups were not significant at any stage during the experiment. Five animals out of 18 in each group, control and supplemented, were cycling by 150 days and 133 days respectively. Supplementary feeding did not result in an appreciable improvement in reproductive status and serum cholesterol. There was no correlation between either TC or HDL-C and serum progesterone concentrations, indicating the possibility that progesterone synthesis is not influenced by the circulating levels of HDL-C and TC.

N-59 TILAKARATNE, N., MATSUKAWA, T., BUVANENDRAN, V. and THANGARAJAH, P. **Growth, feed conversion and carcass characteristics of cattle and buffaloes fed grass and concentrates.** *Ceylon Veterinary Journal* (1976) **24,** 9-12. Veterinary Research Institute, Peradeniya, SL.

Friesian, Red Sindhi and Murrah buffalo steers were used in this study. Red Sindhi cattle and Murrah buffaloes were born and raised at the Livestock Farm, Polonnaruwa. Friesians originated from Bopathtalawa Livestock Farm in the hill country. Animals were 11 - 12 months of age at the commencement of the experiment. The experiment lasted 6 months, the study was conducted at Kundasale and each breed was given similar treatment. Daily feed intake was measured and dry matter intake was calculated. All animals were weighed individually every fortnight. Blood samples were collected every second month and haematocrit values were estimated using the micro - haematocrit method. After the growth study was completed, animals were slaughtered and one half of each carcass was examined by standard carcass analysis techniques. Tenderness of meat was measured by Warner-Bratzler shear meter on a one inch core of the longissimus dorsi muscle cooked at an internal temperature of 70°C.

Comparisons of live weight gain, feed conversion efficiency and carcass characteristics were made between Murrah buffalo, Red Sindhi and Friesian steers after fattening on grass and coconut cake concentrate. The mean daily weight gains for the three breeds were 0.51 kg, 0.38 kg and 0.24 kg respectively. The fat percentage in the buffalo carcass was significantly higher. Muscle/bone ratio and Warner - Brantzler shear force values were not significantly different among breeds. Buffaloes were also superior in feed conversion efficiency than the two *Bos* breeds. It would thus appear that the buffalo has a good potential for beef in the mid country dry zone of Sri Lanka.

N-60 TILAKARATNE, N., RANAWANA, S.S.E., RAJARATNE, A.A.J. and SRIKANDAKUMAR, A. **Studies on adaptation of the buffalo to the wet tropical environment** In: *Proceedings of 3rd meeting of the Co-ordinated Research Programme on the Use of Nuclear Techniques to Improve Domestic Buffalo Population in Asia, 19-23 April 1982, Serdang, Selangor, Malaysia.* Veterinary Research Institute, Peradeniya, SL.

The two experiments were conducted to investigate some of the characteristics in the water buffalo that enable the animal to adapt to the conditions prevailing in the wet tropics. In the first experiment, conducted in the dry zone of Sri Lanka, effects of denying wallowing and restricting drinking water on 5 each of growing, pregnant and lactating buffaloes were studied. In the next experiment, conducted in the wet zone of Sri Lanka, four each of Murrah buffaloes, *Bos indicus* and *Bos taurus* cattle were compared during the dry (mean air temperature 33.8°C ; relative humidity 41.2%), monsoonal (temperature 25.1°C; R.H. 74.6%) and inter monsoonal (temperature 30.0°C; R.H. 66.6%) seasons. In both studies, heat stress was monitored by measuring skin and rectal temperatures, rates of respiration, pulse and cutaneous evaporation.

Results suggested that the water buffalo was intermediate between the two cattle breeds in its ability to withstand hot and humid conditions. Conditions that prevailed between the monsoons caused greater stress in buffaloes than in the dry and monsoon periods. Buffaloes appeared to have a similar capacity as zebu cattle for cutaneous evaporation. Growing heifers had a lower rate of cutaneous evaporation than adults and were more susceptible to the effects of heat and humidity. Denial of wallowing and restriction of drinking water severely stressed the buffaloes effecting their ability to maintain body temperature under these conditions.

N-61 TILAKARATNE, N., RANAWANA, S.S.E. and SRIKANDAKUMAR, A. **Effect of restricting access to water in buffaloes.** *Ceylon Veterinary Journal* (1980) **28,** 59, [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Buffaloes require frequent access to water for both drinking and wallowing. The effects of restricting such access were studied in three physiological groups of Surti buffalo, namely growing heifers aged 10 months, lactating cows producing 2 to 4 litres of milk daily, and pregnant cows in the last trimester. The animals, five in each group, were grazed under coconut palms and subjected to successive 3 week treatments of (i) *ad libitum* drinking water with 2.5 h of wallowing daily, (ii) *ad libitum* drinking water without

wallowing and (iii) restricted drinking water without wallowing. Heat stress was monitored by measuring rectal and skin temperature, respiration rate, pulse rate and sweating rate of individual animals five times a day on five different days during the second and third weeks in each treatment. In all treatments, the readings at mid-day were 1.5, 12 and 50% higher than those at 06.00 hr for rectal temperature, skin temperature and respiration rate, respectively; the increments were greater in lactating and pregnant animals. Compared with treatment (i), the other two treatments caused a greater elevation of rectal temperature and respiration rate, but a reduction in the sweating rate by about 20%. Generally, growing heifers had 40% higher respiration rates and 13% lower sweating rates compared to adults.

Results indicated that despite shade, Surti buffaloes suffered from heat stress with increasing air temperatures and lack of wallowing, and restriction of drinking water further aggravated stress. Compared to adult cows, growing heifers appeared to rely more on the respiratory tract rather than on the skin for evaporative cooling.

N-62 TILAKARATNE, N., RANAWANA, S.S.E. and SRIKANDAKUMAR, A. **Water metabolism in the buffalo** *Ceylon Veterinary Journal* (1980) **28,** 59-60, [Abstract]. Veterinary Research Institute, Peradeniya, SL.

Tritiated water was used to determine the body water content and water turnover of four physiological groups of buffaloes milk-fed calves weaned calves, late-pregnant and lactating cows with mean body weights of 54, 140, 387 and 344 kg, respectively. The body water contents of the milk-fed, weaned, late-pregnant and lactating groups were 1473, 1751, 2107 and 2083 ml/kg$^{0.82}$ respectively. Body solids accounted for 27.9, 28.0, 27.2% of the body weights respectively. The k values for the four groups in the above-mentioned order were 147, 445, 479 and 536, respectively and the water turnover was 0.1, 0.25, 0.23 and 0.26 ml/kg$^{0.82}$ per day, respectively.

The results indicate that following weaning, there was a marked increase in rate of body water turnover. This change was probably associated with the functional development of the rumen. Lactating cows had a higher rate of body water turnover than those in the other groups, reflecting the increased metabolic activity associated with lactation. In general, the daily water turnover and thus the water requirement of the buffalo appears to be much higher than those reported for *Bos taurus* cattle in the tropics and almost double that for *Bos indicus*. The reasons for such a marked difference not clear at present.

N-63 TILAKARATNE, N., RANAWANA, S.S.E. and SRIKANDAKUMAR, A. **Effects of restricting water to growing, lactating and pregnant buffaloes reared in a hot and humid environment.** *Journal of the National Science Council of Sri Lanka* (1983) **11,** 25-39. Veterinary Research Institute, Peradeniya, SL.

An experiment was carried out to examine the effects on certain physiological indices of heat stress in buffaloes subjected to restriction of water in a hot and humid environment. Five each of growing lactating and pregnant Surti buffaloes were grazed under young coconut palms and subjected to three treatments in successive periods, each of three weeks duration. Each treatment was imposed on all groups of animals simultaneously. In treatment I, which simulates the normal management system, animals were allowed drinking water *ad libitum* and allowed to wallow for 1.5 hours daily. In treatment II animals were denied wallowing and in treatment III drinking water was restricted and wallowing was denied. Thermal stress was monitored by measuring rectal and skin temperature, respiration, pulse and cutaneous evaporation rates for each animal several times a day.

All physiological variables studied showed a progressive increase from 0700 hours till 1400 hours and declined thereafter up to 1800 hours. The time effect was very highly significant ($P<0.001$). Under normal management, growing heifers were found to be more stressed than adults. Denial of wallowing and restriction of drinking water aggravated heat stress with an average elevation of 0.9 - 1.2°C in rectal temperature and 16 - 18 respirations per minute at mid day over the respective base values. No significant group difference was observed during the latter treatments. The average rate of cutaneous evaporation of 310 ± 15 during treatment I decreased to 271 ± 15 g/m^2/hour in treatments II and III. Heifers generally showed a lower rate of cutaneous evaporation and a higher rate of respiration.

The results indicate that despite the availability of shade, buffaloes suffered from heat stress as the ambient temperature increased. Lack of wallowing and restriction of drinking water aggravated stress. Young animals were possibly more dependent on the pulmonary route for evaporative cooling. Adult buffaloes did show a capacity to lose moisture through the skin at rates comparable to those of zebu cattle.

N-64 TILAKARATNE, N., RANAWANA, S.S.E., SRIKANDAKUMAR, A. and RAJARATNE, A.A.J. **Buffalo and the tropical environment.** In: *Proceedings Workshop on Water Buffalo Research in Sri Lanka 24-28 November Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden.

SAREC. 1982. pp. 103-109. Veterinary Research Institute, Peradeniya, SL.

The buffalo, which is essentially a shade and water-loving animal, has to adopt itself to high ambient temperatures, humidity and solar radiation deprivation of wallowing and restriction of drinking water on growing, lactating and pregnant females, grazing under coconut, was studied under hot (air temperature = 27.4 to 34.2°C) and humid (relatively humidity = 65 to 84%) conditions. In the second, Murrah buffaloes were compared with *Bos taurus* and *Bos indicus* cattle to study their relative responses to a hot (air temperature 25.8 to 30°C) and humid (Relatively humidity = 66 to 77%) environment.

N-65 TILAKARATNE, N., RANAWANA, S.S.E., SRIKANDAKUMAR, A. and RAJARATNE, A.A.J. **Water metabolism of the buffalo in relation to heat tolerance.** In: *Proceedings of 2nd AAAP Animal Science Congress, 10-13 November 1982, Manila, Philippines*, pp. 20. Veterinary Research Institute, Peradeniya, SL.

The utilisation of water in the buffalo appears to be different from other ruminants and probably related to the mechanisms of thermo-regulation. In treatment II of the first experiment, denial of wallowing and provision *ad libitum* drinking water resulted in the increase in daily water turn-over by 25% but the animals were not stressed any more than under normal management in treatment I. In treatment III, where animals were denied wallowing and drinking water was restricted under hot and humid conditions, heat stress was aggravated and daily water turn-over was reduced. In the second experiment, it was found that buffaloes had a lower body water content compared to European cattle in all seasons, but the magnitude of the difference was greatest in the dry season. In general, body water content was least and solid content was highest during the wet season in all animals. Water turnover of the buffalo was greater during the wet season and less during the dry season when compared to European cattle but the two groups were similar during the intermonsoonal period. Buffaloes, however, were not stressed as much as temperate cattle irrespective the seasons. Indian cattle had the least turnover rates during all seasons but never showed any signs of stress. In general, animals were more stressed by the moderate temperatures and high humidity conditions than by high temperature and low humidity conditions prevalent during the dry season.

These studies show that buffaloes have a high rate of water use, and that in turn they are extremely susceptible to any deprivation of water. If allowed access to water for drinking and wallowing, they seem to be able to cope with the climatic in order to thrive in the tropics. This presentation deals with the results from two of the trials conducted in series designed to investigate the interaction of the buffalo with the tropical environment. In the first study the effect of stresses imposed by the tropical environment. Indian cattle are able to manage with much less water, whereas European cattle, despite a high rate of water use, seem unable to adapt to these climatic conditions.

N-66 YAPARATNE, V.M.K., PERERA, A.N.F. and VAN. J. BRUCHEM **Evaluation of degradation characteristics of fodders and agro-industrial by-products using the nylon bag technique.** *Tropical Agricultural Research* (1993) **5**, 350-358. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL

One of the major constraints in the ruminant livestock production in Sri Lanka is the unavailability of quality green feed, year around. Therefore, tree and shrub fodder and agro-industrial by-products play an important role in the nutrition of the ruminant. Five agro-industrial by-products [rice polish, rubber seed meal, sesame meal, soybean meal and coconut oil meal and seven tree fodder, *Peuraria phasioloides*, *Gliricidia sepium*, Albizzia (*Albizzia fulcataria*), Tithonia (*Tithonia diversifolia*), Erythrina (*Erythrina verigata*), Rain tree (*Samane saman*) and Leucaena (*Leucaena leucocephala*) were used in this study.

Dry matter (DM) and nitrogen (N) rumen degradation was studied using the nylon bag technique for a period up to 48 h, in ruminally cannulated buffaloes fed on Guinea grass (*Panicum maximum* - Eco type A), supplemented with 15 g coconut meal per kg $W^{0.75}$. Results were analysed according to a non-linear regression. The average initial DM solubility of fodder (32.8%) was lower than that of agro-industrial by-products (42.5%). All agro-industrial by-products had very high total degradable DM in the rumen (above 75% disappearance within 24 hours), except for rubber seed meal (44.5%). The average N disappearance in fodders and agro-industrial by-products showed similar trends as DM disappearance. *Gliricidia*, *Leucaena* and *Erythrina* had high potentially fermentable fractions. In contrast to other fodders, Albizzia had very low total degradable N in the rumen as about 74% was undegradable. Among agro-industrial by-products, rubber seed meal had a high readily fermentable N content. However, subsequent potential N disappearance was minimal. More than 80% of the N of agro-industrial by-products disappeared within 24 hours, leaving small quantities for lower gut enzymatic digestion.

Part IV – Reproduction and Breeding

R-01 ABEYGUNAWARDENA, H., and PERERA, B.M.A.O. **Reproductive patterns and performance of Murrah buffalo in Sri Lanka.** *Ceylon Veterinary Journal* (1980) **28,** 60-61, [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, Peradeniya, SL.

The breeding records of 752 buffaloes in two dry-zone farms (Ridiyagama and Polonnaruwa) from 1969 to 1979 were analysed, Climatological data for the two locations during the same period were obtained from the Department of Meteorology. A detailed study on reproductive patterns was conducted in a mid-country wet-zone farm (Gannoruwa) using hormonal measurements and rectal examinations.

The mean ± SEM age at first calving was 3.72 ± 0.039 yrs at Ridiyagama and 3.66 ± 0.069 at Polonnaruwa. The mean calving interval from first to tenth calving ranged from 378 to 699 days at Ridiyagama and from 339 to 569 days at Polonnaruwa. Calvings and conceptions were seasonal. At Ridiyagama 57% of the calving occurred during November to February, and at Polonnaruwa, 49% occurred during October to January. Analysis of conceptions in relation to rainfall showed that periods of high rainfall were followed by periods of increased incidence of conception, with a time lag of about 2 months. A seasonal trend in conceptions was also observed at Gannoruwa. The post partum period was characterised by a prolonged anoestrus, ranging from 110 to 210 days. The onset of ovarian activity and progesterone secretion appeared to be influenced by environmental factors, and conception usually occurred at the first or second post partum ovulation.

R-02 ABEYGUNAWARDENA, H., MOHAN, V., ABAYAWANSA, W.D., RATNAYAKE, D., ARIYARATNE, H.B.S. and KURUWITA, V.Y. **Studies on reproduction in indigenous buffaloes and cattle in Sri Lanka.** In: *Proceedings of the International Symposium on Nuclear and Related Techniques in Animal Production and Health, 15-19 April, 1991. Vienna, Austria.* IAEA-SM-318/22P pp: 128-129. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Indigenous buffaloes and zebu cattle are the predominant types of animals in rural farming systems in Sri Lanka. Reproductive patterns of buffaloes have been well characterised and a major cause of low reproductive efficiency was found to be prolonged post partum anoestrus.

Manipulation of suckling management and hormonal treatment methods were used in attempts to induce oestrous activity in post partum anoestrous buffaloes. Thirty buffaloes were randomly assigned to one of the following treatments: 1.*adlibitum* suckling from calving; 2. *ad libitum* suckling from calving up to day 30 and limited suckling twice a day thereafter and 3. *ad libitum* suckling up to day 45 and complete weaning thereafter. Weekly blood samples were obtained up to 60 days and rectal examination was done on day 90 post partum. The results revealed that animals subjected to complete weaning resumed oestrous activity earlier than those in the other two treatment groups.

Three trials were conducted to assess the suitability of exogeneously administered hormones for inducing oestrus in buffaloes. The signs of heat were recorded. Gonadotrophin releasing hormone (GnRH, Trial 1) or GnRH after priming with Follicle Stimulating Hormone (FSH, Trial 2) failed to induce oestrous activity in buffaloes.

In trail 3 Progesterone Releasing Intravaginal Devices (PRID) were placed in vagina of 8 buffaloes and left *in situ* for 11 days; 700 IU of PMSG were given at the time of PRID removal. Four animals were used as controls. Visual observation for signs of heat commenced 24 hours after the PMSG treatment and continued for 48 hours. Weekly blood sampling was continued for 60 days post-treatment and rectal examination was performed on day 90 post-treatment. Eighty-eight percent of treated animals were pregnant on day 90 compared to 25% in the control group. The consistent and noticeable signs of oestrus were discharge of clear scanty mucus and receptivity to the male.

Since information on reproductive patterns of zebu cattle in Sri Lanka is scarce, an island wide survey and several case studies were undertaken. Preliminary results indicate that, Sri Lankan zebu animals mature slowly and are low producers which can thrive well under very harsh environmental conditions, particularly on low quality herbage. Ten pluriparous Lankan zebu animals were studied by weekly blood sampling and rectal examination from calving until pregnancy. The first elevation of progesterone occurred around day 40 post partum

and the mean calving to conception interval was 70 days.

In a field trial, the efficiency of short term progesterone treatment combined with PMSG or GnRH injections in inducing post partum oestrus was examined. Progesterone implants placed under the skin of the ears in 10 anoestrous animals and 5 mg of estradiol was given intramuscularly at the time of implantation; 9 days later the implants were removed and an injection of either 700 IU of PMSG or 250 μg of GnRH was given intramuscularly. The animals were observed for signs of oestrus closely and inseminated artificially at 48 and 72 hours after the removal of implants. All the animals resumed oestrous activity within 48 hours and the most consistent and notable signs of oestrus were clear mucous discharge, swelling and reddening of vulva and raising of tail head.

The preliminary results from these studies indicate that appropriate suckling management system and some hormone treatment methods can be used as measures to improve the fertility of the native buffaloes and zebu cattle in Sri Lanka.

R-03 ABEYGUNAWARDENA, H., KURUWITA, V.Y., KARUNARATNE, A.M. and ABAYAWANSA, W.D. **Indigenous buffaloes in Sri Lanka: reproductive pattern and characteristics.** In: *Proceedings of the 49th Annual session of Sri Lanka Association for the Advancement of Science, December 1993, Colombo SL. A-14.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Studies aimed at characterising reproductive pattern of indigenous buffaloes *(Bubalus bubalis)* were conducted at an experimental station in the intermediate zone, low-country region. Rainfall was 2056 ± 405 mm/annum with precipitation during North-East and South-West monsoon periods with heavy precipitation in the former. Calvings (n=279) were seasonal (P<0.05) with 72% of calvings during October-February coinciding with the North-East monsoon rains. Calving interval was 506.8 ± 57.0 days and more than 47.8% calving intervals were less than 425 days. Peak conception occurred 2-3 months after calving with calving to conception interval of 206.8 ± 158.0 days. Approximately 29.3% of calving to conception intervals were less than 100 days and out of this more than 85% were from the animals which calved during the months of November to January. Age at calving (n=31) was 1320.0 ± 85.0 days. Annual calving rates range from 55% to 63%. Incidences of other reproductive failures such as abortion, uterine infections etc. were low. Body weight at birth was 17.2 ± 2.3 kg (n=75) with no difference between male and female calves. Prepubertal growth rate was 155.4 ± 37.6 g per day (n=12) and was greater during first 6 months than the other periods. Age at puberty (n=8) was 1059 ± 106 days and weight at puberty was 186 ± 25 kg which was approximately about 70% of the mature body weight of 265 ± 29 kg (n=49). Age at first calving in this group was 1378 ± 105 days. Length of oestrous cycle was 21 ± 1 days and the oestrous signs were not overtly expressed. Progesterone and prostaglandin metabolite (15-keto-13, 14-dihydro-PGF_2, PGFM) profiles during the cycle were characterised by increasing PGFM concentrations coinciding with the declining progesterone concentration. Process of parturition was very rapid while signs of impending parturition became evident within 4 to 5 days prepartum. Plasma progesterone concentration commenced to decline by day 5 prepartum coinciding with an increase PGFM concentrations.

The findings suggest, that the reproductive efficiency of indigenous buffalo is low, primarily due to entertainment of post partum ovarian function by seasonal nutrient availability which is linked with marked seasonal rain pattern. The clinical and endocrinological findings suggest that reproductive physiology of indigenous buffalo closely resembles those in river type and in cattle.

R-04 ABEYGUNAWARDENA, H., KURUWITA, V.Y., KARUNARATNE, A.M. and ABAYWANSA, W.D. **Reproductive characteristics of indigenous buffaloes in Sri Lanka under experimental conditions.** In: *Proceedings of the 4th World Buffalo Congress* 27-30 *June, 1994. Sao Paulo, Brazil.* R-144 vol. 111, pp. 471-473 Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Several studies aimed at characterising the reproductive pattern of indigenous buffaloes (*Bubalus bubalis*) were conducted at an experimental station situated in the intermediate zone, low-country region of Sri Lanka. The average rainfall was 1583±910 mm/annum with precipitation during North-East monsoon (September-December) and South-West monsoon (April-June) periods, with heavy precipitation in the former. Calvings (n=279) were seasonal (P<0.05) with 72% of calvings during the October-February coinciding with the North-East monsoon rains. Average calving and estimated calving to conception intervals were 507±158 days and 207±158 days, respectively. Distribution of estimated conception dates showed that nearly 55% of the conceptions occurred during the period from January to March. Approximately 30% of calving to conception intervals were less than 100 days and of this more than 85% were of the animals calved during the

months of November to January. The mean length of calving to first elevation of progesterone was 185±129 days. Approximately 25% of the animals had short elevation of plasma progesterone and all the animals conceived at the first post partum oestrus. The age at first calving (n=31) estimated from records was 1320±185 days. Annual calving rates ranged from 55% to 63%. The incidence of other reproductive failures such as abortion and uterine infections were low. The body weight at birth was 17±2 kg (n=75) with no difference between male and female calves. Prepubertal growth rate was 155±38 gm per day (n=12) and was greater ($p<0.05$) during first 6 months than the other periods. Age at puberty (n=8) was 1059±106 days and weight at puberty was 186±27 kg which was approximately about 70% of the mature body weight of 265±29 kg (n=49). The age at first calving in this group was 1378±105 days. The length of oestrous cycle was 21±1 days and the oestrous signs were not overtly expressed. The progesterone and prostaglandins metabolite, 15-keto-13, 14-dihydro-$PGF_{2\alpha}$ (PGFM) profiles during the cycle were characterised by increasing PGFM concentrations coinciding with the declining progesterone concentration. Process of parturition was very rapid with signs of impending parturition becoming evident within 4 to 5 days prepartum. Plasma progesterone concentration commenced to decline by day 5 prepartum coinciding with an increase PGFM concentrations. In conclusion, the findings of this study suggest that the reproductive efficiency of indigenous buffalo is low, primarily due to entrainment of post partum ovarian function by seasonal nutrient availability which is linked with marked seasonal rain pattern. Further, the clinical and endocrinological findings suggest that reproductive physiology of indigenous buffalo closely resembles those in river type buffaloes and in cattle.

R-05 ABEYGUNAWARDENA, H., KURUWITA, V.Y. and PERERA, B.M.A.O. **Effects of exogenous hormones on fertility of post partum anoestrous buffaloes.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by B.M.A.O. Perera *et al.*] Colombo, Sri Lanka, NARESA Press 1996. pp. 337-359. Faculty of Veterinary Medicine and Animal Science University of Peradeniya, Peradeniya, SL.

Seasonal calving and low calving rate, caused by long post partum anoestrus, have been identified as the major factors which limit the productivity of buffaloes in Sri Lanka. As a management strategy to improve fertility of buffaloes during the post partum period, the effects of the following regimes of exogenous hormone treatments were tested in anoestrous animals; (a) two injections of 250 µg of GnRH (Receptal, Hoechst) 24 h apart; (b) two injections of 4 mg of FSH (Intervet) given 12 h apart, followed 12 h later by treatment (a); (c) progesterone releasing intravaginal device (PRID, Sanafi) for 11 days and 500 IU of PMSG (Folligon, Intervet) at the time of coil removal and (d) progesterone releasing silastic ear implant (Synchromate B, Intervet) for 11 days and 500 IU of PMSG at the time of implant removal. An untreated group of animals remained as control (e). After the hormonal treatments they were allowed to run with stud bulls. Subsequent calvings were recorded. The number (and percentage) of animals which became pregnant within 90 days of treatment in groups a,b,c,d and e were: 0/10 (0%), 0/12 (0%), 19/23 (83%), 32/44 (73%) and 15/45 (33%), respectively. In a separate trial, 9 cows were given treatment (d), kept away from bulls and observed for oestrous signs. Plasma progesterone was measured by RIA in blood samples collected at frequent intervals up to 45 days. All treated animals showed distinct signs of oestrus following implant removal and 8 (89%) had ovulations as indicated by plasma progesterone. However, two animals had abnormal luteal phases and relapsed into acyclicity. The lack of response to GnRH treatment could be due to refractoriness of the ovary and pituitary, and the lack of tertiary follicles. The combination of progesterone and PMSG given sequentially appears to be capable of overcoming this refractoriness, possibly through the build up of LH reserves and stimulation of follicle development, and appears to be an effective method for inducing oestrus and improving pregnancy rates in anoestrous buffaloes. However, more studies are needed to determine the factors which influence the success rate.

R-06 ABEYGUNAWARDENA, H., KURUWITA, V.Y. and PERERA, B.M.A.O. **Effects of different suckling regimes on post partum fertility of buffalo cows and growth and mortality of buffalo calves** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by B.M.A.O. Perera *et al.*] Colombo, Sri Lanka, NARESA Press 1996. pp 321-336. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Low annual calving rates in indigenous buffaloes have been shown to be due to prolonged post partum anoestrus, caused primarily by seasonal fluctuation of quantity and quality of pasture and fodder and by free suckling of calves. This study was conducted to determine the effects of different suckling regimes on post partum fertility of buffalo cows and growth and mortality of calves. Six suckling management's were tested: free (*ad-libitum*) suckling (FS); and weaning by day 45 (FS+W45); FS and weaning by day 60 (FS+W60);

FS and weaning by day 90-120 (FS+W90); once a day suckling from day 7 (OS); and twice a day suckling from day 7 (TS). Different combinations of those were tested during 4 successive calving seasons. Calves were weighed at monthly intervals. Conception date was calculated by subtracting the mean gestation length of 301 days from the actual calving date. The pregnancy rates at 90,120 and 150 days were: 19,20 and 23% in FS (n=74); 54,73 and 73% in FS+W45 (n=11); 6,31 and 37% in FS+W60 (n=16); 5,17 and 27% in FS+W90 (n=18); 38,59 and 59% in OS (n=29);and 31,45 and 59% in TS (n=22). The calf mortality in these groups were 5.4,55,31,33, 6.8 and 4.5% respectively. Free suckling resulted in the lowest pregnancy rates. Weaning after 60 days did not improve post partum fertility. Calf mortality was high with all three weaning ages tested. Suckling once or twice a day improved fertility and, although the former resulted in slower growth rates during the first 3 months, there was no difference from 4 months onwards. In conclusion, the results show that once a day as well as twice a day suckling can be adopted as suitable regimes to improve post partum fertility in indigenous buffaloes.

R-07 ABEYGUNAWARDENA, H., ABAYAWANSA, W.D. and PERERA, B.M.A.O. **A comparative study of reproduction and productive characteristics of indigenous swamp and exotic river buffaloes in Sri Lanka.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by B.M.A.O. Perera *et al.*] Colombo, Sri Lanka, NARESA Press 1996. pp 297-308. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The multipurpose, indigenous swamp buffalo (Lanka buffalo) forms an integral component of rural crop-livestock production systems. With a view to increasing the dairy characteristics of the indigenous buffalo population, exotic river buffaloes were imported into the country from time to time. They are maintained in state livestock farms and the progeny, primarily males, are issued to small holders for upgrading their indigenous animals. A retrospective study was undertaken by analysing farm records to assess the reproductive and productive performance of the three main exotic river types, Surti (S), Murrah (M), and Nili-Ravi (N) with those of the Lanka (L) buffalo. The mean values recorded for S,M,N and L respectively were: birth weight (kg) 27.1,27.6, 30.1 and 17.9; prepubertal growth rate (kg/d) 0.25, 0.46, 0.52, and 0.16; age at first calving (months) 51.8,55.0,52.1 and 44.9 and calving interval (days) 482, 510, 491, and 507. S,M and L showed a clear seasonal calving pattern with 69%, 68% and 68% of calvings respectively occurring during the period September to January. The mean lactation yield (litres) and lactation length (days) respectively were: 1003 and 267 in S; 1052 and 287 in M; and 1761 and 309 in N. In conclusion, all three exotic river type buffaloes maintained in large farms performed below the expected levels for the genotype in milk production as well as in reproduction. Of the three exotic breeds, N showed higher ($P<0.05$) milk production; the reproductive performance did not differ among breeds. This poor performance may be due to the sub-optimal management conditions, augmented by seasonal shortages of pasture and fodder. The indigenous buffaloes appear to reach sexual maturity early, suggesting that they attain optimum body weight at an earlier age than the river types.

R-08 ABEYGUNAWARDENA, H., PERERA, B.M.A.O and SIRIWARDANE, J.A.de S. **Reproduction in buffaloes and cattle.** SAREC/NARESA Buffalo Research and Development Programme, Leaflet No. 4, Publication No. 8, Colombo, SL. National Science Foundation Press, (1998) 6 pp. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This publication is a farmer's guide to improvement of the reproduction efficiency of buffaloes and cattle. The information provided includes a description of the sexual cycle, heat signs and the best time for insemination or mating of females in heat; a brief set of guidelines are provided on how to raise to ensure the attainment of sexual maturity at the optimum age and how to ensure that the first calving occurs early in life and a calf is born every year. A brief note is also provided on the value of maintaining records of important events in the farm.

R-09 ABEYGUNAWARDENA, H., PERERA, B.M.A.O., JEYARUBAN, M.G. and SIRIWARDENE, J.A.de S. **Breeding of buffaloes and cattle.** SAREC/NARESA Buffalo Research and Development Programme, Leaflet No. 5, Publication No. 9, Colombo, SL. NARESA Press, (1998). 8 pp. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, SL.

This is a farmers' guide on how to improve the production potential of the offspring of cows in the herd through breeding. The paper gives information on the desirable and undesirable characteristics of indigenous cattle and buffaloes and the importance of the application of appropriate breeding practices to ensure that the progeny of females have higher genetic potential for milk production under the different climate and management conditions. The reasons why it is important to make the right selection of the bull or semen is set out and the necessity to adhere to

breeding recommendations is emphasised. A brief description of the different breeding programmes recommended is given. An example on how to use the breeding values of the sire and the dam to calculate the expected performance of the progeny is provided.

R-10 ABEYGUNAWARDENA, H., ABAYAWANSA, W.D. and KADUWELA, S.C. **Post partum anoestrus in cattle and buffaloes: Experiences with hormonal therapy.** *Sri Lanka Veterinary Journal (1993)* **40,** (1) 31, [Abstract], Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Six clinical trials were conducted to test the effectiveness of hormones in inducing oestrus in anoestrous cattle and buffaloes. The strategy adopted in the treatments was to stimulate pituitary gonadotrophin secretion by exogenous hormones. In the first trial, 12 anoestrous buffaloes were given 2 injections of 250 μgm of GnRH, 24 hours apart to stimulate the pituitary directly. None of them responded. At the second trial 6 anoestrous buffaloes were primed with 4 mg of FSH, 12 hours before the GnRH injections with a view to stimulate the follicular growth. As this approach too was not effective, synthetic progesterone in a form of slow releasing device as an intra- vaginal (PRID) or sub-cutaneous ear implant (eg. synchromate-B or Crestar) was tested. Progestagen treatment was left for a 9 day period followed by PMSG treatment (300 to 500 IU on body weight basis) at the time of device removal. In one trial, either the PRID (n=14) and ear implant (n=13) was used on anoestrous buffaloes. Pregnancy rate following PRID was 57.14% while it was 92.31% in ear implant group. In another trial, 85 anoestrous zebu cattle, both exotic and indigenous, were treated with sub-cutaneous progestagen ear implant. The oestrus induction rate was 100%. However, the pregnancy rate at the induced oestruses was 37% and final pregnancy rate was 87%. Thirteen percent failed to conceive and their plasma progesterone profiles showed that they had gone into anoestrus following a short oestrous cycle and most of them were in poor body condition. In subsequent trails animals were selected on ovarian status and body condition. Animals (n=9) with good body condition (>2.5 in 0 to 5 scale) with few follicles in the ovary were treated with a single injection of 250 μg of GnRH, while animals (n=15) with body condition (>2.5) without follicles in the ovary were treated with progesterone and PMSG. Both treatments were effective in inducing oestrus in anoestrous animals but the oestrus induction rate was lower in the GnRH-treated group (55%) than in the progestagen treated group (100%). The results suggested that hormonal therapy in combination with proper selection on animals, on the basis of body condition and ovarian status, could be successfully used in fertility management in the cattle and buffaloes.

R-11 ABEYGUNAWARDENA, H., KURUWITA, V.Y., KARUNARATNE, A.M., ABAYAWANSA, W.D. and HERATH, J.C.B. **Factors limiting the reproductive performance of indigenous buffaloes.** *Sri Lanka Veterinary Journal* (1994) **41,** (1) 31-32 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The study was undertaken in an experimental station situated in the intermediate zone of Sri Lanka to determine the factors which limit the reproductive performance of indigenous buffaloes. Approximately 200 heads of indigenous buffaloes were maintained in a coconut plantation of 200 acres with improved and natural pasture. Free grazing was allowed and water source of wallowing was provided. A stud bull always ran with the herd. The animals were not milked. The average body weight at birth was 17.2 ± 2.3 kg and the average growth rate during the prepubertal period was 155 ± 37 gm per day. The average age at puberty was 1059 ± 106 days at an average body weight of 186 ± 25 kg which was about 70% of the mature body weight. The average age at first calving was 1320 ± 185 days. The average calving interval was 506 ± 157 days with about 50% of the intervals were less than 425 days. Calving was seasonal with approximately 72% of calvings occurring during the months of October to December coinciding with North-East monsoon rains. The calving to conception intervals were shorter in animals which calved in early in the calving season than those that calve late in the calving season. Post partum plasma progesterone profiles as estimated by radioimmunoassay of weekly blood samples from calving to conception showed that nearly all animals conceived at the first post partum oestrus. There was no association between calving to conception interval and parity. Unrestricted suckling by the young delayed the calving to conception interval while weaning by day 45-60 but not either by 60-90 days post partum resulted in shorter calving to conception interval. Restricted suckling, either once a day or twice a day both resulted in shorter calving to conception interval. Weaning at any stage as opposed to natural weaning in ad-libitum group, however, resulted in heavy calf mortality. Restricted suckling did not effect the growth rate of calves to a significant extent.

Results of this study suggest that smaller body weight at birth, delayed puberty and age at first calving and variable calving to first oestrous interval which is related to the time of calving in relation to

monsoon rain and unrestricted suckling by the young appear to be the major factors which limit the reproductive performance of indigenous buffaloes.

R-12 ABEYRATNE, A.S., ABEYWARDENA, S.A., KUMARASWAMY, S. and PERERA, B.M.A.O. **The effects of cervical penetrability, calving to insemination interval and time of insemination after cloprostenol treatment on conception rate in buffaloes.** *Ceylon Veterinary Journal* (1979) **27:** 33 [Abstract]. Department of Animal Production and Health, Peradeniya, SL.

In two separate trials, a total of 88 cycling buffalo cows of the river type were treated with two doses, given 11 days apart, of 0.5 mg cloprostenol (Estrumate I.C.I) intramuscularly. Fifty seven of these animals (Trial I) were artificially inseminated twice at 72 and 96 hours after the second injection of cloprostenol. At the time of insemination the cervix was easily penetrable in 39 (68.4%) of the animals and they were inseminated at or beyond the internal cervical os while the others (18 animals) were inseminated in the cervical canal. The first service conception rate diagnosed by rectal palpation at 90 days was 48.7% in those receiving deep insemination and 16.7% in the others. The conception rates for animals with calving to insemination intervals of 60 to 90 days,90 to 120 days and 120 to 150 days were 16.6%, 36.4% and 55.5%, respectively.

Thirty one animals (Trial 2) were inseminated only once following treatment; 15 of them at 60 hours and 16 at 72 hours after the second cloprostenol injection. The first service conception rates in those two groups were 13.3% and 43.7% respectively.

R-13 ABEYWARDENA, S.A., PATHIRAJA, N., MOTHA, M.X.J. and PERERA, B.M.O.A. **The accuracy of hormonal pregnancy diagnosis performed three weeks after service in buffaloes.** *Ceylon Veterinary Journal* (1979) **27:** 34 [Abstract]. Veterinary Research Institute, Gannoruwa, Peradeniya, SL.

Blood samples were collected 21 days after artificial insemination from 54 buffalo cows of the river type. Progesterone concentration in the plasma was determined by a radioimmunoassay technique. The animals were examined rectally for pregnancy 90 days after insemination. Based on the distribution of progesterone concentration at 21 days in animals subsequently found to be pregnant or non-pregnant at 90 days, two levels of discrimination were adopted. Those having more than 1000 pg progesterone/ml were classified positive, those with less than 700 pg progesterone/ml were classified negative and those in the intermediate range (700 to 1000 pg/ml) were considered doubtful. Twenty eight animals gave a positive result and 19 (67.9%) of them were found to be pregnant.

Twenty one animals gave a negative result and 20 (95.2%) of them were found to be non-pregnant. Five animals (9.3%) were within the doubtful range. Of the 22 animals found pregnant at rectal examination 19 (86.4%) had been correctly identified by the assay, while 20 (62.5%) of the 32 animals found to non-pregnant at rectal examination had been correctly identified by the assay. The incidence of false positive results was higher than that reported in cattle, and may reflect a higher occurrence of irregular oestrus cycles and late embryonic death in buffaloes. It was concluded that the greatest advantage of the progesterone test was in detecting non-pregnant animals at an early stage.

R-14 ABAYAWANSA, W.D. and ABEYGUNAWARDENA, H. **Comparative study of reproductive and productive characteristics of indigenous swamp and exotic river type buffaloes in Sri Lanka.** *Sri Lanka Veterinary Journal* (1995) **42,** (1) 30 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A comparative study was made of reproductive and productive characteristics of four buffalo breeds, namely indigenous, Surti, Murrah and Nili-Ravi, managed in large farms by analysing of farm records. Surti, Murrah and indigenous buffaloes showed seasonal calving pattern with peak calving during the period of September to January whereas Nili-Ravi showed year to year variations. For Surti, Murrah, Nili-Ravi and indigenous buffaloes, average calving intervals were 481.8 ± 157, 509.8 ± 183.6, 490.6 ± 126.0 and 506.8 ± 157.9 days respectively, the average birth weights were 27.1 ± 4.0, 27.6 ± 2.7, 30.1 ± 5.1 and 17.9 ± 2.8 kg, respectively. The average age at first calving were 51.8 ± 11.2 , 54.9 ± 7.9, 52.1 ± 9.6 and 44.9 ± 5.1 months, respectively. The average lengths of calving to first service were 149.32 ± 79.4, 177.4 ± 83.2 and 136.9 ± 90.7 days for Surti, Murrah and Nili-Ravi buffaloes, respectively. The average lengths of lactation were 267.3 ± 74.9, 286.6 ± 91.9, 308.9 ± 97.3 and 110.5 ± 20.6 days and the estimates of lactation yield were 1003.0 ± 390.9, 1052.1 ± 496.4, 1760.9 ± 581.4 and 120.5 ± 35.6 litres, respectively for Surti, Murrah, Nili-Ravi and indigenous buffaloes. In conclusion, all three exotic river type buffaloes maintained in large farm conditions performed below expected levels of the genotype in production as well as in reproduction. Out of three exotic breeds, Nili-Ravi buffaloes showed higher ($P<0.05$) milk production performance though the reproductive performance did not differ among breeds. This poor performances

may be due to the sub-optimal management conditions, augmented by seasonal availability of pasture and fodder. Although the milk production level was significantly lower, the indigenous buffaloes were superior ($P<0.05$) to that of exotic river buffaloes as they showed early sexual maturity as signified by early first calving.

R-15 ABAYAWANSA, W.D., ABEYGUNAWARDENA, H. AND PERERA, B.M.A.O. **Fertility and its relationship to bodyweight, body condition, milk yield and post partum length in synchronised and non-synchronised indigenous buffaloes.** *Sri Lanka Veterinary Journal* (1996) **43**, 26-27. [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This study examines the fertility rates and its relationship to the bodyweight, body condition score, milk yield and postpartum length in indigenous Lanka buffaloes at induced and natural oestrus under traditional management of a dry zone village.

The retention rate of progesterone ear implant was 98% and all animals showed oestrus at induction. Calving rate due to oestrus induction was 37.8% compared to 35.7% among untreated controls. Calving rates due to conceptions following natural oestrus were also same for both groups (treated 68.8%; control 67.85%). Low body weight, poor body condition, high milk yield and early breeding at postpartum were associated with reduced fertility rates in both treated and non-treated animals.

In conclusion, there was no difference in fertility rates of indigenous Lanka buffaloes at induced and natural oestrus. Reducing postpartum bodyweight loss and improving body condition through provision of better nutrition at breeding stage, popularising strategies of limited suckling or early weaning of calves among farmers, avoiding breeding at early postpartum, breeding on selection basis and stud bull service other than artificial insemination may increase the fertility rates of indigenous swamp buffaloes at hormonally induced or naturally occurring oestrus in order to optimise their milk production under the traditional farming system.

R-16 ALEXANDER, P.A.B.D., MUNASINGHA, D.M.S., GUNARAJASINGAM, D., ABEYGUNAWARDENA, H. and KURUWITA, V.Y. **Characterization of semen of indigenous swamp buffaloes in Sri Lanka.** In: *Proceedings of the Annual Research Sessions of the Faculty of Veterinary Medicine and Animal Science of University of Peradeniya 3 December,1994. Peradeniya, SL.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A study was undertaken to determine the semen characteristics in indigenous swamp buffaloes. Four indigenous swamp type buffalo bulls at the age of 3-5 years maintained at the university buffalo research farm were used for the study. Semen was collected using electro-ejaculator. Two semen samples at 4 days apart were collected. The probe of the electro-ejaculator which was capable of giving electrical impulses of increasing intensity of 1.5 second duration followed by 1.5 second pause and up to 32 cycles was introduced into the rectum. Most of the animal ejaculated by the 7^{th} or 8^{th} cycle. The semen was collected into a calibrated tube and volume was measured. Concentration of semen was measured manually (Burker-Chamber) as well as by using the photometer. Mass activity (wave pattern) and individual motility were evaluated using a microscope fitted with a warm stage (37°C). Nigrosin-Eosin stain was used to measure the live and dead count. Williams stain was used to study the head abnormalities. Formal saline treated sample was examined under phase contrast microscope to study the midpiece and tail abnormalities. The average volume of ejaculate was 7.4±3.6 ml, with a range of 4-14 ml. The colour of semen ranged from colourless, to white to yellowish. The gross motility expressed as wave pattern was low and on the average most of the samples received only 1+ in an ascending scale of 1+ to 4+s. The percentage of motility was always above 90% (80-95%). The concentration of spermatozoa was $195x10^6$ per ml with a range of $40x10^6$/ml to $289x10^6$/ml. The average live spermatozoa as expressed as percentage was 94.5% with a range of 91-98%. The average number of head abnormalities was 17.6% with a range of 9-34%. The most commonly observed head abnormalities were abaxial heads (3.1%), narrow heads at the base 2%, loose heads 1.6%. The mid piece and tail abnormalities, respectively were 5.5% (1-10%) and 11.2% (3-21%). The most commonly observed midpiece and tail abnormalities were proximal cytoplasmic droplet (1.6%) and single bent tails (5.5%).

R-17 BALASUNDARAM, P., PERERA, B.M.A.O. and KANDADDARAGE, S. **Ovarian response to gonadotrophin-releasing hormone in post-partum buffalo cows.** *Ceylon Veterinary Journal* (1981) **29:** 31 [Abstract]. Department of Animal Production and Health, Peradeniya, SL.

Thirty-eight non-cycling post-partum Murrah cows were selected for the study; 20 of these had calved 30 - 60 days previously (Group I), while the remainder had calved 60 to 90 days previously (Group II). Two intramuscular injections of 0.125 mg gonadotrophin releasing hormone (Gn-RH)

were given four hours apart on day 0 to half the number of cows in each group; the remainder served as controls. The animals were examined per rectum on days 0, 2, 7, 11, 22 and 28. Four treated and four control cows from each group were blood-sampled on the days of rectal examination, and serum progesterone was measured by radioimmunoassay.

Rectal palpation revealed that six treated and four control in Group I, and five of the treated as well as control cows in Group II, commenced ovarian activity during the trial. Of the 16 cows that were blood-sampled, the results of progesterone measurement and rectal palpation corresponded closely in 10 and disagreed only slightly in two; in four cows, the results were at variance in that corpora lutea could be palpated when progesterone level was basal, or elevated progesterone levels were measured without rectally palpable evidence of ovarian activity. Under the conditions of this study, intramuscular administration of Gn-RH did not significantly increase the proportion of cows commencing post-partum ovarian activity.

R-18 BONGSO, T.A., KUMARATILAKE, W.L.J.S. and BUVANENDRAN, V. **The karyotype of the indigenous buffalo (*Bubalus bubalis*) of Sri Lanka.** *Ceylon Veterinary Journal* (1977) **25,** 9-11. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A study on the indigenous buffalo was undertaken to determine whether the karyotype of the indigenous buffalo and establish whether it is genetically similar to the swamp type of other countries. The Asiatic swamp and Murrah buffaloes are reported to have diploid chromosome numbers of 48 and 50 respectively.

Jugular venous blood (5 ml each) was aspirated from 2 male and 2 female indigenous (swamp) buffaloes using heparinised disposable syringes and needles. The somatic chromosomes of the indigenous buffalo in Sri Lanka were studied using the whole blood culture method. A diploid number of 50 was observed which were similar to that found in the river buffalo (Murrah) of Sri Lanka. This report also shows that the karyotype of the Sri Lanka indigenous buffalo is different from that of the Australian and other Asian swamp buffaloes. Although the Sri Lanka buffalo had been classified as the swamp type based on phenotype and habitat, on the basis of similarity in karyotype it would be more appropriate to classify it as the river type. The similarity in chromosome number and structure between the Sri Lanka swamp buffalo and Murrah indicates that a cross breeding or upgrading programme involving the two breeds can be undertaken without danger of loss of fertility arising from incompatibility in chromosome number or morphology. The result of this study highlights the fact that a taxonomic classification of a species may have to be based both on the cytogenetic status and behavioural patterns.

R-19 BONGSO, T.A., KUMARATILEKE, W.L.J.S. and BUVANENDRAN, V. **The cytogenetic status of the swamp buffalo in Sri Lanka.** *Ceylon Veterinary Journal* (1978) **26,** 55 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

In many Southeast Asian countries such as the Philippines, Malaysia and Indonesia, crossbreeding of the local swamp with Indian river buffaloes (Murrah) is being undertaken in order to improve milk production. The F1 hybrids of the Murrah x swamp of these countries possess a chromosome complement of 2n = 49, (intermediate to the parental types) which, some writers claim, causes problems in fertility. Observations made on large number of crossbreds of the F1 and backcross generations of the Murrah x swamp buffaloes of Sri Lanka, however, have shown that all grades of crosses have fertility levels comparable to the pure Murrah. A study was therefore undertaken to determine the karyotype of the swamp buffalo of Sri Lanka and compare its cytogenetic status with its Southeast Asian counterparts. Chromosome analysis of lymphocyte cultures carried out on 2 male and 2 female swamp buffaloes revealed a diploid number of 50, which was similar to that reported in the river buffalo (Murrah). The present study also demonstrated that the karyotype of the Sri Lanka swamp buffalo was different from that of the Australian and other Asian swamp buffaloes. Hence this indicates that crossbreeding programmes involving the Indian Murrah and Sri Lankan swamp can be undertaken without danger of loss of fertility arising from incompatibility in chromosome number or morphology. It is hypothesised that the Sri Lanka swamp buffalo originated from the river type.

R-20 DE SILVA, L.N.A., PERERA, B.M.A.O., TILAKARATNE, N. and EDQUIST, L.E. **Methods and preliminary results of survey on reproductive patterns and management of indigenous buffaloes.** *Ceylon Veterinary Journal* (1981) **29,** 31 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A field survey was initiated to determine the reproductive patterns of the indigenous buffaloes in Sri Lanka in relation to different environmental conditions, management practices and intensity of utilisation. The sampling schedule was designed to include 1% of the national buffalo population. The top-ranking 16 districts, based on intra-district buffalo population, were selected; a number of veterinary ranges was included from each district

such that all agro-ecological zones were represented. Buffalo farmers were visited, a questionnaire administered and stock numbers verified. Wherever possible, the breedable females were examined per rectum to determine their reproductive status.

The preliminary results presented here based on 6457 buffaloes belonging to 224 farmers in Kurunegala (K), Anuradhapura (A), Polonnaruwa (P), Trincomalee (T), Batticaloa (B) and Hambantota (H) districts. The herd size ranged from 16.9 in K to 53.3 in H. The male: female ratios were 1: 1.2 in A, P and H,1.4 in K and T, and 1.5 in B. Of the 2616 breedable females, 662 were examined per rectum; 37.5, 54.0, 46.8, 53.8, 58.3 and 48.0% of those examined in K, A, P, T, B and H, respectively, were pregnant while 45.5 26.4, 35.5, 28.8, 25.9 and 34% were non-cycling. In all six districts, the proportions of non-pregnant cycling animals were remarkably similar, ranging from 16.7 to 19.5%. Incidence of pyometra, endometritis and cystic ovaries was very low.

The percentage of farmers utilising buffaloes for milk at K, A, P, T, B and H were 13, 81, 71, 76, 100 and 95 respectively. More than 80% of the farmers used their buffaloes for ploughing and threshing in all districts except that in H, they were used mainly for puddling. The major constraints were inadequacy of grazing lands and high mortality in young stock due to parasitism and haemorrhagic septicaemia.

R-21 De SILVA, L.N.A., PERERA, B.M.A.O., TILAKARATNE, N. and ARIYAKUMAR, V. **Management patterns and reproductive performance of Lanka buffaloes in different regions of Sri Lanka.** *Sri Lanka Veterinary Journal* (1982) **30,** 35 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A field survey was conducted to determine the reproductive patterns and performance of indigenous buffaloes in relation to environment, climate, management, nutrition and intensity of utilisation for milk and draught. The sample included 11,881 buffaloes belonging to 508 holdings in 16 districts of Sri Lanka. In each district the sample was proportional to the buffalo population of that district; several veterinary ranges were included such that all agro-ecological zones were represented. Buffalo farmers were visited, a questionnaire administered and stock numbers physically verified. Of the breedable females in the sample, 1300 were examined per rectum to determine their reproductive status.

The districts surveyed were Ampara (Am), Anuradhapura (Ap), Badulla (Bd), Batticaloa (Bt), Gampaha (Ga), Hambantota (Ha), Kalutara (Kl), Kandy (Kd), Kegalle (Ke), Kurunegala (Ku), Matale (Ml), Matara (Mt), Polonnaruwa (Po),. Puttalam (Pu), Ratnapura (Ra), and Trincomalee (Tr). The values given below for each variable are the means of all districts with the minimum and maximum district means in parenthesis. Herd size was 22.5 (5.3 at Kd - 53.6 at Ha). Male to female ratio was 1.26 (0.8 at Mt - 2.2 at Am). Of the breedable females examined rectally, 45.0% were pregnant (27.5% at Mt - 65.1% at Pu), 19.9% were non pregnant but cycling(14.8% at Bd - 28.6% at Kl) and 35.0% were non cycling (18.3% at Pu - 54.9% at Mt). The annual birth rate was 57.8% (31.2% at Kd - 74.6% at An) and the calving interval 24 m (16 at Pu - 38 at Mt). Percentage annual mortality was 22 (9% at Po - 40% at Kl) for those below one year of age, 15% (0% at Ka - 43% at Ha) for those between 1 and 2 years and 6% (3% at Pu and Tr - 12% at Po) for adults.

R-22 De SILVA, L.N.A., PERERA, B.M.A.O., TILAKARATNE, L. and EDQUIST, L.E. [Editors] **Production systems and reproductive performance of indigenous buffaloes in Sri Lanka** Uppsala, Sweden., Swedish University of Agriculture Science, (1985) 142 pp. ISBN 9157622507 Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A field survey was conducted on the indigenous buffalo of Sri Lanka, to determine the systems of their management, patterns of utilisation and reproductive performance and the interrelationship among these factors. The sample comprised 11,863 buffaloes (little more than 1% of national population) belonging to 528 holdings distributed in 16 of the 24 districts of the country. A sample representing approximately 1% of the buffalo population was obtained from each of the following districts: Ampara (A), Anuradhapura (An), Badulla (Bd), Batticaloa (Bt), Gampaha (Gm), Hambantota (Ht), Kalutara (Kl), Kandy (Kd), Kegalle (Ke), Kurunegala (Kn), Matale (Ml), Matara (Mt), Polonnaruwa, (PO), Puttalam (Pu), Ratnapura (Rp) and Trincomalee (Tr). Several veterinary ranges were included such that the different agro ecological zones (AEZZ) were represented. Buffalo farmers were visited, a questionnaire administered and stock numbers were physically verified. Rectal examination was done on 1300 breedable females in the sample in order to determine their reproductive status.

Almost all of the buffalo farmers were primarily engaged in paddy cultivation in small holdings, and supporting an average of 7.5 people. Their resources in terms of land, capital and stock were limited. Buffaloes were managed extensively (free grazing only) or semi extensively (tethered with or without free grazing). Former system was

practised in the Dry Zone and the Intermediate Up Country regions whereas in Intermediate Low Country, Intermediate Mid Country and Wet Mid Country zones, the latter practice was predominant. The main source of feed consists of low quality herbage obtained from grazing. Paddy straw is fed in some regions during periods of fodder shortage. No supplementary concentrate feed is provided. The overall average herd size was 22.5 ranging from 5.3 (Kd) to 53.6 (Ht). On average a herd was composed of 17.1%, of 0-1 year, 13.0% of 1-2 year, 9.1% of adult heifers, 32.9% of cows, 14.9% of castrated males and 13.1% of entire males. Main use of buffaloes was in tillage. On average 92% of the farmers used their animals in land preparation (ploughing / puddling / levelling) for paddy cultivation and 82% used in threshing the harvest. The mean age of initial use was 3.1 yr and 82.9% farmers used for both male and females. Number of buffalo days required to plough one acre of land varied from 4.0 to 7.8. Puddling generally required twice as many buffalo days as with ploughing. The mean duration of work was 52.3 days/year. This was fairly consistent throughout the country. Proportion of farmers using buffaloes regularly for milk production was only 14%. This covered only 13% of the buffalo cow population. Milk production from buffaloes was mostly restricted to Tr, Bt, An, Ht, Rp, Mt and Kl in which districts more than 60% of herds were being used for this purpose. The overall milk yield was 1.5 litres/day and lactation length 5-6 months.

There was general agreement between the information on reproductive performance provided by farmers and the findings on rectal examination. The overall means of the respective variables were: age at first calving = 45.7 months, annual calving rate = 57.8% and calving interval = 18.9 months. Rectal examination revealed 56.5% to be pregnant, 17.4% to be non pregnant but cycling and 26.1% non pregnant and non cycling. These variables were, however, found to vary significantly among districts, AEZZ and according to systems of management and utilisation. Fertility was found to be comparatively higher in milking, limited suckling (calf separated during part of the day), and non working groups of buffaloes. Haemorrhagic septicaemia and gastro intestinal parasitism were reported to be the major disease problems. Proportion using vaccination to control infectious diseases was 64.9%. Percentage of annual mortality were 25.4, 21.5 and 8.0% among age groups of 0-1 year 1-2 year and adults, respectively.

R-23 DHARMASENA, L.D.P. and RAJAMAHENDRAN, R. **Preservation of buffalo semen at -196^0 C.** *Ceylon Veterinary Journal* (1980) **28,** 63 [Abstract]. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

The objective of this trial was to evaluate the suitability of citric acid-whey (CAW) and TRIS buffer diluent for the preservation of buffalo semen at -196^0 C. Semen was obtained from 4 Murrahs, 3 Surtis and one local indigenous buffalo. In all, 47 ejaculates were processed and each ejaculate was divided into two and diluted with either CAW or TRIS buffer. Motility and percent dead sperm were checked soon after dilution, equilibration and at 0, 24 and 96 h after freezing. This experiment has shown that buffalo semen can be successfully deep frozen. No difference was observed in the motility and percent dead sperm after dilution and equilibration in the two diluents. However, post-thaw motility with TRIS at 0, 24, and 96 h after freezing was significantly better than with CAW. Field inseminations were carried out using frozen semen and success rates determined.

R-24 GUNARAJASINGHAM, D. and RAJAMAHENDRAN, R. **Testosterone secretion in young and adult buffalo bulls.** *Sri Lanka Veterinary Journal* (1982) **30,** 34 [Abstract]. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

There is a paucity of information concerning (a) the episodic of testosterone (T) in adult buffalo bulls (b), and the relationship between age and T profile, and (c) the response of Leydig cells to Gonadotrophin - Releasing Hormone (Gn-RH) administration in different age groups. In the present study, two experiments were conducted to provide information regarding T profile in adult buffalo bulls, and T secretion before and after Gn-RH administration in buffaloes of different age groups. Serum T ranged from 0.2 to 2.7 ng/ml during a 24 hour collection period in three mature bulls. They had an average of 2.2 peaks during a 24 hour period. Serum T levels were significantly ($P<0.5$) higher during November (rainy season) compared with February (dry season). Significantly lower ($P<0.05$) T concentration was observed during night (0.43 ± 0.05 ng/ml) than during day (0.73 ± 0.14) time. T levels ranged from 0.2 to 0.6 ng/ml in 1 to 36 m old bulls. Gn-RH did not elicit a T response in one month old bulls, and the highest response being elicited in 36 m old bulls.

R-25 GUNARAJASINGAM, D., ABEYGUNAWARDENA, H., KURUWITA, V.Y. and ABEYGUNAWARDENA, W.W. **Evaluation techniques and characteristics of semen of buffalo bulls.** In: *Proceedings of the Annual Research Sessions of the Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, 3 December, 1994.*

Peradeniya, SL, pp 17. University of Peradeniya, Peradeniya, SL.

A study was undertaken to develop and standardise the laboratory techniques for semen evaluation and to characterise the semen of exotic river type Nili Ravi buffalo bulls which have been introduced to artificial breeding programme. Semen samples were collected using an artificial vagina at weekly interval from three Nili Ravi buffalo bulls of 5 to 6 years of age over five months period. Following the initial evaluation of semen for volume, colour, density, mass activity and motility, detailed evaluation was done using the following standardised technique; differentiation of live and dead sperms using Nigrosine-Eosin (N/E) stain, head abnormalities using William's stain, acrosomal, mid piece and tail abnormalities by direct examination of semen samples diluted in formal saline under phase contrast microscope and cells other than sperms, by using Haematoxylin Eosin stain.

The total volume and concentration of semen ranged from 0.5 to 9.0 ml with the mean of 3.12 ± 1.90 ml/ejaculate and 440 to 2490 million sperms with the mean of 1359.26 ± 420.98 million/ml semen, respectively. The colour of the semen samples varied from cloudy to creamy. Mass activity and motility of sperms ranged from 2± to 4± and 70 to 90 percent respectively. The range of dead sperms were 2 to 18 percent. Percentage of head, mid piece and tail abnormalities respectively were 2.78 ± 1.13, 3.11 ± 1.24 and 6.83 ± 3.04. Only desquamated epithelial and spermatogonial line cells were found in the ejaculates. The values of the above parameters were varied within and among bulls during the study.

In conclusion, the comparison of values of this study with the values referred elsewhere showed that the techniques developed here are suitable for the semen evaluation programme and yet more work need to be undertaken to determine the upper and lower limits of various seminal parameters for the need of routine semen evaluation programmes.

R-26 GUNARAJASINGAM, D., ABEYGUNAWARDENA, H., KURUWITA, V.Y., PERERA, E.R.K. and PERERA, B.M.A.O. **Seasonal variations in seminal and testicular characteristics in buffalo bulls.** In: *The Role of the Buffalo in Rural Development in Asia* [Edited by Perera B.M.A.O. et. al] Colombo, Sri Lanka, NARESA Press (1996) pp. 309-320. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, SL.

Studies were conducted in buffalo bulls (*Bubalus bubalis*) to determine whether seasonal factors influence testicular, endocrine and seminal characteristics. In study 1, three Nili-Ravi bulls maintained as semen donors at the Central Artificial Insemination Centre at Kundasale were used. Semen samples (n=132) were collected using an artificial vagina at weekly intervals for twelve months and evaluated for volume, colour, density, mass activity, motility and concentration. Monthly collections (n=36) were used to study live and dead status (Nigrosin-Eosin stain), sperm morphology (unstained or stained with modified William's stain) and cells other than sperms (Haematoxylin-Eosin). The monthly average volume of semen ranged from 1.1 ± 0.1 to 7.0 ± 2.2 ml/ejaculate (mean 2.9 ± 1.9) and concentration from 607 ± 186 to 2050 ± 353 million/ml (mean 1389 ± 567). The colour of semen varied from cloudy to creamy and density from 2D to 4D. Mass activity and motility of sperms ranged from 2+ to 4+ and 70 to 90% respectively. Percentage dead sperms ranged from 2 to 24 (mean 8.2 ± 5). Percentage of head, mid-piece and tail abnormalities were 3.3 ± 1.8, 3.2 ± 1.6 and 7.0 ± 4, respectively. Desquamated epithelial and spermatogonial line cells were also found (1 to 2 cells per microscopic field). Motility percentage showed significant monthly variation ($P<0.05$) with three peaks during January (88%), May (89%) and August (90%). No significant variations were observed in the other characteristics.

In study 2, seasonal changes in testicular morphology were examined in indigenous buffalo bulls during hot (August) and wet (December) seasons. Testes were removed at 3 - 4 years of age (n=3 per season), tissue samples taken from three locations, were preserved in Bouin's solution, processed and stained with H-E stain. The mean diameters of seminferous tubules (n=30 per testis) during the months of August and December, respectively were 177.2 ± 15.2 μm and 193.7 ± 14.2 μm, and this difference was significant ($P<0.01$). However, no difference due to season were detected in the relative frequencies of the seminiferous epithelial cycle.

R-27 JAYATILAKA, T.N., RAJAMAHENDRAN, R., DHARMAWARDENE, J. and THAMOTHARAN, M. **Synchronization of oestrus in buffaloes.** *Ceylon Veterinary Journal* (1978) **26,** 54 [Abstract].Post graduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

Researchers have shown that prostaglandins and the 12-day progesterone intravaginal device treatments are both effective in synchronising oestrus in cattle. However, limited information is available on the use of the above agents in buffaloes. Hence, a study was conducted on 34 Surti buffaloes to determine the feasibility of synchronising oestrus using Prostaglandin $F_{2\alpha}$ (PG $F_{2\alpha}$) and a 12-day progesterone intravaginal device.

Eighteen cycling buffalo cows having functional corpora lutea treated with a single intramuscular injection of 30 mg of $PGF_{2\alpha}$. The oestrous response and pregnancy rates following treatment were 16.6% and 11.1%, respectively. Sixteen randomly selected non-pregnant buffalo cows were treated with a silastic intravaginal device impregnated with 7% progesterone, for 12 days. Ten mg of oestradiol 17-β in 5 ml either was also injected at the time of insertion of the device. The retention rate under field conditions was 72.7% and 100% when housed. Seventy one percent returned to oestrus within 4 to 5 days after removal of device. The mean interval to oestrus was 102.57 ± 11.6 hours. The fertility rate has not been completely assessed yet. The results indicate that short term progesterone intravaginal treatment is more reliable than the single dose of $PGF_{2\alpha}$ treatment for synchronising oestrus in buffaloes.

R-28 JALATGE, E.F.A. and BUVANENDRAN, V. **Statistical studies on characters associated with reproduction in the Murrah Buffalo in Ceylon.** *Tropical Animal Production and Health* (1971) **3,** 114-124. Veterinary Research Institute, Peradeniya, SL.

The objectives of this paper is to present some phenotypic parameters associated with reproduction of the Murrah buffalo in Ceylon and to assess the influence of season on these traits.

Records of 951 buffalo births on Livestock Farm at Ridiyagama during an 11 year period (1955-1965) were analysed. Ridiyagama is situated at an elevation of 18 meters above sea level and the mean annual rainfall is about 117 centimetres over half of which is precipitated during October to January. Temperatures range from 85° F to 88° F. The pastures contain a mixture of *Brachiaria brizantha* and *Brachiaria mutica* species. Coconut cake and rice bran are also fed as concentrates. Stocking rates vary from one cow to every acre to one cow for every two acres. Weaning of calves was done at the age of six months.

The average age of dam at first calving ranged from 37-86 months. The season of birth of dam had a significant effect on the age at first calving. The mean calving interval was 551.4 ± 5.5 days. The season of calving had a marked influence on the calving interval. The gestation period was 308.7 ± 0.75 days. Sex of the calf did not have a significant effect on this character.

R-29 KAKER, M.L. **A review of biochemical factors for poor preservation of buffalo semen.** *Ceylon Veterinary Journal* (1972) **20,** 102-105. Department of Veterinary Physiology, College of Veterinary Medicine, Haryana Agricultural University, Hissar, India.

Biochemical composition of buffalo semen has been compared with bull semen. Buffalo semen has more total phosphorus, acid and alkaline-phosphatases, calcium, chloride and less initial fructose, fructolytic index, citrate, sodium, potassium and magnesium as compared to bull semen, which creates conditions adversely influencing the viability of stored semen in this species.

Of the various diluents used for buffalo semen preservation, it has been shown that the following are satisfactory; Tris buffer with glucose and glycerol; IVT and CME; Glucose bicarbonate yolk with sulphamezathine; Milk diluents; Egg yolk citrate and Egg yolk phosphate diluents. Biochemical factors for poor preservability of buffalo spermatozoa have been discussed.

R-30 KARUNARATNE, A.M., KURUWITA, V.Y. and PERERA, B.M.A.O. **Physiological and endocrinological changes associated puberty in cross bred (Murrah X Lanka) buffalo males.** In: *Proceedings of the Sri Lanka Veterinary Association 11-12 December, 1987, Kandy, SL,* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Eight cross-bred (Murrah x Lanka) males calves were used to study the development of physiological and endocrinological parameters during the puberty. The calves were reared under identical management systems. Physiological measurements such as body weight, height, chest girth. width of testes, epididymides and scrotal circumference were recorded at monthly intervals. Blood samples were obtained by jugular venipuncture every month for determining longitudinal hormone secretory patterns. The maturation of the pituitary was judged by administering a constant dose of GnRH (0.5 μg/kg) at the ages of 6, 12, 15, 17 and 19 months and monitoring plasma testosterone levels. Castrations were done at the ages of 12, 15, 17 and 19 months and samples of testis and epididymis were taken for histological studies.

There was very high correlation between age and the other physiological parameters; height, body weight, scrotal circumference, chest girth, testicular diameter and epididymal width (r=0.93, 0.97, 0.83, 0.93, 0.82 and 0.89, respectively).

The longitudinal testosterone secretory pattern was similar in all animals with values between 0.03 ng/ml and 0.27 ng/ml. A transient prepubertal rise in mean plasma testosterone levels were detected between 5-6 months and at 12 months.

The testicular response to GnRH injections were minimal at 6 months (peak 0.13 ng/ml at 90

minutes) while it was 0.32 ng/ml at 12 months of age. Histological studies revealed that mature sperms appeared in the seminiferous tubules at 17 months of age.

R-31 KURUWITA, V.Y., PERERA, B.M.A.O., KARUNARATNE, A.M., MOHAN, V. and VAN DE WIEL, D.F.M. **The application of an enzyme immunoassay technique for measurement of progesterone in buffalo plasma.** *Sri Lanka Veterinary Journal* (1985) **33,** 39 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The technique used hitherto in Sri Lanka for measurement of reproductive hormones in domestic animals has been a radioimmunoassay (RIA). Although highly sensitive and accurate, it involves the use of radioisotopes and requires expensive equipment. Therefore a new technique termed enzymeimmunoassay (EIA) was tested for its applicability in measuring plasma progesterone using a microtitre-plate method.

Microtitre plates were coated in the Netherlands with gamma globulins raised in rabbits against progesterone 7 a-carboxyethyl-thioether-BSA. They were sealed, sent by air to Sri Lanka and stored at 4^0 C until used. Plasma samples (0.1 ml) collected from buffaloes during the post partum period, early pregnancy and the peripartal period were extracted with 2 ml petroleum ether, dried and resuspended in 1.0 ml assay buffer. Duplicate aliquots of 0.1 ml and a series of progesterone standards (0-20 pg), were placed in the wells of the microtitre plate and incubated with Horse-radish peroxidase coupled to 6 b - OH - Progesterone hemisuccinate for 75 min in dark at 37^0 C. The supernatants were decanted and after washing the wells with Tween-80, the substrate solution (H_2O_2 and tetramethyl benzidine) was added. After 40 min incubation at room temperature the reaction was stopped by adding 2N H_2SO_4 and the optical density was measured in a spectrophotometer at 450 nm.The concentrations of progesterone measured by this method ranged from 0.04 to 0.35 ng/ml in post partum acyclic buffaloes, and from 0.4 to 2.0 ng/ml in pregnant animals. Sequential samples measured by the RIA and EIA showed parallel changes in hormone concentration, although the values from the latter method were consistently lower. It is concluded that EIA is a cheap and rapid method for measurement of progesterone, and should be further validated for routine use.

R-32 KURUWITA, V.Y., CHANDRATILEKA, D., MOHAN, V. and PERERA, B.M.A.O. **Criteria used for diagnosing the stage of pregnancy by rectal palpation in Lanka buffaloes.** *Sri Lanka Veterinary Journal* (1987) **35,** 39 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Rectal palpation has been used as a reliable method for diagnosing pregnancy in cattle during the last four decades. Buffaloes can also be examined for pregnancy by rectal exploration of the genital tract. Since there are no specific guidelines available for assessing stage in pregnancy in buffalo cows, a comparison is usually done with the information available in the rectal findings in cattle. However buffaloes are known to have longer gestation period (316 days for Lanka buffaloes) and a diagnosis made on the guidelines which exist for cattle is always approximate. In this experiment 50 Lanka buffalo cows from two research farms were monitored recently at biweekly intervals for the changes in the uterus and associated structures throughout pregnancy. The results indicate that major differences do exist in development of rectally palpable structures in these two species. Hence a guideline in assessing the stage of pregnancy of buffalo cows is presented.

25 -40 days: Uterus in pelvic cavity; asymmetry of uterus horns, with pregnant horn 3-4 cm in diameter; membrane slip may be present and amniotic vesicle may be palpated.

60 days: Uterus at pelvic brim; pregnant horn 6 - 8 cm in diameter; membrane slip, amniotic vesicle present; cotyledons start to appear (1 cm).

90 days: Descent of uterus begins; pregnant horn 10-12 cm in diameter; hypertrophy of middle uterine artery (MUA) begins; cotyledons 1 x 2 cm.

120 days: Uterus mostly in abdominal cavity; foetus can be ballotted; cotyledons 1.5 x 2 cm; M.U.A. about 1 cm in diameter with amplitude mainly on pregnant side.

150 days: Uterus in abdominal cavity; foetus can be ballotted or palpated; M.U.A. 1 cm in diameter cotyledons 2 x 2 cm;

180 days: Descent of uterus completed; foetus can be ballotted in the abdominal cavity; fremitus begins on the pregnant side (M.U.A. 1 - 1.5 cm in diameter); cotyledons 2 x 3 cm.

210 days: Foetus palpable in the abdominal cavity; M.U.A. on pregnant side 1 - 2 cm in diameter and fremitus present, while on the other side it is 0.5 - 1 cm in diameter with increased amplitude; cotyledons 3 x 4 cm.

240 days: Foetus palpable near the pelvic brim; M.U.A 1.5 - 2 cm in diameter on pregnant side with fremitus present; cotyledons 3 x 5 cm.

270 days: Foetus palpable in the pelvic or abdominal cavity; M.U.A. 1.5 - 2 cm in diameter on pregnant side, and 1 cm on the other side; fremitus present on both sides; cotyledons 5 x 3 cm.

300 days: Large head of foetus palpable in pelvic cavity; suckling and pain reflexes present in the foetus; fremitus present on both sides; but may not be felt due to the presure on vessels by the ascending foetus; M.U.A., 1.5 - 2 cm in diameter; cotyledons 2 x 6 cm.

R-33 KURUWITA, V.Y., KARUNARATNE, A.M. and PERERA, B.M.A.O. **Physiological and endocrinological changes associated with puberty in cross bred (Murrah X Lanka) buffalo males.** In: *Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka 7-10 March, 1989. Kandy, SL.* pp. 23-24. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Eight cross-bred (Murrah x Lanka) male calves were used to study the development of physiological and endocrinological parameters during puberty. The calves were reared under identical management systems. Physiological measurements such as body weight, height, chest girth, width of testis, epididymides and scrotal circumference were recorded at monthly intervals. Blood samples were collected by jugular venipuncture every month for determining longitudinal hormone secretory patterns. The longitudinal hormonal data were further supplemented by performing short profiles for four hours at 15 minutes intervals at the age of 6,1 2, 15, 17 and 19 months. The changes in the functional capacity of the pituitary and testis were determined by administering a constant dose of Gn-RH (0.5 μg/kg) in the short profile sampling regime. Castrations were done at the ages of 12, 15, 17 and 19 months and samples to testis and epididymides were taken from histological studies.

The height, body weight, chest girth, scrotal circumference, testicular diameter and epididymal width were positively correlated with age (r = +0.93, +0.97, +0.83, +0.82 and +0.89, respectively). A transient rise in mean plasma testosterone concentration were detected between 5-6 months, and 12 months. Plasma Testosterone concentration at 90 minutes post-GnRH injection was 0.013 ng/ml, 0.32 ng/ml. 0.73 ng/ml and 0.31 ng/ml at 6, 12, 15 and 17 months of age. Normal spermatozoa appeared in the seminiferous tubules at the age of 17 months.

R-34 KURUWITA, V.Y. **Physiological and endocrinological changes associated with puberty in cross bred (Murrah x Lanka) male buffalo calves.** In: *Proceedings of the International Buffalo Congress, 27-30 June, 1994. Sao Paulo Brazil.* pp. 510-513. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Thirty cross bred (Murrah x Lanka) male buffalo calves of 2-4 months age were reared under the same management conditions at a research station to study the physiological and endocrinological changes associated with puberty. The pastures available were *Brachiaria miliformis* and *Brachiaria rhuziensis* under coconut plantation. The animals were free grazed during the day and were housed in the night.

Physiological measurements such as body weight (BW), height (H) chest girth (CG) and the width of the testes (WT) were very closely related to the age ($p<0.001$). The longitudinal hormonal secretory pattern of testosterone was seen to increase gradually with age and levels ranged between 0.042-0.177 ng/ml. An overall increase was recorded at 12 months of age while a transient rise was detected between the age of 5-6 months. The testicular responses to exogenous GnRH were evident at 6, 12, 15 and 18 months of age. The response was quicker and higher at 15 months which was two months prior to the appearance of mature spermatozoa in the seminiferous tubules. The results indicate that (Murrah x Lanka) cross bred buffaloes reach puberty at age of 17 months but attains sexual maturity later.

R-35 KOMORI, M., PERERA, E.R.K., PERERA, A.N.F. and RAJAGURU, A.S.B. **Productive and reproductive performances of Nili-Ravi buffaloes in Sri Lanka** *Journal National Science Council Sri Lanka* (1994) **22,** (2) 201-211. Department of Veterinary Anatomy, Obiniro University of Agriculture and Veterinary Medicine, Obibiro, Japan.

The productive and reproductive performances of imported Nili-Ravi buffaloes were evaluated under Sri Lanka condition. The mean calving interval between the 1st and the 2nd calvings was 453.9±56.1 (S.D.) days. The mean interval between a calving and the 1st service was 134.2±93.1 days. The mean birth weight for male and female were 30.5±4.52 kg and 28.6±4.58 kg, respectively. The average daily weight gains for male and female up to 1 year of age were 0.50 kg and 0.43 kg, respectively. The mean lactation milk yield after the 1st parturition was 1698.1±451.3 kg and the mean length of the 1st lactation was 291.4±75.2 days. The findings suggested that the interval between a calving and the 1st service and the birth weight were affected by environmental factors, particularly rainfall.

R-36 KUMARATILAKE, W.L.J.S., PATHIRAJA, N., PERERA, B.M.A.O. and TILAKARATNE, N.

Synchronisation of oestrus in buffaloes *(Bubalus bubalis)* using prostaglandin $F_{2\alpha}$. *Research in Veterinary Science* (1977) **22,** 380-381

Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) was used intramuscularly (IM) in two preliminary trials to determine its effect in cycling buffalo cows. In the first trial, animals with corpora lutea in their ovaries responded to either two doses of 15 mg on two consecutive days, or to a single dose of 30 mg, by showing signs of oestrus commencing 31 to 55 h after the initial injection. In the second trial two doses of 30 mg $PGF_{2\alpha}$ given 11 days apart resulted in oestrus on the third day after the second injection. The results indicate that an IM dose of 30 mg $PGF_{2\alpha}$ is effective for inducing luteolysis in buffaloes. The two injections eleven days apart were effective in achieving a high degree of oestrous synchronisation.

R-37 LUNDSTROM, K., ABEYGUNAWARDENA, H., DE SILVA, L.N.A. and PERERA, B.M.A.O. **Environmental influence on calving interval and estimates of its repeatability in the Murrah buffalo in Sri Lanka.** *Animal Reproduction Science* (1982) **5,** 99-109. Department of Animal Breeding and Genetics, Swedish University of Agricultural Science, 5-750, Uppsala, Sweden.

Data on 2375 calvings in 726 Murrah buffalo cows were analysed for the period 1968 to 1979 on two state farms (Ridiyagama and Polonnaruwa) in the dry zone of Sri Lanka. The mean ages at first calving were 51.0 (S.D. 8.6) and 52.1 (S.D. 10.5) months, the calving intervals 530.6 (S.D. 168.2) and 538.6 (S.D. 166.7) days, and the repeatabilities of calving intervals 0.36±0.02 and 0.43±0.02 for the two farms, respectively. The calving interval was significantly influenced ($P \leq 0.01$) by the individual cow, year and season of conception, and parity. Conception during January to March led to the shortest calving interval, and during October to December to the longest. The highest percentage of conceptions occurred some 2-5 months after the peak rainfall.

R-38 MANICKAVADIVEL, S. and RAJAMAHENDRAN, R. **Semen characteristics and libido of Murrah, Surti and local buffalo bulls.** *Ceylon Veterinary Journal* (1980) **28,** 62-63 [Abstract]. Postgraduate Institute at Agriculture, University of Peradeniya, Peradeniya, SL.

Four Murrah, three Surti and one local buffalo bulls were used in a 13-week study to determine their semen characteristics and their libido as judged by the reaction time. There was no significant effect of breed on libido. Reaction time 1 (interval between sniffing of the vulva and first ejaculation) was significantly shorter than reaction time 2 (interval between first and second ejaculation). Volume of semen and sperm concentration were highest in Murrahs. However, Murrah semen had a significantly higher percentage of dead spermatozoa in the first ejaculate. The semen of the local buffalo was more voluminous than that of Surti but had lower sperm concentration and higher percentage of dead and abnormal spermatozoa. The first and second ejaculates differed significantly in (a) percent dead sperm and motility in Murrah, (b) sperm concentration and percent dead sperm in Surti and (c) percent abnormal sperm in local buffalo; the second ejaculate was superior.

R-39 MOHAMED, A.R. and WICKRAMASURIYA, U.G.J.S. **Artificial induction of lactation in buffaloes.** *Sri Lanka Veterinary Journal* (1987) **35,** 38 [Abstract]. Veterinary Research Institute Gannoruwa, Peradeniya, SL.

Twenty female infertile Murrah buffaloes were given a 500 kg of cloprostenol ('Estrumate') intramuscularly. Starting seven days later, 10 animals were given a daily single injection of a hormonal preparation containing 2 g of 17 β oestradiol and 5 g of progesterone in 100 ml of absolute ethanol at the rate of 0.5 ml per 100 kg body weight (subcutaneously) for 14 days. The other ten animals were given the same treatment with half the daily dose in the morning and evening. All animals were given a dose of dexamethasone at the rate of 3 mg/100 kg b.w., intramuscularly on the last day of the hormonal treatment and repeated 3 days later. The experiment was conducted during the main calving season of the year when more pasture was available.

In the first group given a single daily injection, lactation was induced in 8 out of the 10 animals (80% success rate), which produced a total milk yield of 5545 litres during a period of 2653 milking days. The daily average milk yield was 2 litres. A lactation yield of above 500 ml was initiated between 14-67 days (mean 36.4 ± 15.2 SD) after the last injection of dexamethasone. The mean lactation length was 331.6 ± 76.2 days (range 169- 433 days). The mean peak yield was 3.1 ± 0.96 litres (range 2.5 -4.5 litres) and was achieved between 46 and 100 days after the last injection (mean 71.4 ± 13.6 days). In the group that was given the daily divided doses of hormone solution only 1 out of the 10 animals responded. She produced a total of 223.5 litres in 242 days. A lactation yield of above 500 ml was initiated 64 days after the last injection and achieved a peak yield of 1.5 litres at 129 days. From the above experiment it could be concluded that artificial induction of lactation using a single daily dose regime of the above treatment for 14 days is a promising method of salvaging uneconomical female buffaloes.

R-40 MOHOMED, A.R. **Accuracy of oestrous detection under field and farm conditions.** *Sri Lanka Veterinary Journal* (1987) **35,** 40 [Abstract]. Veterinary Research Institute Peradeniya, SL.

The accuracy of oestrous detection in milking cows under field conditions and in large farms, by private and government artificial insemination (AI) technicians was studied by measuring progesterone in milk samples obtained from 330 animals. The samples were collected on the day of insemination (D_0), seven (D_7) and twenty three (D_{23}) days after AI. Clinical palpation of genital organs were performed after two months, to diagnose pregnancy. The milk samples were collected into vials containing sodium azide as a preservative. After removal of the fat layer by centrifugation and aspiration, the fat - free fractions were stored at -20°C until assayed. A 'no - extraction', solid - phase radioimmunoassay method using ^{125}I labelled progesterone, was used to assay progesterone. Samples containing less than 0.5 ng of progesterone per ml were considered as having being collected from cows that do not have a functional corpus luteal while those having above 0.5 ng/ml as being from cows in an active luteal phase, or pregnant. If samples collected from a cow had < 0.5 ng/ml on D_0 and 0.5 ng/ml on D_7, she was considered to have had an ovulatory oestrus.

The accuracy of oestrus detection by government technicians under field conditions was 44.8% (range 30.0 - 75.0 %) and in those inseminated by private technicians was 69.2 % (range 53.3 - 85.5%). On large farms the accuracy of oestrus detection among the inseminated animals was 96.0%. Hence, 55.2%, 30.8% and 31.0% of the animals presented for an AI were not in true oestrus at the time of insemination. Of the 55.2 % of the animals that were not in oestrus and were inseminated by the state technicians, 34.5 % were mostly anoestrus; while 20.7 were cycling but inseminated in the luteal phase. Similarly, among the 30.8 % of the animals that were inseminated by private technicians, 16.9 % were mostly in anoestrus and 13.9% in the luteal phase or even pregnant. Under large - farm conditions, of the 31.0 % of the incorrect timing of service, 11.2 % were in anoestrus and 9.9% were in luteal phase of the cycle; the balance 9.9 % had been inseminated while pregnant.From the above results, it can be seen that a major cause for poor conception rates in AI herds are due to incorrect timing of service.

R-41 MOHAMED, A.R., JEYARUBEN, M.G., VERCOE, J.E. and FRISCH, J.E. **Effects of supplementary feeding and environment on the reproductive performance of buffalo in Sri Lanka.** *Ceylon Veterinary Journal* (1988-89) **36,** 53 [Abstract]. Veterinary Research Institute, Peradeniya, SL.

An experiment was conducted on a large buffalo farm in the dry zone to evaluate the reproductive performance of Lanka and Murrah buffaloes reared under similar conditions of feeding and management as practised in the dry zone and under improved nutritional regime, *viz.* supplemented with an extra concentrate ration at the rate of 1.2 kg per 100 kg B.W. per day.

The two breeds comprised of 18 Lanka and Murrah buffaloes and each breed was divided into two equal groups (supplementary and non supplementary groups). The Murrah animals were hand-milked twice a day but the Lanka buffaloes were not milked but their calves were allowed limited suckling twice a day. The weighing and rectal examination of animals were carried out once a week, blood samples for progesterone assay were collected twice a week and daily measurement of environmental temperature, relative humidity and rainfall were also recorded.

During the period of observation all 9 Lanka buffaloes fed with the supplementary ration conceived whereas among the control group only 5 conceived. The calving to conception interval in the supplemented group was 101 ± 41 (SD) days whereas in the control group it was calculated to be more than 193 ± 92 (SD) days. Amongst the Murrah breed, of the 8 animals fed the supplementary ration only 5 conceived whereas among 7 control animals only two conceived.

The day temperature were lowest during the period from October to February. The relative humidity was high from October to January and fell during the dry season from February to September except for a small rise from April to May. All Lanka buffaloes fed the supplementary ration conceived between April and July although environmental conditions varied. Supplementary feeding also improved the reproductive performance in the Murrah breed. It appears that the Lanka buffaloes provided they are adequately fed well managed does not show a seasonally in breeding. The Murrah breed however showed variations in fertility relative to conditions in the dry zone.

R-42 MOHAN, V. **Clinical and endocrinological studies on postpartum ovarian activity in Lanka buffaloes (*Bubalus bubalis*).** *Ph.D. Thesis* (1990). Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Although Lanka buffaloes raised under village conditions in Sri Lanka generally have poor fertility, short calving intervals and high fertility have been reported in certain locations. Four experiments were conducted to determine reasons for the differences in fertility in different locations;

endocrinological changes during the postpartum (PP) period; and effects of suckling on resumption of ovarian activity and other fertility indices.

Sixteen buffalo cows from a "low fertility" area and a "high fertility" area (n=8 each) were brought to the SAREC/NARESA farm and maintained over a period of 3 years under uniform management. Ovarian activity was monitored by oestrus observation, rectal palpation and measurement of plasma progesterone. Calvings were distributed throughout the year and there were no differences between the groups ($p>0.05$) in calving interval, time taken for uterine involution, duration of postpartum anoestrus, or the number of services required for conception. In 14 buffalo cows sequential blood samples were collected on days 7, 14, 21 and 28 PP at 15 min intervals for 8 hours, two injections of 12.5 µg GnRH given i/v two hours apart, and sampling continued for a further 4 hours. Plasma LH was measured by a heterologous (bovine) RIA and assay validity was checked with a specific bioimmunoassay (*in vitro* secretion of testosterone by mouse Leydig cells). LH remained below the detection limit of the assay with no pulses up to day 28 PP, and no LH response was detectable following the low doses of GnRH.

Eighteen pluriparous buffalo cows were allotted to three suckling regimes: AS - continuous (*ad libitum*); RS - restricted (two periods of 20 minutes per day); and ZS - zero (calves weaned within 15 days). Blood was collected on days 30, 45 and 90 PP at 20 min intervals for 8 hours, followed by two doses of GnRH and sampling as previously. Rectal examination and measurement of plasma progesterone were done weekly. Mean LH before GnRH treatment was below the detection limit on days 15 and 30 PP, around 0.5 ng/ml on day 45 and around 0.6 ng/ml on day 60 PP. There was no difference ($p>0.05$) in the mean LH values between the groups, but the response to GnRH was lower ($p<0.05$) in AS compared with that of RS and ZS on days 45 and 60. A further 18 pluriparous buffaloes were assigned to one of three treatment groups. As (*ad libitum*); RS (restricted); and AS/S (AS with supplementary feed). The pre GnRH mean LH increased in all three groups with the days PP. Mean LH for RS was higher ($p<0.05$) than that for other two groups. Resumption of pulsatile LH release was followed by ovarian activity. The pituitary response to exogenous GnRH was greater in RS.

These results confirm that long calving intervals in Lanka buffaloes are mainly due to long periods of postpartum anoestrus, which could be due to delayed reappearance of pulsatile LH secretion caused by managemental factors such as suckling. Restricted calf suckling could be a practical and effective method for improving the efficiency of reproduction in Lanka buffaloes.

R-43 MOHAN, V., KURUWITA, V.Y. and PERERA, B.M.A.O. **Secretary patterns of luteinizing hormone (LH) during the postpartum period in Lanka buffaloes subjected to two suckling regimes.** In: *Proceedings of the Sri Lanka Veterinary Association 41st Annual Scientific Sessions* (1987). Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The efforts of restricted and unrestricted suckling and supplementary feeding on postpartum ovarian activity was studied in indigenous (Lanka) buffaloes at a research farm. Blood samples were collected at 20 min. intervals for a period of 8 hours on days 30, 60 and 90 postpartum. In addition rectal palpation and progesterone measurements in blood were used to monitor the ovarian activity during this period. By day 90 postpartum a distinct pulsatile pattern, which is considered as a prerequisite for the onset of ovarian cycles were seen in all animals managed under restricted suckling regime. However, only 20% of the animals in the other group showed pulsatile pattern of LH release.

The data from progesterone analysis and rectal examination revealed that animals under restricted suckling group had an early resumption of ovarian activity when compared to the others. These differences in the pattern of LH release and the time taken for commencement of postpartum ovarian activity suggest that restricted suckling may improve the reproductive performance of Lankan buffaloes after parturition. This appeared to be mediated by an early resumption of pulsatile secretion of LH in animals which are subjected to restricted suckling.

R-44 MOHAN, V., KURUWITA, V.Y., PERERA, B.M.A.O. and ABEYGUNAWARDENA, H. **Clinical and hormonal studies on postpartum ovarian activity of indigenous buffaloes.** In: *Proceedings of the SAREC/NARESA Symposium on Buffalo Research in Sri Lanka 7-10 March, 1989, Kandy SL.* pp. 20-22. Department of Animal Science, Eastern University, Batticaloa, SL.

Three experiments were conducted to determine the following:

1. reason(s) for the differences in fertility in different locations.
2. endocrinological changes during the postpartum (PP) period and
3. effect of suckling on resumption of ovarian activity in Lanka buffaloes

First, sixteen buffalo cows from a 'low fertility' area and a 'high fertility' area (n=8) were brought to a different environment and maintained over a period of 5 years. Postpartum ovarian activity was

monitored by clinical and hormonal methods. Results showed that there were no significant differences in fertility indices between those two groups. Calvings were distributed throughout the year and mean calving interval was similar to what was reported for this area.

Second, the endocrinological changes during PP period were monitored in 14 buffalo cows. On days 7, 14, 21 and 28 postpartum, sequential blood samples were collected at 15 min. intervals for 8 hours preceding intravenous administration of 2 injections of 12.5 ng GnRH 2 hours apart, which was followed by further 4 hours of blood sampling at the same frequency Plasma LH concentrations were measured by heterologous RIA (detection limit 0.45 ng/ml). The LH concentrations remained lower than 0.45 ng/ml and no pulses were observed in these animals.

Third, 12 buffalo cows at calving were assigned either to restricted suckling (RS. n=7) or a *ad libitum* suckling (AS, n=5) group. On days 30, 45, 60 and 90 PP blood sampling and GnRH administration were performed as in experiment 2. Postpartum ovarian activity was monitored by clinical and hormonal methods. Eighty six percent of the animals in RS group resumed ovarian activity by day 90 as opposed by 20 percent in AS group. Mean LH concentration in RS group were greater ($P < 0.05$) than that of AS group (1.4 *vs.* 0.7 ng/ml) on day 30 but similar to that of RS on days 45 and 60. The response to the GnRH as measured by LH, maximal LH response and area under LH response curve was also greater ($P<0.05$) in the RS group than that of AS group on day 30 but similar to that of AS group on days 45 and 60. Animals in RS group resumed the pulsatile LH secretion earlier than ($P<0.05$) the animals in AS group.

These results suggest that the differences in fertility in Lanka buffaloes in different locations may be due to effects of environment and management on the resumption of ovarian activity. Further, suckling appears to prolong the postpartum anestrous period and this may be by delaying the resumption of pulsatile LH secretion postpartum.

R-45 MOHAN, V., KURUWITA, V.Y., PERERA, B.M.A.O. and ABEYGUNAWARDENA, H. **Effect of suckling on the resumption of postpartum ovarian activity in buffaloes.** *Tropical Agricultural Research* (1990) **2,** 306-315. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Delayed puberty and extended calving intervals of Lanka buffaloes were found to be major constraint to economical production. Studies have revealed that long periods of postpartum anoestrus is the primary cause for the extended calving intervals and that conditions such as repeat breeding, endometritis and pathological conditions do not significantly contribute to poor fertility in this species. In traditional dry zone farming systems, buffalo cows are suckled by calves for extended periods and are maintained on natural herbage, the quality and quantity of which are dependent on the seasonal rainfall. The experiment was undertaken to examine the effect of suckling and improved nutrition on the resumption of ovarian activity, postpartum LH secretion and response of the pituitary to small doses of exogenous GnRH.

Eighteen pluriparous Lanka buffaloes were assigned to one of three treatment groups; restricted suckling (RS), *ad libitum* suckling (AS) and *ad libitum* suckling with supplementary feed (AS/S). Blood samples were collected for 8 hours at 20 minute intervals on days 30, 45, and 60 where 2 GnRH injections were given at 0400 and 0600 hours, and on day 90 without GnRH. Rectal examination of ovaries was performed weekly. Plasma concentration of LH and progesterone were measured by RIA. The mean LH for groups RS was higher ($P<0.05$) than those of the other two groups. There was no difference ($P>0.05$) between groups AS and AS/S. In the RS group pulsatile LH secretion was observed by day 60 in all the animals, whereas animals of groups AS and AS/S did not show this. The number of animals which commenced ovarian activity by day 90 was higher ($P<0.05$) in group RS when compared to AS and AS/S. The findings of this experiment suggest that *ad libitum* suckling, a common calf rearing method, can delay the resumption of episodic LH release postpartum which is a prerequisite for the commencement of ovarian activity.

R-46 MOHAN, V., KURUWITA, V.Y., PERERA, B.M.A.O. and ABEYGUNAWARDENA, H. **Postpartum reproductive functions in Lanka Buffaloes.** *Sri Lanka Veterinary Journal (1991)* **38,** 27 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Lanka buffalo plays an important role in the rural agricultural systems in Sri Lanka. In the light of increasing demand for animal power in the subsistence agricultural sector there is great need, scope and potential for buffalo production in this country. Poor reproductive performance was reported as one of the major constraints for buffalo production in the past. However, detailed studies for buffalo production conducted by our group indicated that, the reproductive efficiency of buffaloes tends to vary with the environmental conditions in which they are reared and at least at locations Lanka buffaloes can reproduce as efficient as cattle.

Various factors were suspected to be responsible for the difference in the fertility observed

among different locations of the country. Our studies at the Mawela farm on animals from 'poor' and 'high' fertility areas of the country confirm that these factors are external in nature. The main reasons for the low fertility was due to long calving intervals resulted by extended periods of postpartum anoestrus.

Further studies conducted at Mawela and in the coconut triangle indicated that continuous suckling, a common calf rearing method in buffalo sector is one of the major factors responsible for uneconomical long calving intervals in buffaloes. Different calf management regimes were tried out to minimise the effect of suckling on postpartum reproduction, without affecting the calf performance. Restricted suckling was identified as useful calf management system. More detailed studies are being conducted by our group to work out the most suitable time of weaning and methods of restricted suckling as a measure to improve the reproductive efficiency of Lanka buffaloes at field level.

R-47 PERERA, B.M.A.O., PATHIRAJA, N., ABEYRATNE, A.S., KUMARATILLAKE, W.L.J.S. and BUVANENDRAN, V. **Oestrous synchronisation and artificial insemination in buffaloes.** *Ceylon Veterinary Journal* (1977) **25**, 41 [Abstract]. School of Veterinary Science, University of Peradeniya, Peradeniya, SL.

Prostaglandin (PG) $F_{2\alpha}$ and its analogue cloprostenol (Estrumate, I.C.I) were both found to be luteolytic in buffaloes when given intramuscularly in doses of 30 mg and 0.5 mg, respectively. A regime of two injections of either PG $F_{2\alpha}$ or cloprostenol given 10-11 days apart, effectively synchronised oestrus in all but one out of 25 experimental animals. Oestrus, as determined by mucous discharged from vagina, crystallisation pattern of cervical mucus, mounting by the bull, and uterine tone at rectal palpation, occurred in the majority of animals on the third day after the second injection of the luteolytic agent.

Cloprostenol was used in two further trials to determine fertility at the synchronised oestrus. Using natural services, 6 out of 18 synchronised heifers conceived, while 3 out of 9 control heifers conceived. This gives a first service conception rate of 33.3% in both experimental and control groups, as determined by rectal palpation at 60 days.

Using artificial insemination at 72 and 96 hours after the second injection of cloprostenol, 3 out of 10 synchronised heifers conceived, giving a first service conception rate of 30%. Semen was collected using artificial vagina, extended in egg yolk citrate and used for insemination on the same day.

R-48 PERERA, B.M.A.O., PATHIRAJA, N., KUMARATILAKE, W.L.J.S., ABEYRATNE, A.S. and BUVANENDRAN, V. **Synchronization of oestrus and fertility in buffaloes using a prostaglandin analogue.** *Veterinary Record* (1977) **101**, 520-521.

Cloprostenol, a prostaglandin analogue, was administered intramuscularly to a total of 35 buffalo cows and heifers in two doses, each of 0.5 mg, given 11 days apart. Out of five cows and 12 heifers subjected to observation after the second injection of cloprostenol (day 0), all except one heifer responded. Signs of oestrus were most marked on day 3 or 4. Eighteen treated heifers were kept with buffalo bulls for four days after the second injection while a control group of nine heifers was kept with bulls for 21 days. The first service conception rate, diagnosed by rectal palpation at 60 days, was 33 1/3 per cent in both groups. Twelve treated heifers were artificially inseminated at 72 and 96 hours after the second injection of cloprostenol, using fresh semen diluted in egg yolk-citrate extender. The first service conception rate at 60 days was 30 percent.

R-49 PERERA, B.M.A.O. **Synchronization of oestrus and fertility in buffaloes of Sri Lanka.** *Buffalo Bulletin* (1978) **2**, 25-34. School of Veterinary Science, University of Peradeniya, Peradeniya, SL.

The studies described here have shown the applicability of methods for controlling and monitoring reproductive events in order to overcome some of the constraints to better reproductive performance. Further research should be aimed at examine the ways in which those procedures can be combined and adapted for the formulation of a usable regime. This would have been undertaken separately for institutional farms and at the small farmer level, since the appropriate combinations are likely to be dissimilar. A suggested system for use in the former situation, where the immediate requirement rapid multiplication of superior river buffaloes for cross-breeding with the indigenous buffaloes animals of Sri Lanka, is as follows: a) synchronisation of oestrus, (b) fixed time A.I., (c) detection of non pregnant animals based on plasma progesterone level at 21 days, (d) repetition of PG treatment in such animals at around 30 days after the previous A.I., and (e) reinsemination 06 treated animals. The sequence could be applied in conjunction with sexual health control programmes when fertility is maximal, and should provide a means for reducing the calving interval.

R-50 PERERA, B.M.A.O., PATHIRAJA, N., BUVANENDRAN, V. and ABEYWARDENA, S.A. **Plasma progesterone levels during natural and prostaglandin-synchronized oestrous cycles in**

buffaloes. *Ceylon Veterinary Journal* (1978) **26,** (1) 29-34. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The buffalo is a triple purpose animal, providing meat, milk and draught power to the small farmers of Asia. It is also an important source of manure. One of the greatest impediments to programmes for genetic improvement of this species is the difficulty of heat detection, due to poor external signs and the lack of homosexual behaviour among animals in heat. A solution to this problem, however might be provided by oestrus synchronisation and set - time insemination as adopted in cattle.

Progesterone levels were measured by a radioimmunoassay in blood plasma of river buffaloes during two natural and eight prostaglandin-synchronised oestrous cycles. During natural cycles, progesterone levels fluctuated in a manner similar to that in cattle, with low levels (50 pg/ml) at and around oestrus and higher levels (1010 pg/ml) during the luteal phase of cycle. However, the absolute values obtained were far lower than those in cattle.

Treatment of buffaloes with either 30 mg prostaglandin $F_{2\alpha}$ or 500 mg cloprostenol intramuscularly resulted in rapid luteolysis as indicated by a sharp fall in blood progesterone levels. No significant differences were observed between progesterone profiles of control and synchronised oestrous cycles. Progesterone levels varied from below 50 pg/ml to 175 pg/ml during oestrus, while the peak luteal phase levels varied from 420 to 1010 pg/ml.

R-51 PERERA, B.M.A.O., PATHIRAJA, N., ABEYWARDENA, S. A., MOTHA, M.X.J. and BUVANENDRAN, V. **The application of a radioimmunoassay technique for studying progesterone levels in the buffalo.** *Ceylon Veterinary Journal* (1978) **26,** 54 [Abstract]. School of Veterinary Science, University of Peradeniya, Peradeniya, SL.

A radioimmunoassay technique for measuring plasma progesterone was established and validated for use in buffaloes. This assay was applied for studying the levels of progesterone in peripheral blood of buffaloes during natural and prostaglandin-synchronised oestrous cycles.

Blood samples were collected from control animals every two or three days during a complete oestrous cycle. Cycling animals were treated with either prostaglandin $F_{2\alpha}$ (30 mg) or its analogue, cloprostenol (0.5 mg) intramuscularly. Blood samples were collected as in the control animals until the completion of a cycle after the treatment.

The plasma progesterone pattern in buffaloes during the oestrous cycle was similar to that in cattle with the exception that the absolute values obtained were much lower. Progesterone levels were less than 100 pg/ml at and around oestrous (follicular phase), while the peak levels attained during the luteal phase varied from 350 to 1000 pg/ml.The levels in cattle are five to ten times greater at comparable stage of the cycle. Treatment with prostaglandins at the dose rates recommended in cattle resulted in rapid luteolysis in buffaloes, as indicated by the sharp fall in blood progesterone levels. Since no differences were observed between the progesterone profiles of control and synchronised oestrous cycles, it is concluded that the use of prostaglandins for this purpose is unlikely to result in any adverse hormonal disturbances which might interfere with fertility during the ensuing cycle.

R-52 PERERA, B.M.A.O., PATHIRAJA, N., MOTHA, M.X.J. and WEERASEKARA, D.A. **The application of radioimmunoassay technique for measuring plasma testosterone in buffalo bulls.** *Ceylon Veterinary Journal* (1979) **27,** 33 [Abstract]. School of Veterinary Science, University of Peradeniya, Peradeniya, SL.

Blood samples were collected hourly over a period of 10 hours by jugular vein puncture from each of two adult Murrah buffalo bulls during April, May, August and December. Testosterone concentration in plasma was measured by a radioimmunoassay technique. The testosterone profile in both bulls showed an episodic pattern of secretion, with basal concentration below 0.2 mg/ml and peak concentration ranging from 0.35 to 1.65 mg/ml. No more than one complete secretory peak occurred during any 10 hour period. The profiles were highest in August and declined through December and April to lowest levels in May.

It was concluded that testosterone levels in buffaloes were almost ten times lower than those reported in *Bos taurus* males, and appeared to vary during different times of the year. Due to low frequency of secretory peak in this species, accurate assessments of androgen status requires either prolonged sampling periods or stimulation tests with gonadotrophic hormones.

R-53 PERERA, B.M.A.O., PATHIRAJA, N., MOTHA, M.X.J. and WEERASEKARA, D.A. **Seasonal differences in plasma testosterone profiles in buffalo bulls.** *Theriogenology* (1979) **12,** (1) 33-38. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Testosterone was measured by radioimmunoassay in blood samples collected hourly over 10 h from two adult buffalo bulls in April. May,

August and December. The basal concentration were below 0.2 ng/ml while peak concentrations ranged from 0.35 to 1.65 ng/ml, with not more than one complete peak occurring during a 10 h period. Both bulls had similar testosterone profiles within each sampling period but differences were evident between periods, the mean concentration being highest in August and falling through December and April to the lowest levels in May. Testosterone concentrations in buffaloes are therefore lower than those in other domestic species, and appear to vary during different times of the year.

R-54 PERERA, B.M.A.O., PATHIRAJA, N., MOTHA, M.X.J. and WEERASEKARA, D.A. **The application of a radioimmunoassy technique for measuring plasma testosterone in buffalo bulls.** *Ceylon Veterinary Journal* (1979) **27,** (1) 33 [Abstract]. School of Veterinary Science, University of Peradeniya, Peradeniya, SL.

Blood samples were collected hourly over a period of 10 hours by jugular venipuncture from each of two adult Murrah buffalo bulls during April, May, August and December. Testosterone concentration in plasma was measured by a radioimmunoassy technique. The testosterone profile in both bulls showed an episodic pattern of secretion, with basal concentrations below 0.2 ng/ml and peak concentration ranging from 0.35 to 1.65 ng/ml. No more than one complete secretory peak occurred during any 10 hour period. The profiles were highest in August and declined through December and April to the lowest levels in May.

It was concluded that testosterone levels in buffaloes were almost lower than those reported in *Bos taurus* males, and appeared to vary during different times of the year. Due to the low frequency of secretory peaks in this species, accurate assessments of androgen status requires either prolonged sampling periods or stimulation tests with gonadotrophic hormones.

R-55 PERERA, B.M.A.O., ABEYGUNAWARDENA, H., TAMOTHARAM, A., KINDAHL, H., EDQVIST, L.E. and KARUNARATNE, A.M. **Hormonal changes in blood of river buffalo before, during and after parturition.** *Ceylon Veterinary Journal* (1980) **28,** 61 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The changes occurring in concentrations of oestrone, progesterone and 15-keto-13, 14 dihydroprostaglandin $F_{2\alpha}$ (PGFM) in peripheral plasma were determined by radioimmunoassay techniques during the peripartal period in five Surti cows.

The perparturient rise in oestrone concentration commenced 15 days prior to calving, reached peak levels (400-700 pg/ml) during the last five days of gestation, and declined to basal levels after delivery. Progesterone concentration fluctuated between 800 and 2000 pg/ml until 15 days before calving and in contrast to cattle showed a gradual increase during the last 15 days of pregnancy. The progesterone levels declined abruptly on the day of calving, and remained basal (<100 pg/ml) for up to 40 days post- partum, confirming the absence of ovarian activity during this period. The levels of PGFM were elevated from 15 days prior parturition, peaked during the last three days of gestation, and declined gradually to basal levels 15 to 20 days after parturition. The post partum elevation of PGFM was less persistent than that reported in cattle.

R-56 PERERA, B.M.A.O., PATHIRAJA, N., ABEYWARDENA, S.A., MOTHA, M.X.J. and ABEYGUNAWARDENA, H. **Early pregnancy diagnosis in buffaloes from plasma progesterone concentration.** *Veterinary Record* **106,** 104-106 (1980) School of Veterinary Science, University of Peradeniya, Peradeniya, SL.

Blood samples were collected from 84 buffalo cows 21 days after fixed time artificial insemination following oestrous synchronisation with cloprostenol. Progesterone concentration in plasma was determined by radioimmunoassay. The animals were examined for pregnancy by rectal palpation 60 to 90 days after insemination. Forty-two animals were predicted pregnant on the basis of progesterone concentration (more than 1.0 ng per ml), and 28 (66.7 per cent) of them were subsequently confirmed pregnant by rectal palpation. Thirty-five animals were predicted non-pregnant (progesterone less than 0.7 ng per ml), in 34 (97.1 per cent) this proved to be so. Of the total number, seven (8.3 per cent) was classified as doubtful because their progesterone concentration were within the range 0.7 to 1.0 ng per ml; two of them were confirmed pregnant and the other five non-pregnant. Out of 31 animals diagnosed pregnant by rectal palpation, 28 (90.3 per cent) had been correctly detected by assay at 21 days. Thirty-four (64.2 per cent) of the 53 animals found non-pregnant had been correctly detected by assay. It was concluded that the determination of plasma progesterone concentration 21 days after insemination was an accurate method of predicting non-pregnancy in buffaloes.

R-57 PERERA, B.M.A.O. **Hormonal profiles and synchronisation of oestrus on animal production and development in the tropics.** *Buffalo Bulletin* (1980) 3 pp. 29, [Abstract]. Faculty

of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Radioimmunoassay (RIA) techniques were used for measuring hormone concentrations in blood of female river buffaloes during natural and prostaglandin synchronised oestrus cycles, pregnancy, peri-partal period and the postpartum period. Ovarian and uterine changes were determined by rectal palpation. The progesterone profile during oestrous cycle was basically similar to that in cattle, with the exception that the actual concentration in blood was lower, peak luteal phase rarely exceeding 1-2 ng/ml. Treatment with prostaglandin $F_{2\alpha}$ or its analogue cloprostenol (Estrumate I.C.I.) during the luteal phase of the cycle resulted in an abrupt decline in progesterone levels, with oestrus occurring 48-72 hours later. First service conception rates in animals synchronised with a two-dose regime of cloprostenol were 30 and 38.6% in two separate trials (67 animals) when fixed-time artificial insemination was done, and 33.3% with natural service (18 animals). This was not significantly different from conception rates in a group of control animals. The accuracy of diagnosing pregnancy and non-pregnancy on the basis of high progesterone concentration in blood 21 days after service was examined in 84 buffalo cows which had been subjected to oestrous synchronisation. Out of 42 animals forecast pregnant on the basis of high progesterone concentration only 66.7% were proved correct by subsequent rectal palpation, whereas out of 35 animals forecast as non-pregnant 97.1% were proved correct. In the river buffaloes of Sri Lanka the post-partum period is characterised by a prolonged duration of ovarian inactivity. In 12 buffalo cows monitored by frequent rectal palpation and twice weekly progesterone measurement, the postpartum anoestrous period ranged from 110 to 200 days. The onset of ovarian activity appeared to be related to seasonal factors, and the majority of animals conceived at the first or second ovulation. Evidence for a seasonal variation in fertility was also obtained in a study on calving patterns in two large buffalo farms, where a high correlation was found between rainfall and incidence of conceptions.

R-58 PERERA, B.M.A.O., ABEYGUNAWARDENA, H., ABEYWARDENA, S.A. and DE SILVA, L.N.A. **Studies on reproductive patterns and hormone profiles of river buffaloes in Sri Lanka.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka, 24-28 November, 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. 1982. pp. 119-125. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Low reproductive efficiency of the water buffalo is one of the major constraints to a fuller utilisation of this species in domestic agriculture. Studies were therefore initiated to investigate the causes of poor reproduction in this species in Sri Lanka.

In order to establish the normal reproductive patterns, calving records and climatological data over a period (1969-1979) were analysed from two large buffalo farms located in the dry zone, at Ridiyagama (R) and Polonnaruwa (P). The mean ± s.e.m. for age at first calving was 3.72 ± 0.039 years (n=445) at R and 3.66 ± 0.069 (n=307) at P. Calving intervals for animals of different parity ranged from 378 to 1900 days at R and from 380 to 1300 days at P. Calvings were unevenly distributed through each year, with 57% of the annual calvings occurring between November and February at R, and 49% occurring between October and January at P. Monthly rainfall during the peripartal and postpartal periods was significantly correlated with conceptions at R (r=0.54) and P (r=0.43). Calving to conception interval was influenced by season of calving, possibly through the effect of rainfall on the availability and quality of fodder during the postpartum anoestrus period.

A detailed study of the events associated with commencement of postpartum ovarian activity was conducted in buffalo herd in the Mid Country wet zone using repeated rectal palpation of the ovaries and twice weekly measurement of plasma progesterone concentration by radioimmunoassay. The ovaries remained small (0.5 to 1.5 cm) and inactive during the postpartum period, with development of follicles and corpora lutea being delayed for more than 70 days after calving. Onset of progesterone elevation (>0.5 ng/ml) in blood occurred between 100 and 200 days after calving, and in most cases conception occurred at the first or second ovulation. Gestation length ranged from 297 to 324 days with a mean of 310 days.

Progesterone measurement 21 days after service proved useful as an early test of non-pregnancy. Measurement of oestrus, progesterone and 15-keto-dihydroprostaglandin $F_{2\alpha}$ in peripheral blood during the peripartal period indicated dissimilarities in their pattern of change from those reported in cattle.

These results confirms that the long calving interval in buffaloes is due primarily to delayed resumption of postpartum ovarian activity, and indicate the need for further studies to elucidate the causes for this reproductive inefficiency.

R-59 PERERA, B.M.A.O., ABEYGUNAWARDENA, H., THAMOTHARAM, A., KINDAHL, H. and EDQVIST, L.E. **Peripartal changes of estrone, progesterone**

and prostaglandin in the water buffalo. *Therigenology* (1981) **15,** (5) 463-467. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The peripheral blood plasma concentration of estrone, progesterone and 15-keto-13, dihydroprostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$ metabolite) were determined by radioimmunoassay techniques during the peripartal period in 5 buffalo cows belonging to river type breed. Estrone levels started to increase from below 200 pg/ml about 15 days prior to parturition, and reached high concentrations (400-750 pg/ml) during the last 5 days of pregnancy. The estrone concentration decreased to baseline levels after delivery. The concentration of progesterone fluctuated between 800 and 2000 pg/ml until 15 days before calving and showed a gradual increase during the last 15 days of pregnancy. The progesterone levels declined abruptly on the day of calving and remained below 100 pg/ml for up to 60 days postpartum. Increased levels of the prostaglandin metabolite were recorded from 15 days prior to parturition with further increases occurring during the last 3 days of pregnancy. $PGF_{2\alpha}$ metabolite levels declined gradually after parturition, reaching baseline levels 15-20 days after calving.

R-60 PERERA, B.M.A.O. **The use of hormone measurement for studying reproductive patterns of buffaloes in Sri Lanka.** In: *Proceedings of the 2nd Research Co-ordination Meeting on the use of Nuclear Techniques to Improve Domestic Buffalo Production in Asia, 2-6 March 1981.* IAEA, Vienna, Austria. pp. 149-156. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Reproductive patterns of river buffaloes in large farms were studied by analysing calving records and climatological data over a 10 - year period. Calvings were found to be unevenly distributed through each year. Periods of high rainfall were followed by periods of peak conceptions, with a time lag of 2 to 3 months. Commencement of postpartum ovarian activity, monitored in 10 animals by frequent rectal palpation and plasma progesterone measurement, occurred between 100 and 200 days after calving. Conception occurred at the first or second postpartum progesterone elevation. The mean gestation length was 310 days, and the mean calving interval 514 days. Peripartal changes in oestrone, progesterone and 15-keto-13, 14-dihydroprostaglandin $F_{2\alpha}$ were basically similar to those in cattle, with a exception that progesterone concentration did not decline until the day of parturition. Measurement of plasma testosterone in buffalo bulls indicated seasonal influences on the episodic pattern of testosterone secretion.

R-61 PERERA, B.M.O.A. **Hormonal profiles and synchronisation of oestrus in river buffaloes in Sri Lanka.** In: *Animal Production and Health in the Tropics.* [Edited by M.R. Jainudeen and A.R. Omar]. Penerbit University of Pertanian Malaysia, Serdang, Malaysia. 1982 pp. 431-434. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Radioimmunoassay (RIA) techniques were used for measuring hormone concentrations in blood of female river buffaloes during natural and protaglandin-synchronized oestrus cycle, pregnancy, peri-partal period and the post-partum period. Ovarian and uterine changes were determined by rectal palpation. The progesterone profile during the oestrus cycle was basically similar to that in cattle, with the exception that the actual concentration in blood was lower, peak luteal phase levels rarely exceeding 1-2 ng/ml. Treatment with protaglandin $F_{2\alpha}$ or its analogue cloprostenol (Estrumate I.C.I.) during the luteal phase of the cycle resulted in an abrupt decline in progesterone levels, with oestrus occurring 48-72 hours later. First service conception rates in animals synchronised with a two-dose regime of cloprostenol were 30% and 38.6% in two trials (67 animals) when fixed-time artificial insemination was done, and 33.3% with natural service (18 animals). This was not significantly different from conception rates in a group of control animals. The accuracy of diagnosing pregnancy and non-pregnancy on the basis of progesterone concentration in blood 21 days after service was examined in 84 buffalo cows which had been subjected to oestrus synchronisation. Out of 42 animals forecast pregnant on the basis of high progesterone concentration only 66.7% were proved correct by subsequent rectal palpation, whereas out of 35 animals forecast as non-pregnant 97.1% were proved correct. Changes in oestrone, progesterone and 15-keto-13, 14 dihydroprotaglandin $F_{2\alpha}$ (PGFM) were measured in blood of five animals during the peri-partal period. The profiles were similar to those in cattle, with the following exceptions: the progesterone concentration did not decline until the day of parturition, and the post-partum elevation of PGFM was less marked and of shorter duration than in cattle. In the river buffaloes of Sri Lanka the post partum period is characterised by prolonged duration of ovarian inactivity. In 12 buffalo cows monitored by frequent rectal palpation and twice weekly progesterone measurement, the post partum anoestrus period ranged from 110 to 200 days. The onset of ovarian activity appeared to be in related to seasonal factors, and the majority of animals conceived at the first or second ovulation. Evidence

for a seasonal variation in fertility was also obtained in a study on calving patterns in two large buffalo farms where a high correlation was found between rainfall and incidence of conceptions.

R-62 PERERA, B.M.A.O., DE SILVA, L.N.A. and KARUNARATNE, A.M. **Postpartum ovarian activity in Lanka buffaloes at a village location with high reproductive efficiency.** *Sri Lanka Veterinary Journal* (1982) **30,** 35 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Based on the findings of an island-wide sample survey, a village in the dry zone where buffaloes apparently had high fertility was selected for a detailed study. The reproductive functions of 55 breedable females kept under traditional management systems were monitored by weekly rectal palpation and measurement of progesterone in milk. Calvings and services were recorded by the herdsmen. The preliminary results presented here are for the period December 1981 to September 1982.

At the commencement of the study, 45 animals (81.8%) were pregnant, 4 (7%) were cycling and 6 (11%) had inactive ovaries. Of those pregnant, 44 calved during the first six months. The mean ± SD of the interval (days) from calving to completion of uterine involution was 32.9 ± 8.2, calving to first service was 45.0 ± 17.3 (n=26). The 10 animals which were non-pregnant had calved two to eight months earlier, and nine received services along with the later calvers from January 1982 onwards. One animal remained in true anoestrus. Among the 54 animals served, first service conception rate was 68.5%. The overall pregnancy rate was 93.6% with 1.25 services per conception. There was one stillbirth and nine calf deaths within two months of birth (21.0%). These results indicate that Lanka buffaloes at this village location have optimum fertility.

R-63 PERERA, B.M.A.O. **Studies on endocrine control of reproduction in buffaloes of Sri Lanka.** *Buffalo Bulletin* (1982) **1,** (2) 5-6. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The objectives of this study were to determine the normal reproductive patterns and their endocrinological basis in river-type and indigenous (Lanka) buffaloes, to investigate the causes for reproductive efficiency, and to examine possible methods for improving reproduction. Initially a radioimmunoassay (RIA) technique for measuring plasma progesterone was established and validated.

Progesterone measurement, together with rectal palpation and other clinical methods, were used for studying the oestrous cycle, pregnancy, parturition and postpartum ovarian activity in river-type (Murrah) buffaloes on state farms. Progesterone profiles during the oestrous cycle were basically similar to those in cattle, with the exceptions that peak luteal phase levels were reached later (day 10-12), and were quantitatively lower. Progesterone concentration remained elevated during pregnancy. The accuracy of early pregnancy diagnosis based on progesterone concentration 21 days after service was only 67% due to high incidence of false positives, but non-pregnancy was diagnosed with an accuracy of 97%.

The mean gestation length was 310 days. Measurement of oestrone, progesterone and 15-keto-13, 14-dihydroprostaglandin $F_{2\alpha}$ (PGF metabolite) in blood during the peripartal period revealed profiles similar to those in cattle, with the exceptions that absolute concentrations of all three hormones were different and there was no gradual decline in progesterone during the last two weeks pre-partum. Post-partum ovarian activity was monitored by repeated rectal palpation of the ovaries and twice weekly measurement of plasma progesterone, in a typical small herd of 15 animals having a history of long calving intervals (mean 594 days, n=46). In 17 complete postpartum periods studied over three years, progesterone concentration remained basal (<0.25 ng/ml) for periods ranging from 92 to 210 days. In 12 of these, conception occurred at the very first major elevation of progesterone (>0.7 ng/ml), and in four others at the second or third elevation. In most cases presence of a palpable corpus luteum was associated with concurrent elevation of plasma progesterone. In a few cases, however, palpable structures, corpora lutea were detected several weeks to a few days before progesterone elevation. This study showed that the major cause of long calving intervals was prolonged postpartum anoestrus, and not conception failure after reestablishment of cyclic activity.

To examine reproductive patterns in the large-farm situation, breeding records were analysed from 726 Murrah buffaloes on two farms within the Dry Zone. The mean (±SD) ages at first calving were 51.0 ± 8.6 and 52.1 ± 10.5 months, and the calving interval 530.6 ± 167 days respectively. Calvings were unevenly distributed through each year, with the highest percentage of conceptions occurring two to five months after the annual peak in rainfall. These findings lend further support to the hypothesis that availability and quality of fodder, which is influenced by rainfall, plays a significant role in the seasonal fluctuations in fertility, through its effect on post-partum ovarian activity. Attempts

were also made to study the possible influence of the male on seasonal patterns of fertility, by examining testosterone profiles during different times of the year, with and without exogenous stimulation by Gonadotrophin - Releasing Hormone (Gn-RH). The results are still equivocal, but it can be concluded that the buffalo bull does not show the characteristics endocrinological differences observed in true seasonal breeders.

Two methods of improving reproduction under controlled farm conditions were tested. Treatment of cycling females with the two-dose regime of cloprostenol (PG analogue) was found to be effective for synchronising oestrus, but first service conception rates with natural service and fixed-time double A.I. were between 33 to 37%. In a preliminary trial, treatment of non-cycling females with Gn-RH (125 mg x 2, 4 h apart) between 30 to 90 days post-partum did not significantly increase the proportion of animals resuming ovarian activity over a 28 day period.

R-64 PERERA, B.M.A.O. **The use of hormone measurement for studying the reproductive pattern of buffaloes in Sri Lanka.** *Buffalo Bulletin* (1982) **1**, 8 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Reproductive patterns of river buffaloes in large farms were studied by analysing calving records and climatological data over a 10-year period. Calvings were found to be unevenly distributed through each year. Periods of high rain fall were followed by periods of peak conceptions, with a time lag of 2 to 3 months. Commencement of postpartum ovarian activity, monitored in 10 animals by frequent rectal palpation and plasma progesterone measurement, occurred between 100 and 200 days after calving. Conception occurred at the first or second postpartum progesterone elevation. The mean gestation length was 310 days, and the mean calving interval 514 days. Peripartal changes in oestrone, progesterone and 15-keto-13, 14 dihydroprostaglandin $F_{2\alpha}$ were basically similar to those in cattle, with the exception that progesterone concentration did not decline until the day of parturition. Measurement of plasma testosterone in buffalo bulls indicated seasonal influences on the episodic pattern of testosterone secretion.

R-65 PERERA, B.M.A.O. **Environmental influences on reproduction of Lanka buffaloes, and the effect of Gn-RH during post-partum anoestrus in Murrah buffaloes.** *Buffalo Bulletin* (1982) **1**, (2) 11 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A field survey was conducted to determine the reproductive patterns of Lanka buffaloes under village conditions. Preliminary analysis of results indicate marked differences in herd size and composition, management practices, intensity of utilisation for draught and milk and reproductive efficiency in the different agro-ecological zone of the country. In districts where a high proportion (>55%) of breedable females was found pregnant, the percentage of animals with inactive ovaries was low (<3)%), and the calving interval was short (<18%). In certain districts, however, the proportion pregnant was less than 40%, the incidence of true anoestrus was greater than 35%, and the calving interval was longer than 24 months.

The effects of treatment with Gn-RH for inducing early postpartum ovarian activity was studied in 38 non-cycling Murrah cows which had calved 30-90 days previously. Two i.m. doses of 0.125 mg each were given four hours apart to half the number of animals, and the remainder were kept as controls. Their ovaries were examined per rectum on days 0, 2, 7, 9, 11, 22 and 28 after treatment. Blood was collected from eight animals in each group on the same days, and serum progesterone was measured by RIA. The percentage of animals commencing ovarian activity during the period of study did not differ significantly between treated and control groups.

R-66 PERERA, B.M.A.O. **Clinical and hormonal studies on reproduction in buffaloes of Sri Lanka** In: *Proceedings of Buffalo Seminar on Reproduction and Meat Production, 15-17 January 1982. Tanaku, India.* pp. 4-5. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Reproductive patterns of 726 river type buffaloes in two state farms in Sri Lanka were analysed over a ten year period. The mean (±SD) age at first calving was 51.0 ± 8.6 and 52.1 ± 10.5 months, the calving interval 530.6 ± 168.2 and 538.6 ± 166.7 days, and the repeatability of calving intervals 0.36 ± 0.02 and 0.43 ± 0.02 for the two farms, respectively. Calvings were unevenly distributed through each year, and the highest percentage of conceptions occurred two to five months after the annual peak in rainfall.

The events associated with commencement of postpartum ovarian activity were monitored by frequent rectal palpation of the ovaries and measurement of plasma progesterone using RIA in group of 12 buffaloes. Cyclic ovarian activity was delayed in the majority of animals for 100 to 200

days after calving, but in most cases conception occurred at the first or second ovulation. Changes in the oestrone, progesterone and 15-keto-13, 14-dihydroprostaglandin F_{α} in peripheral blood during the peri-partal period were basically similar to those in cattle, with the exception that progesterone concentration did not decline until the day of parturition.

Eighty five cycling buffalo cows and heifers were treated with the two-dose regime of cloprostenol. First service conception rates, determined by rectal palpation, were 37.3% after fixed time double AI and 33.3% after natural service. The accuracy of hormonal pregnancy diagnosis based on progesterone in blood 21 days after service was 97.1% for non-pregnancy and 66.7% for pregnancy. Twenty anoestrous buffalo cows were treated with two dose each of 0.125 mg Gn-RH, given four hours apart, at 30 to 90 days post partum. The proportion of animals resuming ovarian activity over a 28 days period did not differ significantly between treatment and control groups.

R-67 PERERA, B.M.A.O., DE SILVA, L.N.A. and KARUNARATNE, A.M. **Reproductive potential of the indigenous buffalo in Sri Lanka.** In: *Proceedings of the 5th World Congress on Animal Production (1983)* pp. 115. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A field survey of indigenous (Lanka) buffaloes in the country revealed that fertility varied markedly between different locations. In order to determine the reproductive potential of this breed, a random sample of 55 breedable cows were selected in a village where fertility parameters were high. They were studied under the traditional extensive management system prevailing at this location. All calvings and services were recorded. Rectal palpation of ovaries and uterus was done weekly from calving until first service, and monthly thereafter. Weekly milk samples were collected from lactating cows and progesterone was measured in fat-free milk using a direct radioimmunoassay technique. At the commencement of the study (November 1981) 53 cows (81.8%) were pregnant and 6 (11%) had inactive ovaries. Over the next six months (Dec - May) 44 (80% of the herd) calved. Among these the mean (± SD) interval (days) from calving to completion of uterine involution was 32.9 ± 8.2 (n=44), calving to first service was 47.1 ± 20.1 (n=43), and calving to palpation of the first corpus luteum was 49.6 ± 14.2 (n=26). Post-partum progesterone profiles in 18 animals revealed a mean interval of 55.2 days (range 27 - 95) to the first elevation above 0.5 ng/ml. The overall mean interval from calving to conception was 80.8 days (n=45), with 60% of those conceiving having an interval less than 60 days. First service conception rate was 70.9%, and the services per conception were 1.34. The only reproductive problem encountered was post partum anoestrus, with nine animals (16.4% having a calving to first service interval exceeding 100 days. These findings indicate that Lanka buffaloes have the potential for high fertility. Further research is warranted to determine why this is not achieved in the majority of farming situations.

R-68 PERERA, B.M.A.O., DE SILVA, L.N.A. and KARUNARATNE, A.M. **Studies on the endocrinology and factors influencing fertility in dairy and draught buffaloes in Sri Lanka.** In: *The use of Nuclear Techniques to Improve domestic Buffalo Production in Asia* (1984), Vienna, Austria. IAEA 1984. pp. 13-28. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Analysis of calving data on farms and field survey in village herds were used in conjunction with radioimmunoassay with plasma progesterone, rectal palpation and other clinical observation to study reproductive functions of river type (Murrah) and indigenous (Lanka) buffaloes. A marked seasonality of calvings and conceptions were observed in both types, with the highest percentage of conceptions occurring 2-5 months after the annual peak in rainfall. In Murrah buffaloes on two state farms the mean ages at first calving were 51.0 and 52.1 months, and the calving interval 17.5 months. Progesterone profiles during the postpartum period showed ovarian inactivity to be the major problem. Most animals remained anoestrus for 100-200 days, but conceived at the first or second postpartum ovulation. Treatment with GnRH during anoestrus had no beneficial effect. Hormonal changes during normal and prostaglandin-synchronised oestrus cycles, pregnancy and the peripartal period were basically similar to those in cattle, with some differences in absolute values. Gestation length (mean ± SD) was 309.9 ± 8.8 days. In Lanka buffaloes under village conditions marked differences in fertility were evident between certain districts and agro-ecological zones. Mean age at first calving ranged from 41.4-49 months, calving intervals from 13-23.5 months, and annual calving rates from 42-75%. Ovarian inactivity was the major problem in area with poor fertility, and was influenced by suckling management and usage for draught and milk. At one village location with high fertility 70% of the animals had calving to first service intervals less than 60 days, first service conception rate of 65.5% and 1.4 services per conception. The mean (± SD) from calving to first elevation of progesterone in milk was 55.2 ± 18.6

days, the calving interval 393.7 ± 79.8 days, and the gestation length 316.9 ± 9.9 days.

R-69 PERERA, B.M.A.O., DE SILVA, L.N.A., TILAKARATNE, N. and ARIYAKUMAR, V. **Effects of suckling management and use for milk or draught on reproductive efficiency of Lanka buffaloes.** *Sri Lanka Veterinary Journal* (1985) **33,** 40-41 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya. SL.

A field survey was carried out on 11,863 buffaloes belonging to 528 farmers in 16 districts of Sri Lanka. The farmers were visited, a questionnaire was administered and the stock numbers were physically verified. Of the breedable females 1,300 were examined per rectum to determine their reproductive status. Data provided by the farmers were used for calculating the age at first calving (AFC) and the calving interval (CI). The finding from rectal palpation for each animal together with its calving history were used for calculating annual pregnancy rate (APR), projected calving rate (PCR) and calving to conception interval (CCI).

The overall mean AFC was 45.7 months; while in the different districts and agro-ecological zones (AEZ), the mean ranged from 42 to 49 months. The CI had an overall mean of 18.9 months, with district and AEZ means ranging from 13 to 24 months.

The mean ARP varied markedly in different AEZ, being highest (67%) in Dry-Low Country Zone 2 and lowest (34%) in Wet-Mid Country Zones 1 to 3. The proportion of animals that were non-pregnant but cycling was high (18-34%) in areas with tethered management, whereas the proportion of animals that were non-pregnant and non-cycling (anoestrus) was high (32 40%) in areas with poor nutrition during prolonged periods of drought. The mean APR was 54.6% in herds with *ad lib.* suckling compared with 62.4% in those with limited or restricted suckling, 53.3% in herds not used for milk compared with 61.8% in those used for milk, and 55% in herds used for work compared with 73.3% in those not used for work. The PCR showed a similar trend, while the CCI had an inverse relationship, confirming that herds with restricted suckling where cows are milked, and those not used for draught had the highest fertility.

R-70 PERERA, B.M.A.O. and DE SILVA, L.N.A. **Gestation length in the Sri Lankan buffalo.** *Sri Lanka Veterinary Journal* (1985) **33,** 42 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Fifty five breedable cows were randomly selected in a village and were studied under the traditional extensive management system prevailing at this location. All services, subsequent calvings and sex of the calf were recorded. Rectal palpation was done at periodic intervals to monitor pregnancies. Milk samples were collected from lactating cows and progesterone was measured in fat-free milk using a direct radioimmunoassay technique. Gestation length was calculated for only those pregnancies where service dates, progesterone profiles and rectal findings enabled an accurate determination of the date of conception.

The mean (± SD) gestation length was 317 ± 10.4 days for male calves (range 294-322 days, n=24) and 316 ± 9.8 days for female calves (range 301-334 days, n=24). The difference between the means was not significant. Thus, irrespective of sex, the mean gestation length for the Lanka buffalo is 316 ± 9.9 days, (n=37).

R-71 PERERA, B.M.A.O., KURUWITA, V.Y. and DE SILVA, L.N.A. **Endocrinology of the postpartum period in buffaloes.** In: *Proceedings of the 1st World Buffalo Congress, 27-31 December, 1985.* Cairo, Egypt. Vol.3. 559-562. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Buffalo is generally considered to have low reproductive efficiency under the majority of environmental and managerial situations in which it is raised. Calving intervals are long and highly variable ranging from 400 to over 600 days in both river and swamp types. Seasonal changes in climate and associated nutritional factors have been shown to markedly influence reproductive efficiency. It had also been shown that buffaloes have the potential for high fertility under certain conditions of management, even in rural small-farm situations. Calving interval is influenced by the interval from calving to subsequent conception (the open period) and the incidence of embryonic and foetal death. The open period is in turn influenced by the time taken after calving for involution of the uterus, re-establishment of cyclic ovarian activity and return to normal fertility.

As in cattle, the concentration of prostaglandin $F_{2\alpha}$ alpha may play a role in involution and regeneration of the endometrium. As in other ruminants, the ovaries of the buffalo remains acyclic for a variable period after calving. This length of acyclicity is known to be influenced by nutrition, milk yield, management, suckling intensity, parity and season of calving. The first postpartum ovulation may occur as early as 20-30 days in certain situations but in others it may be delayed beyond 100 days in both river type and swamp type buffaloes. The information as regards to gonadotrophin secretion in postpartum cows is far

from complete. Few studies have shown that pituitary respond to exogenous GnRH by 30 days postpartum. However, in the absence of studies with frequent sampling to establish the episodic patterns of gonadotrophin secretion, no definite conclusions can yet be made regarding hypothalamic and pituitary control of postpartum reproductive functions of buffaloes. Thus investigations should be undertaken on the effects of improving nutrition using locally available supplements and manipulating managerial factors such as suckling intensity on postpartum ovarian activity. Future studies should aim at clarifying the hypothalamic and pituitary control of ovarian activity and finding simple economically feasible methods of shortening cyclic period in buffaloes.

R-72 PERERA, B.M.A.O. **Use of radioimmunoassay methods for studies on the reproduction of buffaloes**. In: *Proceedings of an IAEA Symposium on Nuclear and Related Techniques in Animal Production & Health, 17-18 March, 1986. Vienna, Austria.* pp. 179-187. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The water buffalo is an important livestock resource of many tropical regions of the world. In Asia it has a crucial role in rural farming systems, providing draught power, meat and milk for small farmers. However, productivity if often limited by many adverse factors which depress reproductive efficiency. Research is therefore necessary to identify the constraints under each specific situation and to generate appropriate methods for overcoming them. Nuclear techniques such as radioimmunoassay for measuring reproductive hormones, when used in combination with clinical and pathological studies, have proved valuable in understanding the reproductive biology of buffaloes. Changes occurring in the major steroid hormones and prostaglandins during the oestrous cycle, pregnancy, parturition and the postpartum period have recently been characterised. The long calving intervals, which constitute the major reproductive constraint, have been shown to be mainly due to prolonged postpartum ovarian inactivity or acyclicity. This is influenced by a variety of managerial, nutritional and climatic factors, among which intensity of suckling, usage for draught and season of calving appear to be specifically important. Nevertheless, it has been established that buffaloes can have optimum fertility with short acyclic periods under certain village conditions and are therefore not biologically limited in this respect. Further studies are therefore needed to clarify the relative importance of the factors delaying postpartum ovarian activity under specific small farm conditions at the village level. Although hormone assays and hormone treatments have been used as management and therapeutic aids in improving reproductive efficiency in certain situations, their applicability at the wider field level is severely limited. The need, therefore, is to study methods of manipulating the management practices which influence fertility by judiciously combining field surveys with clinical methods and hormone assays. It would then be possible to device economically feasible and socially acceptable management systems that would permit the full reproductive potential of the buffalo to be achieved.

R-73 PERERA, B.M.A.O., SILVA, I.D., WEERASEKARA, D.A. and KARUNARATNE, A.M. **Effects of gonadotrophin-releasing hormone and human chorionic gonadotrophin on plasma progesterone in male buffaloes.** *Buffalo Journal* (1986) **2,** 29-35. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya. SL.

Four adult male (8-10 years old) Murrah buffaloes maintained in the mid-country were used to determine the effects of intravenous treatment with Gn-RH and hCG on plasma testosterone concentration. They were grazed during the day and housed at night and water and wallowing facilities were provided. None of the bulls were used for breeding purposes during the period of study of eleven months.

Two buffaloes were given 0.25 mg Gn-RH and the other two 3,000 I.U. hCG intravenously. Jugular blood samples were collected at the half hourly intervals for two hours before and two hours after treatment. This procedure was repeated at monthly intervals over a period of eleven months. Plasma testosterone was measured by radioimmunoassay.

Pre-treatment testosterone concentration ranged from 0.18 to 3.48 ng/ml in the four buffaloes. Treatment with Gn-RH caused elevation in testosterone within 30-60 min in 95% of instances. With peak level between 1.36 and 4.0 ng/ml. With hCG testosterone elevation occurred in only 70% of instances; the response was less regular and tended to diminish with repeated treatment. It is concluded that intravenous treatment with Gn-RH, followed by measurement of testosterone in blood at 30 to 60 min, may afford a practical test of Leydig cell secretory capacity in male buffaloes.

R-74 PERERA, B.M.A.O., DE SILVA, L.N.A., KURUWITA, V.Y. and KARUNARATNE, A.M. **Postpartum ovarian activity, uterine involution and fertility in indigenous buffaloes at selected village location in Sri Lanka.** *Animal Reproduction Science* (1987) **14,** 115-127. Faculty of Veterinary

Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

Reproductive events were monitored over a period of 30 months in a sample of 55 indigenous (Lanka) buffalo cows belonging to five farmers selected at random in a specific village in the dry zone low-country region of Sri Lanka. The animals were maintained under the existing traditional methods of extensive grazing management and low-intensity utilisation for milk and draught power in crop-livestock system. Annual calving rate was 87.2%, with 82.4% of all calvings occurring between December and March (peak calving season). Involution of the uterus, based on rectal palpation, was completed at an interval of (mean ± SD) 32.9 ± 8.2 days post-partum. The majority (70.8%) of first services postpartum were recorded between February and April. The interval from calving to first service was 57.3 ± 49.2 days for 80 animals which calved during the peak calving season and 156.2 ± 95.6 days for eight animals calving outside the peak season (overall 66.4 ± 61.4 days, n=88). The intervals to uterine involution and first service were correlated (r =0.53, $p<0.01$) and both were significantly influenced by month of calving, but not by age or parity of the cow. The interval from calving to palpation of the first corpus luteum was 54.9 ± 17.9 days.

Of the 36 cases where complete progesterone profiles and clinical data were available, first services were recorded in 27 (75%) before palpation of a corpus luteum or elevation of progesterone after calving, and conception to this service was confirmed in 24 (88.9%). Elevation of progesterone preceded first service in seven (19%); the resultant luteal phases were short in four and normal in three. Overall conception rate to first service was 77.7% and the number of services per conception was 1.29. The calving to conception interval ranged from 23 to 502 days (mean 71.5 ± 66.2, mode 41-60, n=82) and the calving intervals from 329 to 816 days (mean 384.9 ± 62.9, mode 351-370, n=79).

These findings confirm that Lanka buffaloes are capable of maintaining high fertility under certain traditional systems of management. The major cause of long calving intervals was prolonged postpartum acyclicity, which occurred mainly in animals calving outside the peak calving season.

R-75 PERERA, B.M.A.O. **A review of experiences with oestrous synchronization in buffaloes in Sri Lanka.** *Buffalo Journal (Supplement) 1.* (1987) 105-114. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A major obstacle to breeding programmes is the poor expression of oestrus signs in the buffalo. Thus artificial insemination (AI) has been much more difficult to implement than in cattle in most developing countries. Several studies have therefore been conducted, both in river type buffaloes in the Indo-Pakistan sabcontinent and in swamp type buffaloes in South East Asia, to examine the feasibility of oestrous synchronisation as a method of overcoming this problem.

Oestrous synchronisation has been done accordingly to the following two methods which are also practised in cattle. One method is based on the use of prostaglandins (PG's) and their analogues to cause regression of an existing corpus luteum (CL) thereby permitting follicular growth and oestrus with ovulation to occur over a relatively well defined period after treatment. Several treatment regimes have been described by various researchers with two-dose eleven-day regime being the most widely used.

The other method is provision of exogenous progesterone or a progestagen to suppress further ovulations until cessation of treatment. This treatment is usually restricted to 12 days and is used in conjunction with oestrogen or PG's to cause luteolysis of early and late CL's respectively. As in cattle, the nutritional status and the level of management of animals subjected to synchronisation are important determinants of success rates. The studies reviewed in this paper also highlight the importance of the correct insemination technique. The cervix of the buffalo is narrow, especially in heifers and unless adequate relaxation has occurred, does not permit ready negotiation with the AI pipette. When natural service is practised, the bull should have good fertility and libido and the ratio of the bulls to cows should be low. Buffaloes in many tropical environments show seasonal fluctuations in fertility involving both female and male. In such situations synchronised breeding programmes are likely to have success if done during the season of highest fertility.

R-76 PERERA, B.M.A.O. **Some factors influencing the postpartum period and fertility in buffaloes and goats.** In: *Proceedings of NCRR Conference on Comparative Reproduction, 23-27 November, 1987. Nairobi, Kenya.* Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

This paper summarises the results from recent studies on buffaloes and goats in the tropics. In buffaloes, clinical and hormonal studies have shown that a major constraint limiting reproductive efficiency is postpartum acyclicity. Ovarian activity may commence as early as 60 days after calving under optimum conditions, but could be delayed beyond 180 days in many practical situations. The

acyclic period is dependent on factors such as climatic conditions and nutritional status during the peripartal period, intensity of suckling by the calf and usage for draught power. In goats too, commencement of ovarian activity can be highly variable; some animals may commence cyclicity between 30-60 days postpartum, while others remain acyclic longer than 180 days. In addition to climatic and nutritional factors, the time of weaning of kids and the time of introduction of stud males have important effects on initiation of ovarian activity. Both species, when kept with intact males, show a variety of patterns in their postpartum progesterone profiles. Some conceive at the first elevation of progesterone, while others have one or more cycles of short or normal duration prior to conception.

R-77 PERERA, B.M.A.O., KURUWITA, V.Y., MOHAN, V., CHANDRATILAKE, D. and KARUNARATNE, A.M. **The effects of some managerial factors on postpartum reproduction in buffaloes and goats.** *Acta Veterinaria Scandinavia, (Supplement 83)* (1988) pp. 91-100. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The effects of restricted (twice a day), zero suckling and unrestricted *(ad lib)* suckling on postpartum ovarian activity and conception was studied in indigenous (Lanka) buffaloes at two locations with contrasting climatic and nutritional conditions, using rectal palpation, measurement of progesterone in blood, and recording of matings and calvings. The sample size at Mawela Farm at Peradeniya was twelve and at Narngalle Farm at Kuliyapitiya was eighteen. Animals managed under less favourable conditions (long periods of drought, native grasses) had extended periods of postpartum acyclicity (>240 days), with no significant differences between groups subjected to different suckling regimes. In contrast, animals managed under more favourable conditions (shorter drought periods, improved grasses) resumed cyclic activity between 60 to 240 days (mean 135 days) after calving. At this location, all animals under restricted suckling had commenced ovarian activity by 90 days, whereas only 20 percent of the animals under unrestricted suckling had done so by this time.

R-78 PERERA, B.M.A.O. **Recent advances in reproduction of male buffaloes.**,In: *Proceedings of 3rd World Buffalo Congress, 13-18 May, 1991. Varna, Bulgaria.* Vol.2. 218-224. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

The objective of this paper is to highlight some of the areas which are currently under study and to examine their possible future applications. It is shown that in the buffalo, maturity is slower and the time lag between the onset of spermatogenesis and the achievement of puberty is considerably longer than that in cattle. Studies on LH and testosterone have shown that buffaloes have the typical episodic or pulsatile pattern of secretion which is characteristic for other domestic ruminants. Some of the newer tests for evaluation of libido and semen quality which are being introduced in cattle could also prove useful in the buffalo. Assessment of hormonal status and cytogenetic composition are indicated under certain conditions for the overall evaluation and selection of breeding bulls.

The three most important infectious diseases of the male are brucellosis, campylobacteriosis and trichomoniasis. Diagnosis of these common infectious diseases are likely to become simpler and more accurate with introduction of new biotechnological developments. The paper highlights areas which require further investigation. The applicability in buffaloes of some techniques used in the evaluation of reproductive parameters in cattle needs to be evaluated.

R-79 PERERA, B.M.A.O., MOHAN, V., KURUWITA, V.Y. and ABEYGUNAWARDENA, H. **Effects of suckling and nutritional supplementation on postpartum ovarian activity and LH profiles in indigenous buffaloes of Sri Lanka.** In: *Proceedings of the 12th International Congress on Animal Reproduction, 1992. The Hague, The Netherlands* Vol. 4. pp. 2081-2083. Animal Production and Health Section, Joint FAO/IAEA Division, IAEA, Vienna, Austria.

Low reproductive efficiency is a common problem in buffaloes raised under typical small-holder crop-livestock farming systems of Asia. Studies in Sri Lanka have shown that average calving interval (CI) was around 19 months, and that delayed resumption of post-partum (PP) ovarian activity (OA) was the major cause for long CI. The length of the PP acyclic period was found to be influenced by the season of calving, availability of feed and management practices such as frequency of suckling by calves. Studies were therefore undertaken to examine the effects at climate, feed availability and suckling management on PPOA in Lankan buffaloes.

Eighteen multiparous Lanka buffaloes (*Bubalus bubalis*) were assigned to one of the three treatment groups immediately postpartum (PP): restricted suckling (RS), *adlibitum* suckling (AS) and AS + supplementary feed (AS/S). OA was determined weekly by rectal palpation and from plasma progesterone levels. LH concentration was determined before and after GnRH injections during 8 hour periods on days 30, 45, 60 and 90 PP. The numbers of animals which had commenced OA in RS, AS and AS/S groups were 2/7, 0/5 and 0/6 at 60

days PP, and 7/7, 1/5 and 3/6 at 90 days. Endogenous episodic LH peaks were seen in 4/7 RS, 0/5 AS and 2/6 AS/S at 60 days, and in 7/7, 3/5 and 4/6 at 90 days. Mean pre-GnRH-LH concentrations increased in all three groups with days PP. Endogenous episodic LH peaks were seen in 4/7 RS, 0/5 AS and 2/6 AS/S at 60 days, and in 7/7, 3/5 and 4/6 at 90 days. The response to GnRH was greater ($P<0.05$) in RS than in AS or AS/S at all stages. Restricted suckling resulted significantly earlier OA, but the supplementary feed used in this trial did not.

R-80 PERERA, B.M.A.O. **Radioimmunoassay of progesterone in the blood of buffaloes during normal and prostaglandin synchronised oestrous cycle.** In: *Proceedings of the Second FAO/IAEA Research Co-ordinating Meeting, 1978 Bogor, Indonesia.* pp. 65-72. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A radioimmunoassay technique is used for measuring plasma progesterone concentration in female river buffaloes during normal and prostaglandin synchronised oestrous cycle. The pattern of fluctuation in progesterone concentration was similar to that in cattle, with low levels at and around oestrus, and higher levels during the luteal phase of the cycle. The absolute values obtained, however, were far lower than those in cattle.

Treatment with either prostaglandin $PGF_{2\alpha}$ or cloprostenol during the luteal phase resulted in a sharp fall in plasma progesterone concentration, and the progesterone profile during the ensuing cycle was similar to that during a natural cycle. A high degree of individual variation was found in peak progesterone concentrations during the luteal phase and the period of secretory activity of the corpus luteum.

R-81 PEIRIS, G.S., MOHAMED, A.R. and ABEYWARDANA, S.A. **Studies on the post-partum involution of the uterus in the buffalo.** In: *Proceedings of the Workshop on Water buffalo Research in Sri Lanka 24-28 November, 1980. Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden 1982. pp 126-130. Veterinary Research Institute, Peradeniya, SL.

Forty eight Murrah buffalo cows which calved normally were examined at weekly intervals post-partum. A rectal examination was conducted to monitor the involution of the uterus and at the same time a cervical mucus sample obtained. The complete involution of the uterus was judged by three criteria while the mucus sample was examined bacteriologically. The mean time of involution of the uterus of the 48 animals was 41.8 ± 1.7 days. When categorised on their calvings, animals that had five or more calvings had a shorter time of involution as compared to those with 1 to 4 calvings, which was statistically significant at 10 per cent level.

Frequency distribution of the cows showed that 14.6 per cent involuted in 20 to 29 days, 33.3 per cent in 30 to 39 days, 27.1 per cent in 40 to 49 days and 25 per cent in 50 to 65 days; thus 60 per cent of the cows involuted between 30 to 50 days. It was found that the mean time of involution of animals 3 to 5 years of age was 47.1 ± 5.8, between 6 to 8 years of age 41.1 ± 1.9 and over 9 years 39.7 ± 2.8 days showing a tendency for a shorter time of involution in the older animals. More bacterial isolates were obtained from cervical mucus samples taken the first two weeks after parturition than from those obtained later. The most common bacterial isolates were *Staphylococcus* Spp. *E. coli* and *Corynebacterium pyogenes.* There was no indication that any particular bacterium affected the time of involution.

No correlation was seen between the time of involution and the calving interval of the animals that calved subsequently. However, the percentage of animals that did not calve for 2.5 years was as high as 50 per cent in the 50 to 65 day involution category compared to 23.1 per cent and 37.5 per cent in the 40 to 49 day and 30 to 39 day involution groups, respectively.

R-82 RAJAMAHENDRAN, R., HAYASHI, T. and DHARMAWARDENE, J. **Preservation of buffalo semen.** *Ceylon Veterinary Journal* (1978) **26.** 56-57 [Abstract]. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

A comparative study of three different diluents was conducted to test their ability in preserving Murrah buffalo semen at 4^0C. The diluents used were, modified TRIS buffer, TRIS with egg yolk and modified Illini Variable Temperature (IVT) medium. Six ejaculates (one per week), obtain from one buffalo bull, were used for preservation. Immediately after collection semen samples were assessed for volume, mass, activity, dead sperm percentage and density. The semen was then diluted with experimental diluents to give a dilution rate of 1:10 in 15 x 125 mm tubes. The tubes were then capped and stored in refrigerator. The refrigerator temperature during the study period varied between 4-6^0 C. Stored semen was examined daily for motility and percentage dead sperm. The results indicate that both TRIS buffer and TRIS with egg yolk diluent could maintain motility of 50% or above of buffalo sperm up to 7 days. However, IVT diluent maintained similar motility up to 48 hours only.

R-83 RAJAMAHENDRAN, R., THANGARAJAH, P. and THANGARAJAH, M. **Preservation of buffalo**

semen at 4°C: A comparative study of three diluents. *Ceylon Veterinary Journal* (1979) **27,** 20-22. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

Three semen diluents, namely citric acid and whey (CAW), milk - egg yolk and egg yolk citrate (EYC) were compared for their relative ability to preserve buffalo bull semen collected under Sri Lankan conditions, at 4^0 C.

The period up to which 50 percent of spermatozoa remain motile (storage length) was determined for semen stored in each diluent. CAW and milk - egg yolk preserved semen for 6.3 ± 2.3 and 4.5 ± 1.1 days, respectively; these diluents were significantly superior to EYC, the storage length in this diluent was only 2.7 ± 0.9 days.

R-84 RAJAMAHENDRAN, R. and PATHIRANA, K.P.M. **Hormonal induction of lactation in buffalo heifers and cows.** *Ceylon Veterinary Journal* (1979) **27,** 32 [Abstract]. Department of Animal Husbandry, Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

Two trials were conducted to study the effect of hormone treatment on udder development, lactation and milk composition in buffaloes. In Trial I, two dry cows and two heifers were subcutaneously injected for 7 days at 12 hr intervals with a mixture of Oestradiol 17 beta (E/2 beta) and Progesterone (P). In Trial II, 3 heifers and 2 dry cows were injected with a mixture of E/2 beta and P for 14 days at 12 hr. intervals. Each injected dose contained 0.05 mg of E/2 beta and 0.125 mg of P per kilogram of body weight. A single injection of Dexamethasone (0.05 mg/kg body weight) was given intramuscularly to each animal on the 7th day after last E/2 beta + P injection. The udder development in heifers was very pronounced compared to dry cows. Milk yield was very minimal in heifers. The highest daily milk yield recorded was 3.7 litres. Peak lactation occurred 40 -70 days after lactation began. The fat %, total solid % and solids not fat % of the milk samples obtained during peak lactation approximated normal values.

R-85 RAJAMAHENDRAN, R. and THAMOTHARAM, M. **Induction of post-partum oestrous in buffalo.** *Ceylon Veterinary Journal* (1980) **28,** 61-62 [Abstract]. Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, SL.

A study was carried out in buffalo cows to advance their post-partum oestrus and to determine, based on heat signs and conception rate, the best time for blind insemination following progesterone treatment. The study involved 15 cows approximately 15 days post-partum. A progesterone-impregnated vaginal device plus a capsule containing 5 mg of oestradiol 17 β was inserted into the vagina using a plastic speculum and a plunger. The device was removed from the vagina after 12 days; the cows were then confined to a paddock and observed for five days continuously for signs of oestrus and standing to males. Different bulls were rotated among cows allowing a maximum of two mountings per bull. Rectal palpation was done 90 days after mating to diagnose pregnancy.

All the cows retained the device for 12 days. Mucus discharges were observed in all treated animals around 48 hours after removal of the device. However, only 10 animals showed maximum receptivity to males; the mean interval from the removal of the device to receptivity was 66 hours. Three cows were successfully bred during the receptivity period and all three were diagnosed pregnant 90 days later.

From this study it can be concluded that post-partum oestrus can be induced by progesterone device treatment and the best time for blind insemination following progesterone device treatment is 66 hours after removal of the device.

R-86 RAJAMAHENDRAN, R., THANGARAJAH, M., THANGARAJAH, P., DHARMASENA, L.D.P. and PATHIRANA, K.P.M. **Characteristics and preservation of semen in buffalo bulls and the use of hormones in buffalo females.** In: *Proceedings of the Workshop on Water Buffalo Research in Sri Lanka 24-28 November 1980 Peradeniya, Sri Lanka.* SAREC Report R3: Stockholm, Sweden. 1982. pp 111-118. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Semen characteristics and libido of 4 Murrah, 3 Surti and one local buffalo bulls were studied over a period of one year. Volume of semen and concentration of sperms were highest in Murrahs. Murrah semen had significantly higher percentage of dead sperms in the first ejaculate. The local buffalo gave a greater volume of semen than Surti males but the semen had lower concentration of sperms and higher percentage of dead and abnormal sperms. Semen characteristics were significantly affected by climatic variation. Libido as measured by reaction time was not affected by either breed or climatic variation.

Coconut milk extender (CME), Illini variable temperature (IVT) and egg yolk citrate (EYC) were evaluated for their ability to preserve buffalo bull semen at room temperature. IVT maintained 50% motility within 24 hours. Preservation at 4^0 C was carried out using Tris diluent, Citric acid whey (CAW), milk egg yolk (MEY) and EYC. Results indicate that Tris could

maintain motility of 50% or above up to 7 days, CAW up to 6 days, MEY up to 4 days and EYC up to 24 hours. The "freezability" of buffalo semen in Tris diluent and CAW was compared. Post-thaw motility at 0, 12, 96 hours and at 3 months after freezing was significantly better for Tris than for CAW.

The use of progesterone vaginal device for the induction of fertile oestrus was tested in a herd of non-lactating buffalo cows. The retention rate of the device was 81% and the conception rate following natural mating was 62%. The above device was also tested in post-partum buffalo cows about 50 days after calving. More than 80% of the treated animals exhibited signs of oestrus after the removal of the device. However, the conception rate following natural mating and after fixed time insemination was only 25%. Pregnant mare serum gonadotrophin plus prostaglandin $F_{2\alpha}$ treatment regime resulted only in poor super-ovulatory response in buffalo heifers. The use of short term oestrogen plus progesterone treatment for the induction of lactation in buffaloes was tested in 4 cows and 5 heifers. The degree of udder development was more pronounced in heifers than cows. Lactation was initiated in all the animals. However, the quantity of milk produced varied widely among individuals.

R-87 RAJAMAHENDRAN, R., GUNASUNDARAM, S. and THAMOTHARAN, M. **Early induction of fertile oestrus in post-partum buffalo cows.** In: *Proceedings of the 2nd Research Co-ordination Meeting on the Use of Nuclear Techniques for Improving Buffalo Production in Asia* (1981), IAEA, Vienna, Austria. pp. 193:201. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

The use of progesterone intravaginal device (PRID) for the induction of fertile oestrus was tested in 16 non lactating cows and 86 post partum buffalo cows roughly 50 days after calving. In non lactating cows the retention rate of PRID was 82% and the conception rate following natural was 62%. In post-partum cows retention rate was 100% and more than 80% of the animals exhibited signs of oestrus after PRID removal. However the conception rate following natural mating (26%) and fixed time inseminations at 60 and 84 hours after PRID removal (36%) was very low. Failure of some animals to resume ovarian activity after PRID treatment or poor libido of some of the bulls used for natural mating or technical difficulties relating to insemination probably account for this low fertility. Studies are in progress to overcome these problems.

R-88 RAJAMAHENDRAN, R. and DHARMASENA, L. **Preservation of buffalo semen in citric acid whey and tris buffer extenders at -196°C.** *Journal of National Science Council of Sri Lanka.* (1994) **12,** (1) 45-51. Faculty of Agriculture, University of Peradeniya, Peradeniya, SL.

Two diluents, citric acid whey (CAW) and TRIS buffer (TRIS) were compared for their ability to preserve buffalo semen at -196°C, under Sri Lanka conditions. Total of 86 collections from 8 bulls were tested. The percentage motility and dead sperms after diluting with CAW and TRIS and following 6 hours of equilibration did not differ. However, there was significant reductions of sperm motility and a increase in percent of dead sperms in both diluents after freezing and thawing. In TRIS the reduction in motility was 27% compared to CAW where it was found to be 66%. In conclusion, TRIS is a better diluent than CAW for freezing of buffalo semen under Sri Lankan conditions.

R-89 RANASINGHE, R.A. and KURUWITA, V.Y. **Superovulation and nonsurgical recovery of embryos from cattle and buffaloes.** *Sri Lanka Veterinary Journal* (1983) **31,** 51 [Abstract]. Department of Animal Production and Health, Peradeniya, SL.

Superovulation is an important step, but, still remains as the weak link in the chain of events influencing embryo transfer in cattle. This technique takes the advantage of the potential represented by thousands of oocytes that will never get a chance to mature and ovulate during a reproductive life of a cow. Exogenous hormones have been used to superovulate donor cows, but, no reports are available up to - date for such procedure in buffalo cows.

A crossbred Sindhi cow and a Murrah buffalo cow were selected as donors for superovulatory treatment. Each donor was given intramuscular injections of 2000 IU pregnant mare serum gonadotrophin ("Folligon"; Intervet) on day 10 of the oestrus cycle, and 25 mg of prostaglandin ($PGF_{2\alpha}$) on day 12 of the same cycle. Both donors exhibited good oestrous signs within 72 h following prostaglandin treatment; the buffalo cow showed signs within 36 h. Each donor was inseminated artificially in the morning and evening on days 14 and 15 of the same cycle. The right and left uterine horns of each donor were separately flushed on day 7 of the subsequent cycle, using a bovine three - way egg collection catheter and modified Dulbeco phosphate - buffered saline with 2 % inactivated calf serum as the flushing medium. After allowing to stand and decanting the excess, about 100 ml of flush from each horn were examined under the dissection microscope (x 80). Six embryos in all

were recovered from the crossbred Sindhi cow, and five from the Murrah cow; rectal palpation of the ovaries at the time of uterine flushing revealed the presence of eight and six corpora lutea in the respective donors. It is concluded that more studies of this nature are warranted before successful embryo transfer procedure is adopted in cattle and buffaloes under local conditions.

R-90 SIVAKANESAN, R., HERATH, H.M., SWARNALATHA, and RAJAMAHENDRAN, R. **Variations in the levels of some biochemical constituents in blood during normal and PGF $_{2\alpha}$ induced oestrus cycles in local buffaloes.** *Sri Lanka Veterinary Journal* (1982) **30**:36, [Abstract]. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

The concentration of several biochemical constituents in blood during normal and PGF 2 induced oestrus cycles in local buffaloes was determined. Statistical analyses revealed no significant differences in serum calcium, phosphorus, blood glucose and haemoglobin levels between the two groups of animals. The mean values for calcium, phosphorus, haemoglobin and glucose during oestrus period were 11.4 mg dl^{-1}, 6.2 mg dl^{-1}, 13.9 mg dl^{-1} and 41.5 mg dl^{-1} respectively. The mean value of 5.42 mg dl^{-1} for protein during, normal oestrus period was slightly lower than the mean value during induced oestrus. When the mean values after 3rd, 8th and 26th days of the second $PGF_{2\alpha}$ injection (2nd injection given 11 days after the first injection) were compared, a significant difference was observed. The serum protein levels remained elevated during the first three days after injection, with a peak level of 5.78 g dl^{-1} on the third day, and then declined to remain at a constant level around 5.28 g dl^{-1} up to the 23rd day. On the 26th day the level increased to 5.57g dl^{-1}.The increased levels observed up to the 3rd day may be due to the anabolic effect of oestrogen secreted as a result of prostaglandin injection. This increase in protein level was largely due to an increase in the albumin concentration. The mean value for haematocrit during normal oestrus cycle was significantly lower than the value during induced oestrus.

R-91 SIVAKANESAN R., RANASINGHE, J.G.S., MARIATHASAN, C. and ABEYGUNAWARDENA, H. **Serum concentrations of progesterone and its precursor cholesterol in buffaloes.** In: *The Role of the Buffalo in Rural Development in Asia.* [Edited by Perera B.M.A.O. *et al.*] Colombo, Sri Lanka, NARESA Press. 1996 pp. 239-250. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

The dependence of steroidogenesis in mammalian ovary on high density lipoprotein cholesterol (HDL-C) prompted a study on the relationship between serum progesterone and HDL-C concentration in buffaloes. All pregnant animals at the Narangalla buffalo farm were divided into two groups and one group was supplemented with urea treated straw. All the animals were allowed to graze freely. Blood samples were collected at fortnight intervals and progesterone, total cholesterol (TC) and HDL-C concentrations were measured.

Pearson correlation analysis gave coefficient values of 0.083 (progesterone and TC, control group, n=62); 0.112 (progesterone and TC, control group supplemented group, n=62); -0.007 (progesterone and HDL-C, control group, n=63); -0.082 (progesterone and HDL-C supplemented group, n=65) indicating very poor correlation. The TC concentration was lowest during the first two weeks postpartum in both control [1.22 ± 0.082 (SEM) mmol/l] and supplemented [1.42 ± 0.061 (SEM) mmol/l] groups and increased significantly up to 10 weeks (control 1.68 ± 0.094; supplemented 1.70 ± 0.089). Thereafter in the control group the levels fluctuated between 1.51 to 1.86 mmol/l whereas in the supplemented group the levels it remained very close to 1.76 mmol/l. The wide fluctuations seen in the control seen in the control group may be due to the availability of food. The TC concentration in the supplemented group did not differ significantly from that of the control group at any stage of the experiment. The HDL-C was lowest during the first two weeks after parturition; the values being 1.00 ± 0.068 (SEM) mmol/l and 1.10 ± 0.044 (SEM) mmol/l respectively for the control and supplemented groups. The HDL-C gradually increased over a period of 8 weeks after which it remained around 1.22 mmol/l in both groups. The differences between the control and supplemented groups were not significantly at any stage during the experiment.

Five animals out of 18 in each group, control and supplemented, were cycling by 150 days and 133 days, respectively. Supplementary feeding did not result in an appreciable improvement in the reproductive status and serum cholesterol. There was no correlation between either TC or HDL-C and serum progesterone concentrations, indicating the possibility that the progesterone synthesis is not influenced by the circulating levels of HDL-C and TC.

R-92 SIVAKANESAN, R., ABEUGUNAWARDENA, H. and RANASINGHE, S. **Effect of urea treated straw supplementation on reproductive performance and on some blood metabolic and nutritional indices in buffaloes.** In: *Proceedings of the 2nd Asian Buffalo Association Congress 9-12 October*

1996, Manila, Philippines. Faculty of Medicine, University of Peradeniya, Peradeniya, SL.

Supplementary feeding has been claimed to improve reproductive performances of cattle and buffaloes. However, the extent of the improvement had never been quantitatively measured in order to use such indices to evaluate the degree of success achieved. Hence, this study was undertaken to observe the influence of supplementary feeding on some blood metabolite concentration.

All pregnant animals at the Narangalla buffalo farm were divided into two groups and one group was supplemented with urea treated straw. All the animals were allowed to graze freely. Blood samples were collected at fortnight intervals and progesterone, total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), total protein, albumin and glucose concentrations were measured in serum and haemoglobin and packed cell volume in whole blood.

The TC concentration was lowest during the 1st 2 weeks postpartum in both control (1.22 ± 0.082 mmol/l) and supplemented (1.42 ± 0.061 mmol/l) groups and increased significantly up to 14 weeks (control 1.74 ± 0.09; supplementary 1.76 ± 0.8). Thereafter, in the control group the levels fluctuated between 1.52 and 1.87 mmol/l whereas in the supplemented group it remained very close to 1.76 mmol/l. The TC concentration in the supplemented group did not differ significantly from that of the control group at any stage of the experiment.

The HDL-C was lowest during the 1st two weeks after parturition; the values being 1.0 ± 0.07 mmol/l and 1.1 ± 0.04 mmol/l, respectively for the control and supplemented groups. The HDL-C gradually increased over a period of 8 weeks after which it remained around 1.22 mmol/l in the supplemented group and between 1.16 and 1.30 mmol/l in the control group. The difference between the control and supplemented groups was not significant at any stage during the experiment.

Postpartum cycling was observed around 85 days in both control and supplementary groups. Twelve animals out of 35 (35%) included in the study were cycling of which 5 animals belonged to the control group of 17 (30%) animals and 7 animals belonged to the supplemented group of 18 (39%) animals. A rise in serum progesterone above 0.5 ng/ml before 150 days postpartum was observed only in 3 animals in the control and 5 animals in the supplemented groups. Five animals out of 17 in the control group were cycling by 150 days whereas 5 out of 18 in the supplementary group were cycling by 133 days.

The mean body weights of the supplementary group was slightly higher than that of the control group and the difference was not statistically significant. The urea treated straw supplemented group had lesser variations in the mean bi-weekly body weights. It also appeared that the postpartum weight loss in these animals was of lesser magnitude than that of the control group.

Total protein, albumin, glucose and haemoglobin estimations did not reveal any significant difference in these parameters between control and supplemented groups of animals. In general these biochemical parameters were low in supplemented animals.

Supplementary feeding with urea treated straw did not result in an appreciable improvement in the reproductive status of Sri Lankan crossbred buffaloes. However, such feeding was observed to minimise the postpartum variation and the decline in body weight. Serum concentrations of cholesterol, HDL-C, protein, albumin and haemoglobin in supplemented animals were no better than those of the control animals. Therefore, urea treated straw supplementary feeding appeared to be of limited value in local buffaloes. Further studies, with urea and molasses treated straw, are required to evaluate the usefulness of supplementary feeding.

R-93 TILAKARATNE, N. and JALATGE, E.F.A. **Lactation and reproductive performance of River x swamp type crossbred buffaloes.** In: *Proceedings of the 5th World Congress on Animal Production* (1983) pp. 38. Veterinary Research Institute, Peradeniya, SL.

Asiatic buffaloes have been classified into river and swamp types. Majority of the recognised dairy breeds belong to river type. Swamp buffaloes, on the other hand, are poor dairy animals, and are used mainly for meat and draught purposes. Attempts are presently being made in many Asian countries to improve the dairy potential of the swamp buffalo by crossbreeding with river breeds. This presentation deals with the results from one such experiment involving Murrah (a river breed) and Lanka - the swamp type indigenous buffalo of Sri Lanka. Data comprised lactation and calving records of 49 Lanka (L), 112 Murrah (M), 68 Murrah x Lanka (F1) and 48 Murrah x F1 (B1) cows. The mean first lactation yield ± standard error (s.e) based on 305 days lactations corrected for year of calving were 353 ± 17, 1427 ± 34, 829 ± 31 and 1096 ± 48 kg for L, M, F1 and B1 respectively. Milk yield in all 4 genotypes reached a maximum in the third lactation followed by a gradual decline in subsequent lactations. Repeatability of milk yield based on first 5 lactations (genotypes combined) was 0.39. The average ages at first calving ± s.e. were 53.6 ± 0.8, 51.2 ± 0.7 and 50.2 ± 0.9 months for M, F1 and B1 respectively. Average calving intervals of

different genotypes were L = 14.9 ± 0.3, M = 16.6 ± 0.3, F1 = 13.9 ± 0.3 and B1 = 15.1 ± 0.4 months. These results indicate a considerable improvement in the potential for milk production in the crossbred compared to the swamp base, although there was no indication of heterosis. Grading up to 3/4 Murrah inheritance resulted in further improvement of milk production. Both F1 and B1 were marginally superior to pure-bred Murrah in reproductive performance.

R-94 THANGARAJAH, M., THANGARAJAH, P. and RAJAMAHENDRAN, R. **Preservation of buffalo bull semen at room temperature: Comparative study of three diluents.** *Ceylon Veterinary Journal* (1979) **27,** 31-32 [Abstract]. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

In this study three diluents were used to test the ability to preserve Murrah buffalo bull semen at room temperature. The diluents used were Illini Variable Temperature (IVT) diluent, Coconut Milk Extender (CME) and Egg Yolk - Citrate (EYC). Six ejaculates of semen, two per week obtained from 4 Murrah buffaloes were used for estimating preservation. The semen sample immediately after collection were used for colour, volume, mass motility, live and dead sperm percentage, abnormal spermatozoa and sperm concentration.

The percentage of live spermatozoa was calculated by differential staining with Eosin-Nigrosin. Two concentration of spermatozoa was determined with haemocytometer. The semen sample with less than 60% gross motility were not considered for the study.

The semen was then diluted with experimental diluents to give dilution rate 1:10 in 15x125 mm tubes. The tubes were then capped and stored in a dark place at room temperature (28 - 30^0 C). The stored semen samples were examined daily for motility and percentage of dead sperm.

The results indicated that IVT maintained motility of 50% up to 3.5 days, CME maintained motility of 50% up to 3 days and EYC maintained motility up to 50% only for 12 hours. The study showed that buffalo bull semen could be stored at room temperature.

R-95 THANGARAJAH, P., THANGARAJAH, M. and RAJAMAHENDRAN, R. **Preservation of Buffalo semen at 4°C.** *Ceylon Veterinary Journal* (1979) **27,** 33 [Abstract]. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, SL.

Three diluents namely egg yolk-Citrate (EYC); Citric Acid-Whey (CAW) and milk were chosen to compare their storing ability of Murrah buffalo semen at 4°C. Semen from Murrah buffaloes collected twice a week were used for this study. Soon after collection semen was assessed for colour, volume, conentration, motility and live/dead sperm count. Semen samples were then diluted to 1:10 in experimental diluents by split sample technique. The extended semen was examined for motility and live/dead sperm count before preservation. The tubes containing extended semen were placed in a 400 ml beaker containing water and transferred to a refrigerator to prevent cold shock and to ensure gradual cooling. The refrigerator temperature varied from 0-4° C during storage. Stored semen samples were examined daily for motility and live/dead sperm count.

The results indicate that EYC preserves buffalo semen with a motility of 50% or above for 2-3 days; CAW for 6-7 days and milk for 4-5 days. From this study it is concluded that EYC is a poor extender for buffalo semen and milk and CAW can be used for preservation of buffalo semen.

R-96 THEVAMANOHARAN, K. **Genetic analysis and evaluation of production traits in the buffalo** *M. Phil. Thesis* 1994 Postgraduate Institute of Agriculture, University of Peradeniya, SL.

Two studies were carried out on buffaloes in Sri Lanka. The first was a survey of 80 farmers to study buffalo farming and production levels in Polonnaruwa and Mannar districts. Ninety-five percent of the farmers cultivated either paddy and and/or highland and all used indigenous buffaloes. The shortage of grazing land was the major limitation to buffalo farming in both districts. The age at first calving, calving interval, number of calves/life time were 44 months, 14.5 months and 9.8 calves, respectively. Buffalo cows that were grazed longer had 2-3 months shorter calving intervals, were 2-3 months younger at first calving and produced significantly (10-12 litres) more milk per herd per day and four more calves per life span. Buffaloes milked had four months shorter calving intervals than those not milked. Calving intervals were two months shorter and milk yields were higher among dams that were not worked in the fields. The milk yields and lactation lengths were 1.6 litre/day and 6.5 months respectively. On an average Polonnaruwa animals produced 28 litres more milk than those of Mannar (317 litres) in a lactation.

In the second investigation, data from the first four lactations over an eleven year period from 1971 to 1981 on 273 pure Murrah (M) and 233 Murrah Grades (GM) from the Ridiyagama Farm were used in the analysis. The total number of calvings over this 11 year study was 820 for M and 774 for GM: Although the first calvings occurred at almost equal frequencies in maha and yala in the M and GM groups, subsequent conceptions and calving

occurred in a ratio of almost 3:1 in maha and yala respectively. Murrah heifers had their first calves at the age of 50.7 months while heifers calved at 48.7 months, the difference being statistically significant ($P<0.05$). Male calves outweighed female calves at birth by 830g. A mean reduction of 0.39kg of birth weight and an increase of 1.8 month per year of age at corresponding calvings was observed over the study period.

The 305-day adjusted milk yields of M breed were 1501, 1533, 1488 and 1364 kg at I, II, III and IV lactations while the respective figures were 1359, 1342, 1271 and 1258kg for GM. Milk yield differed among the breeds ($P<0.05$) for all lactations except the fourth. The least square means for the first, second, third and fourth lactation lengths of breed groups pooled were 359, 327 and 314 days. The means of the first, second and third calving intervals were 640, 507 and 485 respectively. A mean reduction of 80.1kg in a 305-day milk yield and 4.5 days in lactation length per year was observed over the study period. Animals calved in *yala* had 102 litre and 21 days more in the milk yield and length of lactation at II and III lactations than *maha* calves. Buffalo cows conceived during August to October had 136 days shorter ($P<0.01$) calving interval than dams conceived during January to March at third calving. Therefore in addition to its effect on calving pattern, season was also found to influence the milk yield, lactation length and calving interval.

Upgrading at Ridiyagama has resulted in an improvement of birth weight, milk yield and lactation length but has had no effect on calving interval and age at calving. The observed mean reduction in milk yield and birth weight per year may be attributed to genetic deterioration and limitation on the level of management. Unless more genetic variability could be incorporated into the gene pool further progress in milk production and birth weight is likely to be restricted

NA - 192 - 5

LIST OF PUBLICATIONS OF THE WATER BUFFALO INFORMATION DISSEMINATION PROGRAMME

Report of the planning workshop on assessment of training needs of farmers and extension workers on buffalo development in the coconut triangle, Sri Lanka. (1995) 11 pp.
Publication No. 1

SAREC/NARESA regional symposium on the role of the buffalo in rural development in Asia: Programme and Abstracts.. PERERA, B.M.A.O., SIRIWARDENE, J.A. DE. S., IBRAHIM, M.N.M. AND HORADAGODA, N.U. [EDITORS] Colombo, Sri Lanka. NARESA Press (1995) 40 pp.
Publication No. 2

Role of the buffalo in rural development in Asia. PERERA, B.M.A.O., SIRIWARDENE, J.A.de S., HORADAGODA, N.U. and IBRAHIM, M.N.M. [EDITORS] Colombo, Sri Lanka. NARESA Press (1996) xx+522 pp. ISBN 955-590-007-8. Publication No. 3

Swedish assistance for buffalo research and development in Sri Lanka – Impact on livestock production. Buffalo Research and Development Programme. (under preparation)
Publication No. 4

Fibrous feeds and their utilisation. PERERA, A.N.F., SIRIWARDENE. J.A. de S. and ABEYGUNAWARDENA, H. SAREC/NARESA Buffalo Research and Development Programme, Information leaflet No. 1. Colombo, Sri Lanka. NARESA Press (1998) 7 pp. *Publication No. 5

Urea-molasses-mineral (UMM) multinutrient feed supplement. ABEYGUNAWARDENA, H., SIRIWARDENE, J.A. de S. and PERERA, B.M.A.O. SAREC/NARESA Buffalo Research and Development Programme, Information leaflet No. 2. Colombo, Sri Lanka. NARESA Press (1998) 5 pp.
*Publication No. 6

Body condition scoring system for assessing the nutritional status of buffaloes and cattle. PERERA, B.M.A.O., ABEYGUNAWARDENA, H. and SIRIWARDENE, J.A.de S. SAREC/NARESA Buffalo Research and Development Programme, Information leaflet No. 3. Colombo, Sri Lanka. NARESA Press (1998) 5 pp. * Publication No. 7

Reproduction in buffaloes and cattle. ABEYGUNAWARDENA, H., PERERA, B.M.A.O. and SIRIWARDENE, J.A.de S. SAREC/NARESA Buffalo Research and Development Programme, Leaflet No. 4. Colombo, Sri Lanka. National Science Foundation (NSF) Press (1998) 6 pp.
*Publication No. 8

Breeding of buffaloes and cattle. ABEYGUNAWARDENA, H., PERERA, B.M.A.O., JEYARUBAN, M.G. and SIRIWARDENE, J.A.de S. SAREC/NARESA Buffalo Research and Development Programme, Leaflet No. 5. Colombo, Sri Lanka. NARESA Press (1998) 8 pp.
*Publication No. 9

Health and diseases of buffaloes and cattle. DE ALWIS, M.C.L., ABEYGUNAWARDENA, H., SIRIWARDENE, J.A.de S., SUBASINGHE, D.H.A. and HORADAGODA, N.U. SAREC/NARESA Buffalo Research and Development Programme, Leaflet No. 6. Colombo, Sri Lanka. NARESA Press (1998) 9 pp. *Publication No. 10

Use of tree fodders in ruminant feeding. PERERA, A.N.F., PERERA, E.R.K., ABEYGUNAWARDENA, H., SUBASINGHE, D.H.A. and PREMALAL, G.G.C. SAREC/NARESA Buffalo Research and Development Programme, Information Leaflet No. 7. Colombo, Sri Lanka. NSF Press (1998) 7 pp.
*Publication No. 11

Management of buffaloes and dairy cattle. SUBASINGHE, D.H.A., ABEYGUNAWARDENA, H., PERERA, E.R.K. and PERERA A.N.F. SAREC/NARESA Buffalo Research and Development Programme, Information Leaflet No. 8. Colombo, Sri Lanka. NSF Press (1998) 8 pp.
*Publication No. 12

Feed formulation for cattle and buffaloes. IBRAHIM, M.N.M., ABEYGUNAWARDENA, H. and SUBASINGHE, D.H.A. SAREC/NARESA Buffalo Research and Development Programme, Information leaflet No. 9. Colombo, Sri Lanka. NSF Press (1988) 9 pp.
*Publication No. 13

Crop-Livestock integration for maximising smallholder farm income. SUBASINGHE, D.H.A., ABEYGUNAWARDENA, H. and PREMALAL, G.G.C. SAREC/NARESA Buffalo Research and Development Programme, Information Leaflet No.10. Colombo, Sri Lanka. NSF Press (1998) 17 pp.
*Publication No. 14

Water buffalo - Improved utilisation through new technologies. SUBASINGHE, D.H.A., HORADAGODA, N.U., ABEYGUNAWARDENA, H. and SIRIWARDENE, J.A.de S. [EDITORS]. Colombo, Sri Lanka. NSF Press (1998) 94 pp. ISBN. 955-590-015-9. Publication No. 15

Cattle and buffalo farming training manual for extension workers. ABEYGUNAWARDENA, H. SIRIWARDENE, J.A.de S. and SUBASINGHE, D.H.A. [EDITORS]. Colombo, Sri Lanka. NSF Press (1998) 113 pp. ISBN. 955-590-014-0. Publication No. 16

Water Buffalo Research in Sri Lanka – Compendium of research information. SIRIWARDENE J.A.de S., HORADAGODA, N.U., ABEYGUNAWARDENA, H. and SUBASINGHE, D.H.A. [EDITORS]. Colombo, Sri Lanka. NSF Press (1999) 130pp. ISBN. 955-590-016-7. Publication No. 17

Cattle and buffalo farming – A handbook for veterinarians. ABEYGUNAWARDENA, H. and SIRIWARDENE, J.A. DE S. [EDITORS]. Colombo, Sri Lanka. National Science Foundation (1999) (under preparation) Publication No. 18

* Published in Sinhala as well.