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NATURAL ENEMIES OF MITE PESTS OF TEA AND BIOLOGICAL CONTROL ASPECTS

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INTRODUCTION

The increasing importance of phytophagous mites as serious pests and the development of acaricide resistance among pest mites have brought about considerable interest in biological control of mite pests all over the world.

It has been estimated that the sporadic yield losses due to mite injury on tea was about 50% and reduction of the growth of young tea was retarded by around 30% (Sudoi *et al.*,1991).

There are ample reasons for resorting to biological control of pests of tea. Firstly tea is an economically important crop in Sri Lanka earning annually nearly 50 billion rupees in foreign exchange and providing employment for about million persons associated with the tea industry. Any hazardous chemical residues exceeding maximum residue limits in exported tea could have detrimental effects on tea exports.

Furthermore wide scale use of synthetic broad spectrum-pesticides has been proven to be harmful to non-target beneficial organisms in the environment. Some examples of these include pest resurgence and appearance of new pests due to death of their natural

enemies, phytotoxicity effects, impaired crop flavour or taint and development of resistant strains of the pest.

It is recognized that in highly managed agro ecosystems such as orchards, green houses and plantations are subjected to changes that destabilize the ecological balance. The conditions in these systems augment the rate of increase of the pest and at the same time reduces the efficacy of their natural enemies. Tea is such a system and currently mite pests of tea are controlled by chemicals.

BIOLOGICAL CONTROL

Biological control provides an environmentally safe (absence of harmful effects on man and environment), cost effective and energy efficient means of pest control either alone or as a component of integrated pest management. There is thus much to gain in directing research efforts towards biological solutions with regard to major mite pest problems in Sri Lankan tea plantations.

Biological control of mites began more than 100 years ago. The earliest example was the predatory mite *Tyroglyphus phylloxerae* sent to France from United States in 1873 to control an insect damaging grape root stocks (Sweetman, 1936).

The main advantages of biological control over chemical control are summarized by Helmet and Emden in 1974 as follows (Coppel & Mertins, 1977) ;

1) Selectivity - where pest problems are not intensified or new ones are not created.
2) Availability - biological control agents are really available in the environment concerned.
3) Searching ability - most biological control agents are able to seek out and find the pest.
4) Multiplication - they can reproduce and increase their numbers often at a faster or a similar rate to the pest.
5) In most instances pests do not develop resistance against biological control agent.

6) The control agents are self-perpetuating.

One must also consider disadvantages of biological control in relation to control strategy. The main disadvantages may be summarized as follows;

1) The control is slow in contrast to immediate result achievement with chemicals.
2) Biological control will not completely eliminate a pest.
3) The method is often unpredictable.
4) Initial investment in development of a biological control agent can be very costly.
5) Not all pest species are amenable to biological control

NATURAL ENEMIES OF MITES

Previous investigations have indicated that several biological control agents are active in the tea ecosystem exerting natural regulation of many pest populations including phytophagous mites. Typically naturally occurring biological control agents are often responsible for the control of many potential mite pests in agricultural systems. In many cases they are effective in delaying population buildup.

Important natural enemies of mite pests have been classified as three categories, which are predators, parasites and pathogens. Of the three categories, it is mainly the predators that are important in controlling of mite pests. There are no known parasites of phytophagous mites (Yaninek & Moraes, 1989). Published research show that numerous species of insects and arachnids prey on mites (Riehert & Lockley, 1984).

PATHOGENS

Microorganisms, which are harmful to mites include bacteria, fungi and the viruses. Previous investigations have revealed that pathogens are capable of reducing populations of plant feeding mites. The fungal infections are more virulent at high humidity

conditions (Jeppson, *et al.*, 1975). According to Sweetman (1936) there are two fungal groups infecting mites Mucorales and Entomophthorales, which includes two genera namely *Empusa* and *Entomophthora*. For example the fungal pathogen *Neozygites* sp. has been used in controlling the pest populations of spider mites of soyabeans in USA.

Pathogenic fungi penetrate the mite integument and destroy the underlying tissues and inject toxins to the host. It has been possible to monitor field populations for the occurrence of epizootics in several crops, since fungal activity was dependent upon environmental conditions. However, practical use of pathogens to control mite pests is impracticable at present due to the difficulties in development of adequate culturing procedures and appropriate application media.

VIRUSES

Viruses are another group of possible biological control candidates, which could be considered as important natural control agents of mites. Few viral diseases have been recorded for mites and all of these belong to the group of non-inclusion viruses (Lipa, 1971). The earliest record of a virus infection of a mite was of citrus red mite *Panonychus citri* in Florida. This virus disease was easily disseminated artificially by spray applications or by an introduction of diseased mites in to healthy populations. Another epizootics at dense population conditions in citrus red mite *Panonychus ulmi* was in California and later in Canada. These observations suggested that two viral diseases might affect *P. ulmi.* The non-inclusion virus disease of citrus red mite was capable of rapidly destroying laboratory reared colonies and high field populations too (Jeppson *et al.*, 1975).

MITE PREDATORS

Predators of mite pests belong to two groups namely insect predators and predatory mites. Important insect predators can be classified as follows;

1. Coleoptera - Beetles
    a. Coccinellidae
    b. Staphylinidae

2. Neuroptera - Lace wings
    a. Chrysopidae
    b. Hemerobidae
    c. Coniopterygidae

3. Hemiptera - The bugs
    a. Miridae
    b. Anthocoridae
    c. Nabidae
    d. Lygaeidae

4. Diptera - The flies
    a. Cecidomyidae
    b. Syrphidae
    c. Dolichopodidae
    d. Empididae

5. Dermaptera - Ear wigs

Beetles: Coleoptera

Family Coccinellidae, the lady bird beetles consist of about 3000 species. Impact of Coccinellids as mite predators were studied by various workers (Balduf, 1935; Sweetman, 1936; Jeppson *et al.*, 1975; Chazeau, 1985) and most of them were used as effective biological control agents. Well known species among the genera are *Coccinella, Rodolia, Adalia; Hippadamia, Hyperapis, Lindorus, Scymnus* and *Rhizobius.*

Coccinellid beetles are considered as highly specialized predators of teranychid mites and to a lesser extent of tenuipalpids. Both the adults and the larvae are predaceous on aphids, diaspidids,

scale insects mites and other small insects. 40% of the known species have been reported to attack spider mites of economic importance. Two common examples of biological control agents of mite pests are *Stethorus weise* and *Stethorus punctillum Weise*. There are about 60 species of Stethorus beetles described (Chazeau, 1985). Various workers have investigated their ability to control tea mites. Das (1960) had studied biology and feeding capacity of *Stethorus gilvifrons* Mulsant a Coccinellid predator of red spider mite on tea in India.

Family Staphylinidae the rove beetles live in decaying plants or in fungi, in stored products or under the bark of a tree. More than 170 species of this family have been described. The larvae as well as the adults of the species prey upon tetranychid mites and small insects. Staphylinids were recorded as mite predators in several instances. *Holobus* sp. and *Oligota* sp. known to play a major role in controlling mite pests. For example *O. flavicornis* and *O. pallidicornis* Cameron have been observed preying upon all stages of the mites in Madagacar where they have attacked the active instars more readily than the eggs. The larvae suck their prey and adults consume the whole prey (Collyer, 1953).

In our studies several beetle species have been observed predating on tea mites belonging to these two families. Examples are *Jauravia simplex* (Walker), *Pseudaspidimerus flaviceps* (Walker) and *Stethorus* sp. (Zhang 1998 unpublished). These beetles could be considered as potential biological control agents of mites pests of tea.

PREDATORY MITES:

Majority of the mite predators are known to belong to the familes Phytoseiidae, Stigmaeidae, Cheyletidae, Cunaxidae, Erythraedae, Bdellidae, Anystidae Tarsonemidae and Erythridae (Jeppsons *et al.*,1975; Helle & Sabelis, 1985)

Phytoseiidae

Mites of the family Phytoseiidae are considered as most effective and wide spread predators of injurious plant-feeding mites. They are distributed in a variety of climatic conditions. The first published record relating to the possible value of Phytoseiids as predators of plant feeding mites were those of Parrot *et al.* in, 1906.

Phytoseiulus persimilis is a promising biological control agent of the family Phytoseiidae. Numerous studies have been conducted of their suitability for integrated pest management programs. In comparison with other predators *P. persimilis* which is indigenous to Kenya has the fastest generation time, highest metabolic rate, highest fecundity per female, and remains fecund for longer and hence has the greatest potential for population increase (Laing & Huffaker 1969). *Phytoseiulus persimilis* has been tested against tea red spider mite in Sri Lanka and obtained promising results (Vitharana pers. comm.1997)

Amblyseius sp. is also a predatory mite of the family Phytoseiidae that have been experimented and used as successful bio control agents of mite pests in several countries. *Amblyseius* has been associated with tea mites in all tea growing districts in Kenya. (Sudoi *et al.*, 1991) Two species were recorded namely *Ambluseius (Typhlodromalus)* sp. and *Amblyseius (Typhlodromips) cumulus* Van der Merwe (Sudoi 1989) and also, *Amblyseius albizia* (Swirki, 1991).Investigations revealed that although the *Amblyseius* sp. Occurs in low numbers they could be manipulated as a biological control agent for red spider mite and scarlet mite of tea (Sudoi et al., 1991).

We have found a species of *Amblyseius syzigii* which is a predator of red spider mites of tea in Kandy and Passara areas in our experiments. This mite also shows active feeding on red spider mite eggs and adults.

Attempts of biological control of mite pests using phytoseiid predators of tea has been carried out in several tea growing countries

such as Kenya *i.e., Amblyseus* sp., *Neoseilus idaeus* and *Phytoseiulus persimilis* (Sudoi, *et al.*,1991); in Japan by *Amblysieus longispinosus* has been used in integrated control of mite pests of tea. Furthermore three species were recorded in association with tea mites in India *i.e., Agistemus* sp. (Acarina: Stigmeidae), *Exothorhis caudata* Summers (Acarina: Eupalopsilidae). *Cunaxa* sp. (Acarina: Cunaxidae).

Biological control of *Agistemus* sp. has been studied in the laboratory (Borthakur & Das, 1987) and observations revealed that this steigmatid predator was capable of feeding on all four phytophagous mites of tea in North East India and was expected to be a promising biological control agent for tea mite complex (Borthakur , 1987). These mites were recorded as active feeders of eggs of both red spider mites and scarlet mites of tea and all the stages of purple mites. *Agistemus* sp. are also recorded as predators of tarsonemid, brevipalpid and tydeid mites previously (Jeppsons *et al.*, 1975). Further examples are *Agistemus fleschneri* which was found to feed on red spider mite *Tetranychus kanzawi* Kishida, in Japan by Osakabe (1963) and another Stigmeid predator also was recorded by Oomen (1982) which predator was responsible for suppression of scarlet mites on tea in Indonesia. *Pronematus* sp. belonging to family Tydeidae also was found to be predaceous on Tetranychids and also on Scarlet mite of tea was reported from India (Borthakur 1981). *Pronematus* sp. (Tydeidae) was found feeding on scarlet mite adults as well as eggs on tea.

Thrips: Thripidae

The phytophagous thrips are categorized as facultative predators of tetranychid mites on cotton in Australia (Wilson, 1993). It has been reported that predaceous thrips which are also plant pests may also be significant predators of spider mites.

Lace wings: Neuroptera

Order Neuroptera contains four families which include useful biological control agents. These are the Chrysopidae, Sympherobidiidae, Hemerobiidae, and Coniopterygidae.

They are brightly coloured insects named as lace wings due to their conspicuous wing venation. Because of their destruction of enormous numbers of phytophagous mites and insects this order is considered beneficial to man kind. *Conwentzia hageni* Banks (Family - Coniopterygidae) and *Chrysopa carnea* Stephens (family - Chrysopida) are two examples. The green lace wing *Chrysopa* sp. (Chrysopidae) Could be seen abundant on tea where mite populations are high. They are considered as useful predators at low mite populations owing to a very high searching capacity and were said to be better than Stethorus. However, an antagonistic effect of some *Chrysopa* species on *phytoseiid* mites also has been observed which is important in considering interactions among predators (Kramer, 1961).

Species belonging to Sympherobiidae and Hemerobiidae families are known as the brown lace wings. The brown lace wing - *Hemetobius pacificus* Banks, a predator of the red spider and is a well known species. The chief hosts are red mites, such as the European red mite, the common red mite the two spotted mite, the six spotted mite, and others small insects such as aphids.

Spiders : Araneidae

One of the earlier demonstration that spiders have a strong influence on determining the density of phytophagous mites was by Clarke & Grant (1968). They found that natural presence of high numbers of spiders early in the season prevented exponential increase of mites later in the season. The influence of spiders on insects populations under natural and agricultural systems has been experimentally demonstrated by Reichart & Lockley (1984).

Our observations at Hanthana Estate, Kandy (field No. 6B) as well as at Shawlands Estate, Passara showed that there are over 25 species of spiders inhabiting in tea lands (1997 census). The more common of these spider species which are known to feed on tea mites have been identified. They could be categorized as mite predators and potential mite predators on tea in Sri Lanka. The most common species are named as follows.

Spiders found at tea plantations in Sri Lanka

1. Family - Araneidae *Cyrtophora cicatrosa* (Stolizka)
2. Family - Clubionidae *Cheiracanthium triviale* (Thorell)
3. Family - Tetragnathidae *Leucauge* sp.
4. Family - Araneidae *Cyclosa* sp
5. Family - Dictynidae Genus and species not identified
6. Family - Salticidae Genus and species not identified
7. Family - Psechridae *Psechrus torvus* species

Riechart and Lockley (1984) have reviewed the spiders as biological control agents and defined that the spiders fall within the general area of natural control factors as they were known to form one of the most ubiquitous groups of predaceous organisms in the animal kingdom (over 30000 species). Numerous investigations identify specific spider species as important predators of arthropod pests. For most of these instances consumption is not limited to winged adults, larvae and nymphs are preyed upon as well.

Furthermore the spiders exert buffering effects by the assemblage of spider species in a given habitat. Hence conservation of the spider fauna is important in maintaining mite populations below economic injury levels. Thus community diversity must be maintained to maximize the number of predators that will encounter the pest species, (Reichart and Lockley, 1984). Numerous species of spiders have been identified as important predators under laboratory conditions and the capture efficiencies have been determined for some of these (Reichert and Lockley 1984).

However in relation to using spiders as biological control agents a word of caution is warranted at this initial stage. Although spiders are numerous, their occurrence as natural control agents, and examples of their actual use in biological control are either few or non-existent. Yet individual species of spiders appear to be incapable of tackling population changes in specific prey species, either through increases in rates of attack or through changes in effective

population densities of pests in local areas (Coppell & Mertins, 1977).

The reason for this must most certainly be the polyphagous (feeding more than one prey species) nature of their feeding behavior. In other words they lack the prey specificity component which is regarded as an important endowment of a good biological control agent. Nevertheless, the progressive researcher does not give up simply because something is generally regarded as "Unachievable". In view of the fact that spiders appear to be the most important predators of tea mites it seems worthwhile to strive on for success as Robert Bruce did long ago to win his war before we turn our attention to other possibilities.

Stethorus (Readshaw, 1975); aoligota (Gonzalez, 1971); Mirids (Collyer, 1952); Readshaw, 1975); Anthocorids (Niemczyk, 1980) Ceidomyiids and Thrips (Oatman *et al.*, 1981); Thrips and Stethorus (Putman & Herne, 1966) have been recognized as the most important or major predators (Helle & Sabelis 1985).

A summarize review of Croft and Brown (1975) on mite predator systems lists them in the following order of descending efficiency

1. Phytoseiid mites
2. Beetles of the *genus Stethorus*
3. Araneida the Spiders
4. Hemiptera the Bugs
5. Neuroptera the Lace wings
6. Diptera the flies

Our current investigations show that the most important predator groups in Kandy and Passara tea plantations are predatory mites, thrips (Thysanoptera: Thripidae), spiders (Araneiidae), rove beetles of the genus *Oligota* (Staphylinidae) and Ladybird beetles of the genus *Stethorus* (Coccinellidae). These biological enemies identified which are mainly generalist predators are important in delaying or dampening the pest outbreaks in a given crop system.

Rearing of mite predators for biological control purposes

Feasibility of mite pest management in tea by predators can be established only after studying various life parameters of predators under green house conditions and in the field. A stock culture of the predators can be maintained in the laboratory by regular supplying of the hosts. Tea mites could be reared on young tea plants or on tea leaves kept on petridishes under humidified conditions in the laboratory covered with a glass tray for introduction of mite predators for studies of biological control.

However, it must be made clear that how predators are adapted to prey and their efficiency in controlling prey populations vary with the species under consideration as well as with their interactions with other predators and environmental factors in ecosystems.

Conclusion :

Experimental evidence suggest that in the tea ecosystem in Sri Lanka several biological control agents are found actively exerting a natural regulation on the population of many pests. Therefore, most efforts to control mite pests involve either conserving the exsisting natural enemy or the augmentation of a dominant predator species.

Because biological control is complex it should be founded on a proper scientific basis. A comprehensive understanding of it will almost certainly provide greater possibilities for effective implementation with provision of compatibility with economic and social needs. The variety of natural enemies available in a given pest situation is often enormous. It stands to reason that more fully a pest is studied the more diverse its natural enemy complex is found to be. This in fact is what we found during our investigations on the population ecology of tea mites at tea plantations in Kandy and Passara districts.

REFERENCES

1. BALDUF, W.V. (1935) *The bionomics of Entomophagous Coleoptera.* John S. Swift Co., Inc., St. Louis, Mo., 220.

2. BORTHAKUR, M. (1981) Biological notes on a mite predator of the scarlet mite Brevipalpus phoenicis (Geijskes) *Two and a Bud* **28** (1) 18.

3. BORTHAKUR, M. & DAS, S.C. (1987). Studies on acarine predators of phytophygous mites on tea in North-East India. *Two and a Bud* **34**,21-24

4. CHAZEAU, J. (1985) Predaceous insects in Helle, W., & Sabelis, M.W. (eds.) *1985 Spider mites: Their Biology Natural Enemie and Control Vol* **1A** and **1B**. Amsterdam: Elsevier. 405- 457.

5. CLARK, J. AND GRANT, P. (1968) - An experimental study of the role of spiders as predators in a forest litter community. *P. I Ecology* **49**: 11252-54.

6. COLLEYER, E. (1953) Some important predators of mite *J.Hortic. Sci.*, **28**, 85-97. of mite.*J.Hortic. Sci.*, **28**, 85-97.

7. COPPEL, H.C. & MERTINS, J.W. (1977) *Biological insect pest suppression.* Springer-Verlag, Berlin Heidelberg Newyork.

8. DAS, G.M. (1960) Pests of tea red spider, Oligonychus coffeae (Nietner). *Ann. Rep. Toklai Expt. Sta.*, 110-114.

9. HELLE, W., & SABELIS, M.W. (eds.) *1985 Spider mites: Their Biology Natural Enemies and Control* Vol **1A** and **1B**. Amsterdam: Elsevier. 405- 457.

10. JEPPSON, L.R. KEIFER , H.H. & BAKER, E.W. (1975) *Mites injurious to Economic plants* 307-315 University of California press London.

11. KRAMER, P., (1961) Untersuchungen uber den Einfluss einger Arthropoden auf Raubmilben (Acari). *Z. Angew. Zool.*, **48**: 257-311.

12. LAING, J.E. & HUFFAKER, C.B. (1969) Comparative studies of predation by Phytoseiulus persimilis Athias Henriot and Meta seiulus occidentalis (Nesbitt) (Acarina: Phytoseiidae) on populations of Tetranychus urticae Koch (Acarina:Tetranychidae). *Res. Pop. Ecol.* **11**: 1095-106.

13. LIPA, J.J. (1971) *Microbial control of mites and Ticks*. Academic Press London Newyork. 357-373.

14. MCMURTRY, J.A & CROFT, B.A. (1997) Life- styles of Phytoseiid mites and their roles in Biolcgical control *Ann. Rev. Entomol.* **42**, 291-321.

15. OOMEN, P.A. (1982) Studies on the population dynamics of the scarlet mite. *Brevipalpus phoenicis a pest of tea in Indonesia.* Meded. Landb. Wageningen, **81** (1); 88

16. OSAKABE, M. (1963) On the natural enemies of tea red spider mite Tetranychus kanjawai Kishida. *Study of Tea*, **27**, 11-14.

17. PYKE, B.A. & BROWN, E.H. (1996) *The cotton pest and beneficial guide*, Goprint, Woolloongabba, Qld.

18. RIECHERT, S. E. & LOCKLEY,T. (1984). Spiders as biological control agents. *Ann. Rev. Entomol.* **29**, 299-320.

19. SUDOI, V., KARIUKI, C. W. & KIPSANG, D. (1991) Can predacious mites be used for biological control of mite pests in Kenya tea fields/. Preliminary indications. *Tea* **12**(2), 109-114.

20. SWEETMANN, H.L. (1936) *The biological control of Insects.* Ithaca; Comstoc.

21. WILSON, L.J. (1993) Seasonal abundance and distribution of Tetranychus urticae (Acari; Tetranychidae), the two soptted mite on coitton in Australia and implications for management. *Bull. Ent. Res* **83**, 291-303.

22. YANINEK, J. S. & DE MORAES, G. J. (1989). Mites in agricultural and biological control. *Biological control manual* **2**, 71-92.