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PADDY PESTS IN SRI LANKA

By

M.A.S.K. Ranasinghe

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by

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1. PREFACE

Few books written on the insect pests of Sri Lanka are available either to the students or to the teachers interested in this subject. This book is intended to be a supplementary reading material to the G.C.E. (Advanced Level) students and a guide to the teachers.

Studying text book material alone will not give a student an appreciation of the pest problems in rice. The teachers should strongly encourage the students to go to a nearby paddy field and attempt to observe the damage done by these insects and to collect them. Wherever this is not possible due to the location of a school, it is desirable to maintain a collection of insect pests and the plants damaged by them for the students to observe.

I have drawn information given in this book from various sources listed in the bibliography. The Department of Agriculture which is given the mandate of all aspects of scientific research on rice grown in Sri Lanka, publishes semi-annual and annual reports which highlight the current status of knowledge about the pests of paddy. The students and teachers are encouraged to refer to these reports to up-date their knowledge on the pests of paddy.

II. ACKNOWLEDGEMENTS

I am indebted to the Natural Resources, Energy and Science Authority (NARESA) of Sri Lanka for giving me an opportunity to write this book. The illustrations on rice stemborers are reproduced under permission from the UPLB book entitled "Rice Production Manual in the Philippines". I thank Mr. G.G. Ranbanda of the Department of Agricultural Biology for typing this manuscript. My wife Kalyani gave her encouragement and unfailing support to me throughout this work.

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FOREWORD TO THE SERIES

The dissemination of scientific information is one of the functions of the Natural Resources, Energy & Science Authority. The Journal of the National Science Council published by this Authority provides a medium for the publication of scientific research papers, and "Vidurawa", the quarterly science bulletin contains scientific articles of a general nature which is of interest to the public.

There is still a wide gap in the availability of reading material on scientific subjects of local interest. One result of this is that science students confine their reading only to their school notes and to the few available text books which are mostly published abroad. In an attempt to improve this situation, the Working Committee on Science Education Research of the Natural Resources, Energy and Science Authority decided to publish a series of booklets on scientific topics of local interest as supplementary reading material for students and the general public. The authors who have been selected by the Committee to prepare these booklets are experts in their respective fields. The manuscripts that were submitted by the authors were examined by referees before being accepted for publication. The views expressed in these publications are those of the authors and are not necessarily those of the Natural Resources, Energy & Science Authority.

I must thank the Working Committee on Science Education Research of the Natural Resources, Energy & Science Authority, and in particular Prof. V. Basnayake who is the Hony. Director of the Working Committee for the work they have done to make this project a success.

R.P. Jayewardene
Director-General

I. INTRODUCTION

Rice is the most important crop grown in Sri Lanka. In 1981, this crop contributed 23 percent i.e. more than any other crop, to the gross domestic product in agriculture (Anon. 1983). Rice provides about 60 percent of the total daily calorie intake of Sri Lankans (Anon. 1984). In 1983 nearly 30 percent of all the cultivated area i.e. 824,000 ha in Sri Lanka was under paddy and the total production was 2.479 million metric tons. (Anon. 1984).

Pest problems are a major constraint against production of paddy in Sri Lanka. Among these pests are arthropods, birds, mammals, nematodes, pathogens and weeds. The arthropod pest complex includes crabs, insects and mites.

Wickramasinghe (1977) reported that arthropod pests damaged an estimated 130,000 ha causing an average loss of 220 kg/ha (8.98 bu/ac).

The major pests of rice vary from country to country. Within a given country the status of a pest may vary among different agroclimatic zones, between the growing seasons and according to the prevailing weather pattern. For a given location and a given season, the damage done by an insect pest depends on the

pest species, level of pest population, variety and the stage of growth of the plant at the time of infestation. It is also known that certain insect species either previously not identified as pests or identified only as minor pests could later assume major pest status with certain changes in the agroecosystem. For example, the brown planthopper became a major pest during 1970 s with the introduction of new succulent varieties and fertilizer mixtures with higher levels of Nitrogen (Fernando 1975).

The pests of rice could be categorized either according to the taxonomic classification of the pest or based on the part of the plant that is attacked by it. A more useful approach though, particularly from the pest management point of view, would be to classify them in relation to the stage of growth i.e. phenology of the rice plant. It is this phenological approach that is followed throughout this text.

The rice plant is known to undergo several distinct stages of growth. These phenological stages and their characteristics are shown in Table 1.

Different pests are known to be associated with these phenological stages of the rice plant. Some pests are of rather short duration and are

TABLE 1. PHENOLOGY OF RICE

<u>Stage of Growth and its Duration in a 3 Month Crop</u>		<u>Major Characteristics</u>
<u>Major phase Sub-division</u>		
Vegetative phase 0-6th week	Germination	Emergence of radicle and coleoptile
	Seedling (transplanting)	Development of lateral roots and up to fifth leaf; endosperm is fully utilized.
	Tillering	Appearance of first tiller to the tertiary production of tillers
Reproductive phase 7th-11th week	Panicle initiation	Initiation of panicle primodium at the growing shoot
	Elongation and booting	Elongation of upper internodes; panicle development and spikelet becomes distinguishable

	Heading	Emergence of panicle tip out of flag leaf sheath
	Flowering	All spikelets in the panicle bloom; pollination and fertilization
Ripening phase 11th - 15th week	Milky stage	Starch in grain changes from watery to milky consistency
	Dough stage	Starch turns from soft dough to hard dough
	Maturation stage	50 percent of grains become hard, clear and free from greenish tinge; leaves turn yellow in ascending order

Source; Vergara (1970)

confined to a specific stage but others may occur throughout one or more phases of growth. The insect pests associated with the different phenological stages of growth of rice grown in Sri Lanka are shown in Fig. 1.

II. Pests Attacking Rice During its Vegetative Phase

The rice plant during its vegetative phase is attacked by various pests. Most of these are foliage feeders. There are some pests that attack the stem and at least one is known to damage the roots of the rice plant in its vegetative phase.

Early in the vegetative phase, i.e. at the seedling stage, pests could become serious due to their potential ability to kill the host plant. However during its late vegetative phase the plant could tolerate a certain degree of damage without an economic loss in yield.

Among the insect pests that occur locally, those which predominantly attack the seedling rice are: rice thrips, Baliothrips biformis (Bagnall); rice whorl maggot, Hydrellia philippina; rice stem fly, Atherigona exigua Steiner and rice gall midge, Crseclia cryzae (Wood-Masch).

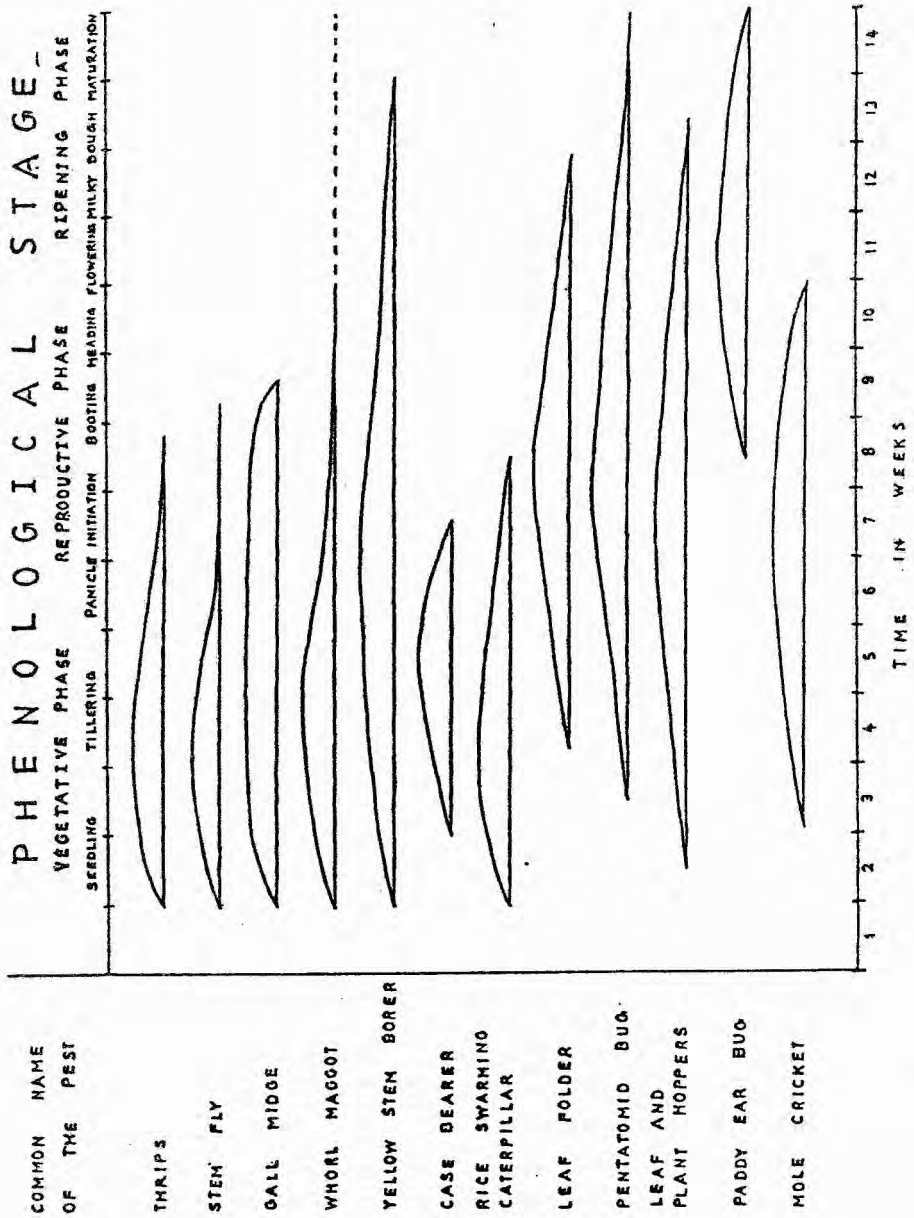


Fig. 1

1. Rice thrips, Baliothrips biformis(Bagnall)

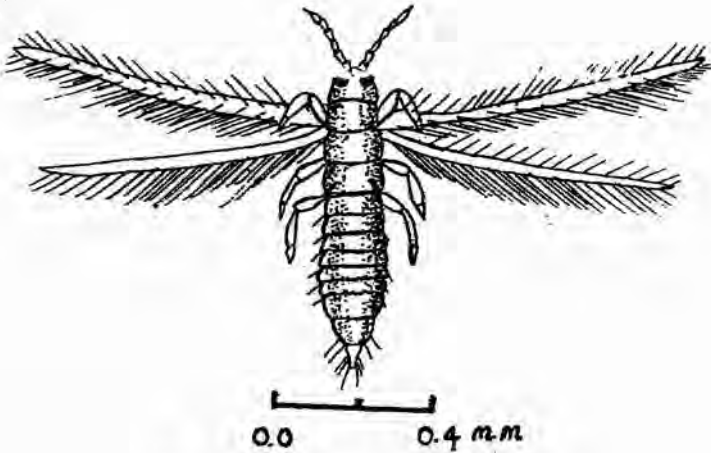


Fig. 2 Rice thrips, adult

Rice thrips are a pest which may exhibit occasional serious outbreaks that can be extensive, particularly when the crops are planted late due to socio-economic pressures on the farmers (Wickramasinghe 1980). Usually these outbreaks occur due to failure of the rains which are normally expected early in the growing season. This pest is islandwide in distribution and could occur both in lowland and in upland rice.

This insect belongs to the family Thripidae in order Thysanoptera; this order is characterized by the presence of asymmetrical mouth parts in a cone and narrow wings with a long fringes of hair (Fig. 2).

Earlier this insect was known as Thrips oryzae (Williams). Bhatti and Mount (1981) placed this in genus Stenchaetothrips as S. biformis (Bagnall).

DAMAGE

Usually the plants one to two weeks old are the most susceptible to thrips attack. Thus thrips are a serious pest in the nurseries and in seedlings in broadcast-sown rice. The susceptibility of plants to thrips attack may persist up to six to eight weeks from sowing (Anon. 1960). However, plants older than four and a half weeks are seldom attacked. (Anon. 1970). According to Pathak (1970) rice crops at heading stage may be attacked by thrips.

The adult thrips as well as the nymphs suck the sap from the tender leaves after lacerating the tissues. This damage leads to the formation of yellow streaks which may join to impart a yellow colour to the leaf. Another characteristic symptom of thrips attack is the

longitudinal rolling up of the leaf from the lateral margin towards the mid-rib. Inside the rolled leaf one may find yellowish brown or blackish thrips. The unopened leaves, when attacked, remain so. Under heavy infestation the leaf may wither and its tip dries off. The plants that survive the attack exhibit poor growth and bear lesser amount of grains. Heavy infestation may also result in formation of unfilled grains. Areas with severe attack may assume a scorched appearance (Pathak 1970).

LIFE HISTORY

Eggs

The eggs of B. biformis are laid in slits made by the female in the blade of tender leaves. They are tiny and limpid at the beginning and turn yellow before hatching.

Larvae

The newly emerged larva is colourless. It becomes pale yellow by the second instar (Pathak 1970). The larvae feed within the rolled tender leaves.

Pupae

The pupal stage is a quiescent stage where no feeding occurs. It is usually of short duration. This stage is preceded by a pre-pupal stage.

Adult

The adult is a small insect about 1.0 mm long. It is either brown or black and has narrow wings fringed with long hair. The female bears a saw-like ovipositor at the tip of her abdomen.

ECOLOGY

The known host range of this insect includes some graminaceous weeds. Among the cultivated plants it has been recorded from rice and maize.

Thrips are mainly a dry season pest which damage plants under water stress. The population dynamics of this pest under local conditions is little known. The population builds up and reaches a peak during the seedling stage of the rice crop. The late planted crops are therefore prone to serious attacks.

CONTROL

No effective biological control agents of this pest have hitherto been reported from Sri Lanka.

Kudagama (1977) screened over 600 indigenous rice varieties and found that two Dahanala varieties and Kaluheenati were resistant to thrips damage. However, in breeding programmes these varieties have turned out to be poor donors as they combined very poorly with the new improved high yielding rice varieties. Some IRRI (International Rice Research Institute) varieties also showed resistance to moderate thrips infestations but could not tolerate heavy attacks.

Although flooding and adding a kerosene oil film to the field has been suggested as a cultural practice to control this pest, this method has practical limitations because thrips are a dry season pest. Harrowing of old plants under, after a harvest, is said to reduce the severity of the damage on the subsequent crop.

The use of insecticides remains the main control method of thrips damage to plants. The screening of insecticides for thrips control

was hindered by the non-availability of suitable insecticides in the form of seed dressings up until recently. Many of the emulsifiable concentrates (EC) and granules (G) when used as seed dressings, were found to be phytotoxic. Although carbofuran and dactonix gave enough protection under experimental conditions, the method used was considered to be too hazardous for farmer use and the effective period was also limited. A slow release formulation could be expected to give better results (Wickramasinghe 1980). Barwal and Rao (1963) found that quinalphos gave the best results with carbaryl coming next in terms of the control obtained seven days after application, a period too short to give complete protection from thrips attack. To control this pest, the Department of Agriculture (Ancn. 1981) recommends the use of any one of the following insecticides, at the rate of 490-700 ml of active ingredient (a) diluted to 222-330 L/ha depending on the planting density and the stage of growth: carbaryl 85 percent WSP; diazinon 40 percent EC, fenthion 50 percent EC or quinalphos 75 percent EC.

2. Rice Whorl Maggot, Hydrellia philippina

At present this is a minor pest of rice but has the potential of becoming a major rice pest in Sri Lanka (Wickramasinghe 1980). This pest was first recorded locally in 1965. It has recently reached the level of an economically important pest. In Sri Lanka the rice whorl maggot is widely distributed in lowland rice fields up to an elevation of 600 m. above mean sea level.

This is a fly that belongs to the family Ephydriidae in the order Diptera. This family of insects is characterized by having a large mouth but no oral vibrissae. The frons of the head is bumpy and the wings lack either the subcostal vein or an anal cell. The common name refers to their habit of feeding on the inner whorl i.e. unopened leaves, of the rice plant.

DAMAGE

This is basically a pest of seedling rice. The plants are susceptible up to six weeks from transplanting and cease to be so after reaching the booting stage (Pathak 1970). Occasionally even the mature crop may be attacked (Wickramasinghe 1980).

The damage is done by the maggots (larvae) who feed on the mesophyll of the leaves. If the flag leaf is attacked the emerging earhead is also prone to suffer damage. In related species the larvae are also known to mine the leaf sheath (Anon. 1970).

The usual symptom of whorl maggot attack is the yellow and ragged appearance of the infested seedlings. The leaf mine first appears as a whitish streak 0.1 - 0.2 mm wide and later appears as a blotch (Anon. 1970).

LIFE HISTORY

The following account of the life history is based on a description by Pathak (1977) on a related but unnamed species of Hydrellia.

Egg

The eggs are laid singly on either surface of the leaves. They are cylindrical and white with opaque yolk. The eggs measure 0.72-0.76 mm in length and 0.17 -0.20 mm in width. With development the black skeleton of the embryo becomes visible. The incubation period ranges from two to six days.

Larvae:

The larva is transparent to light cream soon after hatching but becomes yellowish with feeding. When full grown it is 6.5-7.2 mm long and cylindrical with the posterior end of the body tapering to a pair of spiracles. A heavily sclerotized mouth hook is also visible. The larval period is 10-12 days.

Pupa:

The pupa is found outside the feeding stalk. It is light brown, ovoid to cylindrical with the posterior end gradually tapering. The adult emerges after 7-10 days of pupation.

Adult:

The adults are dull gray-coloured flies. The females are 1.8-2.3 mm long and the males are slightly smaller.

ECOLOGY

The common weed, Cyanodon dactylon which is abundant on the bunds of local paddy fields is an alternative host of this insect.

This pest is usually confined to paddy fields located up to 600 m above the mean sea level. In a given season the population reaches a peak between seedling and early tillering stages of the rice crop. It dwindles after the booting stage due to unavailability of suitable whorls for feeding and probable effectiveness of the parasites. A strong positive correlation has been found to exist between the plant density and the maggot population. With increase in the planting distance from 5x5 cm to 20x20 cm there was a gradual increase of the percent of tillers attacked (Wickramasinghe 1980).

CONTROL

Four larval parasites of H.philippina have been recorded from Sri Lanka. Their activity reaches a peak at tillering (Wickramasinghe 1980).

At present no rice varieties resistant to this insect are available in Sri Lanka.

In view of the correlation between the pest population and the planting density, the planting distance could be adjusted to minimize the pest attack.

Usually the insecticides are used for the control of this pest and the following are currently recommended by the Department of Agriculture (Anon. 1981). Either broadcast carbofuran three percent G at the rate of 37 kg/ha or diazinon five percent G at the rate of 22 kg/ha. Alternately either 10 percent BHC dust could be used at 22-35 kg/ha rate or diazinon 40 percent EC could be sprayed at the rate of 700-1050 ml/ha.

3. Rice Stem Fly, Atherigona exigua

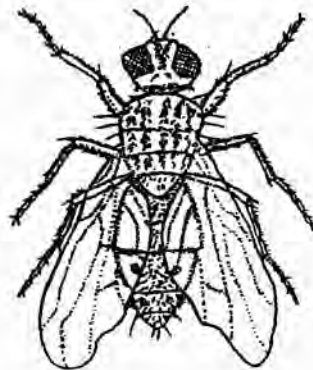


Fig. 3 Rice stem mining maggot, Atherigona Sp., adult

The rice stem fly, Atherigona exigua Steiner was a major pest of rice grown in Sri Lanka during the 1950s but has lost its importance since then. Fernando (1964) regarded this as the least important of the major stem boring insect pests of rice.

This pest is usually found in the dry zone. Both irrigated and rain-fed fields are affected by this pest during periods of water shortage.

The rice stem fly is also known as the rice seedling fly or the stem mining maggot and belongs to the family Muscidae in the order Diptera.

DAMAGE

The seedlings within the first two weeks of growth are most susceptible to attack by this pest. However, the plants upto eight weeks of age can also be damaged. Mature rice plants are not known to be attacked (Fernando 1964) by A. exigua.

The damage is done by the first stage larva which bores into the growing shoot. This results in yellowing and withering of the central shoot which is an early symptom of the

attack. Later, as the larva moves towards the base of the stem, the plant gradually turns brown and begins to rot. The presence of creamish maggots with their distinct heads is another indication of the presence of this pest (Anon. 1968b).

LIFE HISTORY

Complete details of the life history of this insect under the local conditions have not been reported. The account given below is based on a publication by Fernando and Manickavasagar (1957).

Egg:

The eggs are laid on the leaf blades of paddy seedlings. Each egg is oval and elongated, white and about 1.5 mm long. The eggs hatch in two days.

Larvae:

The larva is a creamy maggot i.e. legless larva. The first instar bores into the growing shoot and all subsequent instars are found within the stem. The larval period is one week.

Pupa:

The pupation occurs either in the stem or in adjacent soil. The pupa is found in a small yellow puparium. The adult emerges in one week.

Adult:

This is a small fly which is 3.0-3.5 mm long. It resembles a small house fly. Dorsally it has a greenish yellow thorax with three dark stripes. The abdomen is yellowish brown with a dark median line and three dark spots on either side.

ECOLOGY

Rice appears to be the preferred host of this insect because Fernandc (1964) could not find them on wild grasses when rice seedlings were abundant. The alternate hosts under local conditions are not known but the common graminaceous weed Cynodon dactylon is a possible alternate host.

The population dynamics of this insect under the local conditions are not known.

CONTROL

The identity of natural enemies, if any, of A. exigua in Sri Lanka has not been established. At present no rice varieties resistant to this pest are known.

Although flooding of the paddy fields has been advocated as a control measure this is bound to be a difficult in practice because this insect is known to attack during periods of water shortage.

Fernandc and Manickavasagar (1957) reported that parathion was the most effective of a series of contact and systemic organophosphorus compounds tested. At 0.003 percent concentration this compound as well as ekatin gave 100 percent mortality of maggots within 48 hours. Gusathion and diptrex also gave effective control but diazinon and malathion were not effective. The timing of application is critical because the contact insecticides could only be effective against the ovipositing adults and the first stage larva before it bores into the stem. An alternative approach is to use the insecticides with some systemic action. The current recommendation by the

Department of Agriculture (Anon, 1981) is to use trichlorphon 70 percent WSP at the rate of 0.56 - 1.84 kg/ha.

4. Rice Gall Midge, Orseolia oryzae (Wood Mason)

The gall midge is one of the more serious pest problems of the paddy growing areas in the wet zone of Sri Lanka (Fernando 1964). It is endemic to the low country wet zone and under favourable climatic conditions could spread over to the intermediate and dry zones (Wickramasinghe 1978). This pest may cause 10-40 percent loss of tillers and in extreme cases 65 percent loss is possible.

This insect caused sporadic attacks in the 1950s and 1960s. Since then it has assumed increasing importance and now this insect is considered to be a major pest of rice (Wickramasinghe 1978).

Most of the research on this pest was locally carried out by Perera and Fernando (1966 and 1969), Wickramasinghe (1969) and Moóóer and Alagóóa (1970). Fernando (1964) reviewed the local literature on this pest and the following description is based on the publications by the above workers.

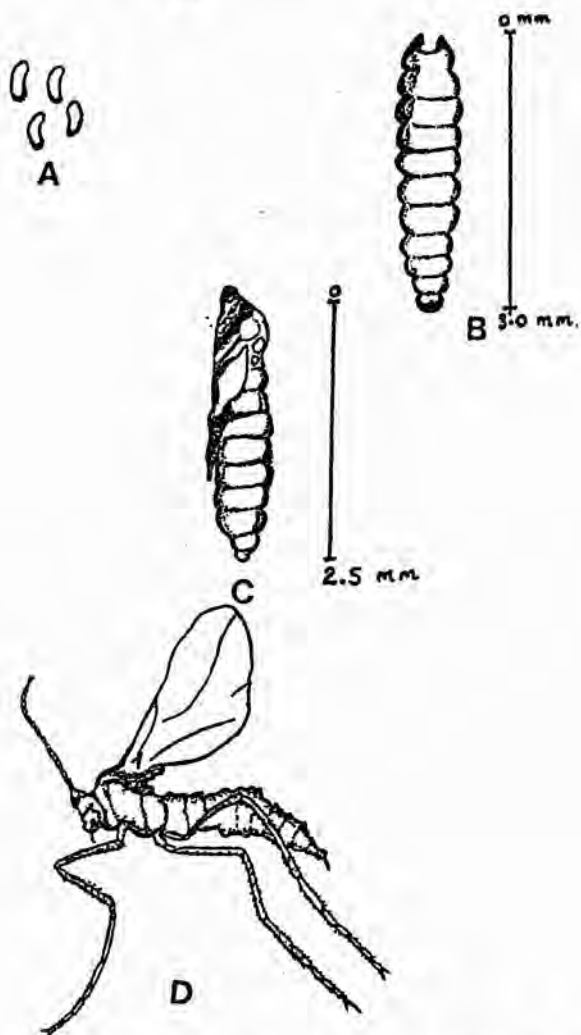


Fig. 4 Rice gall midge, *Pachytiplosis oryzae*, adult.

- A. Egg
- B. Larva
- C. Pupa
- D. Adult

This insect is a dipteran belonging to the family Cecidomyiidae whose members are well known for their ability to induce formation of galls in their host plants. These are minute delicate flies with long legs, long antennae and reduced wing venation. Earlier this insect was known as Pachydiplosis oryzae (Wood Mason).

DAMAGE

The rice gall midge is mainly a pest of seedling rice but is capable of attacking reproductive shoots as well. In 4-4 1/2 month rice varieties the incidence of this pest during the first nine weeks could cause economic losses in yield.

The most visible symptom of gall midge damage is the appearance of a gall that resembles an onion leaf. The gall is fully elongated in three weeks after the infestation. The gall which is initially about two mm may eventually reach a length of 190 mm. The morphogenesis of the galls and the effect of multiple infestation were described by Perera and Fernando (1966). According to them the gall

formation results from the suppression of the growth cone, development of radial ridges from the innermost leaf primodium just above the level of the posterior end of the larva and then an elongation of the leaf sheath. When a large number of larvae hatch on the same seedling even auxillary shoot apices are infested. Multiple infestation by gall midge larvae has also been observed. In mature paddy, the gallmidge attack causes the last emerging leaf to be crumpled and under-sized (Fernando 1964). Occasional infestation on reproductive shoot apices cause gall formation in parts of the panicle. The death of either the first or second stage larva permits the renewed growth of the plant but results in the first emerging leaf to be wrinkled permanently. The gall midge attack also induces extensive tillering.

LIFE HISTORY

Egg

The gall midge lays its eggs either singly or in small clusters. Most of the eggs are located on the underside of the leaves but a few may be found on the leaf sheaths.

The oviposition commences in the evening following emergence of the adult; it reaches a peak from 7.00 to 10.00 p.m.

The freshly laid eggs are translucent, creamish brown, frequently with an orange tinge. The two polar regions are reddish brown. Each egg is long and tubular with mean dimensions of 0.44 x 0.125 mm. As embryonic development progresses the egg becomes darker orange-brown. The deep red to crimson, kidney-shaped eye spots of the developing larva become visible by the 36th hour of development. By 72 hours these 2 eye spots become adjacent forming an X-shaped structure.

The egg hatches in 72 hours, beginning at dusk and this activity reaches a peak by about 10.00 p.m.

Larvae:

There are three instars. Each instar has a 13 segmented body. The following description is based on Perera and Fernando (1969).

The first instar is spindle-shaped and colourless. The average dimensions of this instar are 0.55 x 0.13 mm at hatching. This

larva has a pair of red eye spots dorsally. It is characterized by the presence of one similar pair of spines on the 12th segment and two dis-similar pairs on the 13th. The duration of this stage is 3-4 days.

The second instar is 1.5x0.4 mm in dimensions. It is translucent white with a visible brown mid-gut. The last segment of the body has three very short spines on each side. This instar lasts 3-4 days. The third instar is 3.2x0.8 mm in dimensions. A Y-shaped sternal spatula is located mid-ventrally between its first and second body segments. The spiracles are located on segments two and 4-12. The 13th segment has a pair of very short spines. The duration of this instar is 6-7 days.

Pre-pupa:

The pre-pupa is similar to the third instar but has the anterior end rounded, expanded and fluid-filled. The kidney-shaped eye spots are found dorso-laterally. The duration of this stage is one day.

Pupa

The pupa is exarate, i.e. the appendages are not glued to the body. The occipital region has two large cephalic horns each bifurcating to form chitinized spines. Behind each cephalic horn is a small hair-like spine. The male pupa has a pair of claspers on the last abdominal segment. It is smaller (3.2x0.8 mm) than the female pupa (3.6x0.9 mm). The pupal stage lasts 6-7 days.

Adult

The adult male is three mm long and has a yellowish brown body. The female is slightly larger (3.5 mm) and is bright reddish brown. The male has sparsely haired antennae as long as the body. The female is capable of laying 100-200 eggs. The adults feed on dew drops and live for 2-5 days.

ECOLOGY

The known alternate hosts include Cynodon dactylon and Panicum fluitans.

Gall midge is known to develop for 1-2 generations on wild grasses before infesting seedling rice. Therefore the crops planted late are bound to suffer heavier infestations. However in multi-cropping rice there is progressive decrease in gall midge infestation from the first to the third crop (Pathak 1970). This fly requires high humidity and therefore prefers lowland rice crops. The favourable conditions for crop infestation by this pest are a combination of the prolonged periods of overcast skies and moderate to light rains (Fernandc 1964). The favourable temperature for a build-up of this pest is 25-30°C (Anon. 1970).

Fernandc (1964) collected small numbers of C. oryzae throughout the growing season by using light traps and water traps. He was not successful in recording population fluctuations of this midge even by using light traps with varying wavelenghts. Later the studies on gall midge population by means of suction traps and direct counts of galls in

the field indicated a marked synchrony in pest incidence and crop phenology (Wickramasinghe 1969). When the pest incidence in a crop planted monthly over several seasons was studied, a large drawn out peak of gall formation in Maha (October–November) and a smaller peak in Yala (May) were observed. These peaks coincided with the onset of monsoon rains.

The continuity of gall midge attack in the field and carry over of their population from season to season could be explained on the basis of the arrested growth of first stage larvae at inactive axillary shoot apices (Perera and Fernando 1968).

CONTROL

Biological:

The relatively common predatory carabid beetle, Casanoidea interstitialis, feeds on the pupae of C. oryzae. Nabis capsiformis Germar is a predatory bug known to feed on the adults of this midge. Two parasitic hymenopterans, Platygaster oryzae Mani and Dinarasus sp. are known to attack the pupae. These natural enemies extent only a low degree

of control (Fernando 1964). After tillering stage, even 90 percent parasitism of midge larvae is not sufficient to prevent economic damage (Wickramasinghe 1980).

Resistant varieties:

In general heavy tillering varieties are more susceptible to gall-midge damage due to multiple infestations of first instar larvae at immature tillers. Modder and Alagoda (1971) reported that the resistance of cross W 1263 to gall-midge damage is due to the inhibition of the first moult of the larvae. Heavy necrosis of infested apices which eventually killed the larvae is the source of resistance of some Indian varieties (Fieries 1980).

At present two gall-midge resistant local varieties BG 400-1 and BG276-5 are available to the farmers in Sri Lanka.

Cultural:

Early planting of the crop helps to avoid heavy gall-midge infestations. The removal of alternate hosts could also help to minimize

the pest incidence. Because the first stage larva is known to hibernate on dormant axillary shoot apices, the burning of stubble is recommended as a control measure.

Chemical:

The use of contact insecticides to control the midges is of little value because of the nature of midge damage. Fernandó and Perera (1968) studied the field applications of different formulations, different modes of application and timing of treatment of promising insecticides. They concluded that the use of either a pre-planting root dip or a systemic soil treatment in nursery followed by a granular application of diazinon three weeks after transplanting was the best way to control this pest. The Department of Agriculture (Ancn. 1961) recommends the use of following insecticides after the water level in the field is reduced to one to two cm. Carbofuran three percent G or diazinon ten percent G at the rate of 16.3 - 21-6 kg/ha. In the nursery these should be used ten days after sowing and plants be left at least for another five days. The application is to be repeated 2-3 weeks after transplanting. In

broadcast sown rice the treatment should be applied 10-14 days after sowing and repeated 5-6 days after.

Caterpillar Pests of Rice

A number of caterpillar pests are known to attack the vegetative phase of rice grown in Sri Lanka. At present the most important of these is the rice leaf folder, Cnaphalocrocis medinalis (Guenee). Among other caterpillar pests of local economic importance are the rice case bearer, Nymphula depunctalis Guenee and the rice swarming caterpillar, Spodoptera mauritia Boisdu. In addition the borolia caterpillar, Borolia venalba Moore, S. lunda and Parnara mathias also occasionally attack our rice crops.

5. Rice Swarming Caterpillar, Spodoptera mauritia Boisdu.

This was a major pest of rice up until 1950s but has receded in importance since (Wickramasinghe 1978). In the 1920s it was considered to be a major insect pest and this is reported to have occurred in various rice growing districts of this country (Hutson 1920).

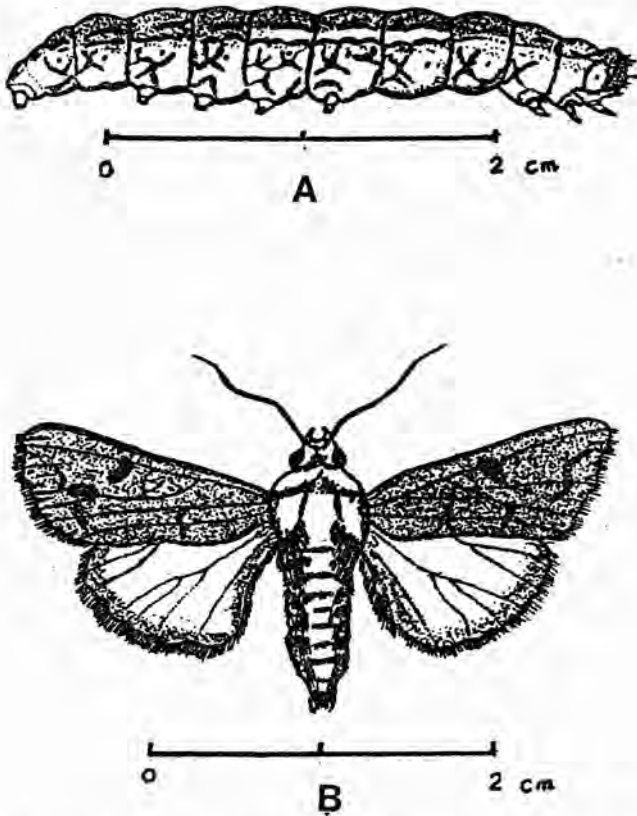


Fig. 5 Rice army-worm or swarming caterpillar,
Spodoptera mauritia.
 A. Larva
 B. Adult

This is a Lepidopteran belonging to the family Noctuidae (=Agrotidae). This family is characterized by the presence of a stout body and rounded wing-tips. The rice swarming caterpillar is also known as the army worm.

DAMAGE

This is predominantly a nursery and seedling pest of broadcast sown rice. It prefers to attack plants less than 25 days old (Pathak 1970) and rarely attacks plants over seven weeks old although attacks up to ear formation have been reported elsewhere (Anon. 1970).

The caterpillars feed on the foliage, nibbling leaves at first but later completely defoliating the plant. The late instars may cut-off the stem at ground level and the field after a serious attack, may appear as if a herd of cattle grazed through. The late instars, in particular, are gregarious and move from field to field in large numbers. The flocking of birds to feed on the caterpillars is an indication of their presence in the field.

LIFE HISTORY

Egg:

The eggs are laid as irregular-shaped masses of 250-350 on the leaves of wild grasses and rice plants. Huston's (1920) claim that the eggs are laid on cratichneumon plants needs verification though. The lower surface of an upright expanded leaf is usually preferred for

oviposition. Each egg mass is covered by the greyish-brown hair of the female. Each female may lay up to four egg masses. The incubation period is 5-9 days (Pathak 1970).

Larvae:

There are five instars. The first instar is about two mm long. It is pale green. This larva is mainly a leaf skeletonizer (Hutson 1920). The mature larva is 35-40 mm long, cylindrical and light to dark brown. The head is dark coloured and has a pale forked line. The body is dark green dorsally. A pale line is visible on the back and three stripes are found on each side. Above the stripes are distinct crescent-shaped spots. When disturbed the larva curls into a ring. The larval period is about four weeks (Ancn. 1970).

Pupa:

The pupa is found in the soil. Its cocoon is reddish brown and has two slender spines at its apex. This pupa is about 13 mm long. Duration of the pupal stage is 1-2 weeks.

Adult:

This is a greyish-brown moth which is 25-30 mm.

long. The wing span is 35-40 mm. The forewing has several wavy lines and a black spot near the center. A tiny white patch is seen below this black spot. The hind wings are brownish with thin black margins. The forelegs usually bear large tufts of hair. The male is more greyish than the female.

ECOLOGY

The alternate hosts of this insect are the wild grasses commonly growing on bunds.

This insect occurs mostly during rainy season although it may be found year-round. The occurrence of a dry spell in October- November may promote a population build-up of

S. mauritia (Hutson 1920). The larvae as well as the adults are nocturnal. However the adults are not strongly attracted to light. The larvae are gregarious towards the late instars. During day time they hide in the cracks in paddy soils.

CONTROL

Hutson (1920) reported occurrence of a parasitic wasp and two predatory insects (one an unnamed hemipteran and the other a

cicindelid beetle, Cicindela sexpunctata) of this pest in Sri Lanka. In addition, birds, crows and ducks in particular, are known to feed upon the larvae.

Among the cultural practices recommended by Huston (1920) to control this pest are the digging of trapezoid trenches 45-60 cm deep, use of small channels as barriers to larval movement, flooding of the fields to drown the larvae and pupae, plastering the bunds with clay to prevent adult emergence and the sprinkling of quick lime on to the levees. The removal of alternate hosts is another. The current recommendation by the Department of Agriculture (Ancn, 1981) is to use: chlorphytoszo percent EC or the rate of 1.05-1.75 4 ha or fenthion 50 percent EC at the rate of 1.4 - 2.1 L/ha or monocrotophos 60 percent EC at the rate of 1.05 - 1.4 L/ha.

6. Paddy Case Bearer, Nymphula depunctalis Guerner



Fig. 6 Rice case-worm or leaf roller Nymphula depunctalis, adult.

In the 1960s this insect was considered to be one of the important leaf eating caterpillars of paddy (Fernando 1964) and sporadic outbreaks of this pest still occur.

This is a pyralid moth belonging to the order Lepidoptera. It is commonly known as the rice casebearer, rice caseworm or rice leaf roller.

DAMAGE

The larvae of this insect usually attack young rice plants in early stages of tillering. The caterpillars feed on the leaf chlorophyll on

the lower surface thus leaving only the upper epidermis intact. This results in white patches with a papery appearance on the leaves, a characteristic symptom of casebearer attack. In addition each larva cuts off the tip of a leaf and makes a case by webbing its lateral larve edges. The changes the cases as it grows and thus a given larva will go through several before it reaches maturity. The damage eventually results in stunted growth and lower yield.

LIFE HISTORY

Egg:

The eggs are laid singly on leaves of rice plants. The larva emerges from the egg after three days of incubation.

Larva:

It is pale green and translucent with a light brownish orange head. The larva feeds on the leaves and makes a case by fastening the lateral edges of the cut tip of a leaf. This case is filled with water. The larva is aquatic and bears lateral filamentary gills for breathing. It maintains

a supply of fresh water by its respiratory movements. Every time the larva outgrows a case it makes a new one, until it reaches maturity. The full grown larva is about 20 mm long and the larval period is from 15-20 days.

Pupa:

The pupa is found in a brownish tube attached to the basal part of tiller. The yellowish-brown pupa is seed-like. It takes 4-7 days to develop into an adult.

Adult:

The adult is a small moth with a wing span of about 20 mm. Both foreand hind wings are white with brownish yellow spots. The life span is about three weeks.

CONTROL

No records of the natural enemies of this insect are available. The main control method is by the use of cultural practices viz. draining the fields for two to three days or distributing the larvae thus inducing them to jump into water to which a film of kerosene oil is added.

The recommended chemical control is same as that for paddy swarming caterpillar.

7. Rice Leaf Folder, Cnaphalocrocis medinalis (Guenee)

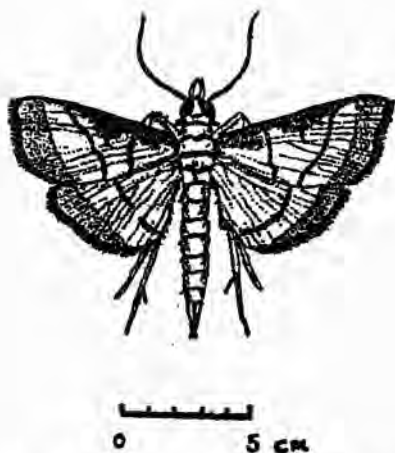


Fig. 7 Rice leaf folder (Cnaphalocrocis medinalis, adult)

The rice leaf folder, Cnaphalocrocis medinalis (Guenee), has become an important insect pest of rice grown in Sri Lanka since the 1960s. Fernando (1964) listed this as one of the chief leaf eating caterpillars. In 1969 a major outbreak of C. medinalis was reported from Minipe area. At present it is distributed in many parts of the country (Wickramasinghe 1980).

This is a pyralid moth belonging to the order Lepidoptera. Earlier it was known as Marasmia bilinealis Hampson.

DAMAGE

The larvae of this moth attack young rice plants. Usually the plants between 4-10 weeks after transplanting are the most susceptible.

The larvae feed within the folds of leaves tied together by silken threads attached to opposing margins. Usually the leaf is folded longitudinally (Wickramasinghe 1978) although occasionally the tip of the leaf may be fastened to the basal part (Anon. 1970). The larva is a leaf skeletonizer which feeds on the mesophyll of the leaf leaving the epidermis. This results in the drying up of the leaves. In a severe outbreak 60-80 percent of the leaves get skeletonized and the crop assumes a scorched appearance. This may result in a yield loss of up to 60 percent (Grist and Lever 1964) because the growth of the plant is affected.

LIFE HISTORY

Egg:

The eggs are laid either singly or in pairs on young leaves usually on the lower leaf surface. Each egg is 0.8x0.4 mm on the average, oval, flat and yellow. The incubation period is four days.

Larvae:

The pale yellowish green larva fastens the leaf with the silken threads and begins to feed on the mesophyll. It reaches a length of 16-20 mm in 15-25 days after passing through three instars and becomes greenish brown (Anon. 1970).

Pupa:

Pupation occurs within the rolled leaf. The cocoon is dark brown and it is 7.3-9.0 mm long. The adult emerges in 6-8 days.

Adult:

The adult is a small moth with a wingspan of 20 mm. It is 8-10 mm long and brownish-orange. The forewing is light brown with dark brown to gray along the margin and

two narrow wavy lines. The male is smaller (12-15 mm) than the female (13-18 mm). The latter has a relatively thin and long body.

ECOLOGY

Several graminaceous weeds are among the alternate hosts of this insect.

Wickramasinghe (1970) compared several sampling techniques and found that the number of larvae in fresh leaf-rolls gave a satisfactory measure of the immediate and residual effectiveness of insecticides. More recently pheromones have been used to monitor the populations of this pest (Kudagama 1983). Usually the outbreaks of rice leaffolder follow the use of insecticides to control either the brown plant hopper or stemborers. The fields receiving unbalanced nitrogen fertilizers are also prone to rice leaffolder attack (Wickramasinghe 1980). The use of pheromone traps by Kudagama (1983) showed that the peak damage to the crop occurred 10-20 days after the number of moths in the traps peaked.

CONTROLBiological:

A complex of larval parasites of this insect in Sri Lanka has been found in recent studies (Wickramasinghe 1980). Among the known larval parasites are the braconids, Apanteles nificry (Ital), Elasmus sp. and Melcha maculiceps and the ichneumonid, Paniscus testaceus Gram. The pupal parasites known are the chalcid, Brachymeria sp. the ichneumonid, Xanthopimpla emaculata Krieg and the mite, Oxyopes javanus Thor. Beside these, the general predators viz. Carabid larvae, spiders, lizards and birds are known to feed on this insect.

Resistant Varieties:

Although several hundred varieties have been screened, so far no promising varieties resistant to rice leaffolder have been found in Sri Lanka (Senadhira et al. 1980).

Cultural:

Wickramasinghe (1978) reported that all dust formulations were ineffective against the leaf folder. Chloropyriphos is one of the

insecticides that was found to have the quick action and the necessary residual activity of two weeks. The current recommendation by the Department of Agriculture (Anon. 1981) is given below.

<u>Chemical</u>	<u>Amount ml/ha</u>
Chlorpyrifos 20 percent EC	1000-1650
Fenthion 50 percent EC	1400-2100
Monocrotophos 60 percent EC	1000-1300

This has to be repeated in a fortnight if larvae are again found on fresh foliage.

8. Rice Stemborers

The stemborers are among the serious pests of rice grown in Sri Lanka. Of these the yellow stemborer, Tryporyza incertulas (Walker), is estimated to reduce up to 60 percent of the potential harvest (Fernando 1964).

These stemborers have been pests of rice grown in Sri Lanka at the turn of this century (Henry 1917, Molegoda) Lord (1928) reported that stemborers were a limiting factor to rice cultivation in this country. The stemborers were considered as major pests in the 1950s and in 1960s; these continue to cause damage of various extents, to-date (Wickramasinghe 1979).

The stemborers belong to the order Lepidoptera which is characterised by the presence of sucking mouthparts in the form of a proboscis and scales on the wings. At present three species of lepidopteran stemborers are known to occur in our paddy fields (Fernando 1964). Two of them are pyralid moths, i.e. yellow stem borer, T. incertulas which comprises almost 90 percent of the stemborer populations and a Crambus sp. which is rare. A noctuid, Sesamia inferens (Walker), forms about eight percent of the local stemborer populations. In 1920s, Chilo simplex reportedly was a common pest of paddy in Sri Lanka (Henry 1917).

The description here is limited to T. incertulas due to its predominance in Sri Lanka. This insect has been formerly recorded as Schoenobius incertulas (Walk.,) (Anon. 1922), S. bipunctifer (Walk.) (Henry 1917), S. punctellus (Walk.) and S. minutellus (Walk.) (Pathak 1970).

The yellow stemborer is widely distributed in Sri Lanka. It has been recorded from Central, Northwestern (Anon. 1927), Sabaragamuwa and Western (Fernando, 1964) provinces. The attack is severe in rainfed tracts of rice (Wickramasinghe, 1979). In upland paddy it is

less destructive than in wetland paddy (Coombs 1916).

DAMAGE AND SYMPTOMS

This insect could attack most of the growing stages of rice plant, beginning with seedling through tillering and up to ear-setting.

The yield losses due to this pest are high. In general up to 50 percent reduction of potential harvest could be attributed to this pest alone (Wickramasinghe, 1980). Over a 12 years period in three rice growing districts i.e. Colombo, Galle and Kandy in the wet zone of Sri Lanka, the average yield loss due to yellow stemborer was estimated to be 34 percent (Fernando, 1964).

The damage symptoms vary according to the stage of growth of the plant. During the very early stages of growth the larvae damage the growing point in the terminal shoot. This condition is known as 'dead-heart'. The larvae also feed internally within the leaf sheath and damage the vascular tissue by feeding inside the stem. The damage to stem results in the entry holes with some frass around. If the borer attack occurs at flowering the resulting panicles become white and empty, a condition

known as the 'white-head'. Among the other symptoms of damage of this pest are the presence of egg culsters on the leaves, presence of adult moths either flying around or floating on water and the curling of the young leaves (Pathak, 1970).

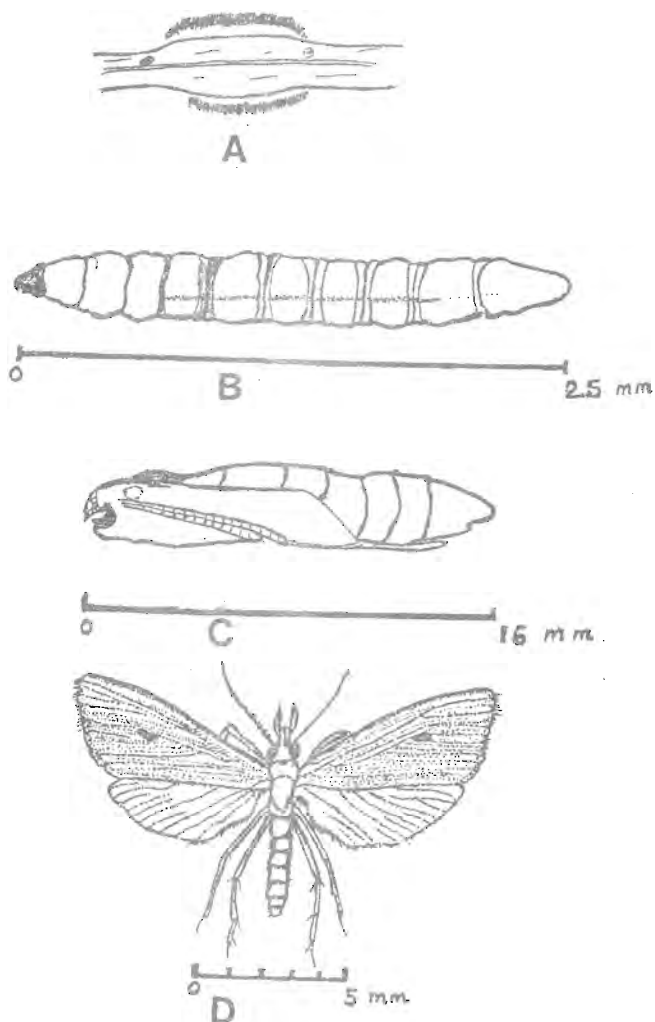
LIFE HISTORY

Fig. 8 Yellow stem-borer, Tryporyza incertulas

- A. Egg mass
- B. Larva
- C. Pupa
- D. Adult

Egg:

The eggs are laid in oval clusters of 80-150 on either the lower-or the upper surface of the leaf. Usually the egg culsters are found 7.5-10.0 cm from the tip of the leaf. The egg culster is covered by the soft, silky-brown anal hairs of the female. The eggs hatch in four (at 36⁰C) to fourteen (at 21⁰C) days depending on the ambient temperature.

Larva:

There are five laval instars. The larva is slender and yellowish with a velvety surface texture. The head capsule is relatively small and orange. The last instar is 25 mm long. In Sri Lanka, the first instar does not migrate; the second and fourth instars show little migration but the third instar migrates actively. The fifth instar migrates only rarely (Fernando, 1964). The early instars feed by scarifying the lower epidermis of the leaf and later ones enter the stem to feed on the internodes. The usual point of entry is above the point where the leaf blade diverges from the leaf sheath. After feeding on the tissue of the uppermost internode the larva bores through the node to the internodes below. If the attack occurs on stemless

seedlings the larva moves on to another plant later (some larvae may injure 2-3 stems). These larvae get transported either by wind currents or the raft-like pieces of leaf floating on water. Some larvae may diapause in the stubble. The larvae are solitary. The larval stage may last up to 40 days.

Pupa:

The pupation occurs at the base of the larval tunnel which sometimes may be below the water level. From this tunnel a silken tube is found to extend to the exit hole.

The pupa is yellowish-white with a tinge of green. It is 16x2.5 mm in dimensions. Depending on the environmental conditions the pupal stage may last from 6-14 days.

Adult:

The adults show sexual dimorphism. The male is light brown with numerous brownish dots; five along subterminal area and 8-9 near the tip of the forewing. The female is straw coloured with a pointed head. The yellow colour deepens towards the tip of the wing. The female is characterised by the presence of a black spot near the centre of the forewing. The hind-

wings are pale straw-coloured. The moths are relatively small with the length of the body ranging from 13-16 mm and a wingspan of 22-30 mm.

The adults do not feed and are short-lived with a life span of 4-5 days. The female lays 2-5 egg clusters. In this insect, up to six generations, each lasting 3-6 weeks, are possible annually.

ECOLOGY AND BEHAVIOUR

Fernando (1964) and Wickramasinghe (1979) have reported on the population dynamics of this insect pest in Sri Lanka. According to these authors the first brood reaches a peak during early planting to tillering stages. A second brood occurs from late shooting to heading and a third after the harvest. There are two peaks, each lasting 15-20 days and occurring about eight weeks apart, in terms of the number of adult moths. However, the cycle of adult moth emergence may not occur at the same time in each year. The occurrence of stemborer attack on short duration crops is not significant.

This species is monophagous with no known alternate hosts. In Sri Lanka, their survival

between rice cultivating seasons is on the ratoon crop, stubble and on the volunteer plants that originate from the seeds which are shed during harvesting. Thus the boggy tracts support their off season occurrence and the dry conditions decrease the same.

These moths are nocturnal. They become active and mate around 7-9 p.m. The adults get attracted to violet light and therefore the light traps could be used to sample their populations. During day time they hide under the leaf sheaths.

CONTROL

Biological:

The egg parasites of this insect are relatively more active compared to the larval and pupal parasites. In Sri Lanka, four species of egg parasites are known to occur (Fernando, 1964). These include two species of eulophids: Tetrastichus schoenobi Ferriere (10 percent) T. israeli Mani and Kurian (2 percent); a scelionid: Telenomus dignus (70-90 percent) and a rare trichogrammatid, Trichogramma sp. Of these T.dignus is the most active, some times parasitising as much as 100 percent of the egg

masses and up to 90 percent of eggs in an egg mass. The introduction of the egg parasite, T. japonica has been attempted but was a failure in this country (Wickramasinghe, 1979).

Several braconids viz. Apanteles flavipes Cameron, A. schoenobii Wilkinson, Shiraka schoenobii Viernich (oorsalis Matsumura), an eulophid, Aprotocetus sp. and an ichneumonid, Isotima sp. are among the larval parasites of yellow stem borer known to exist in Sri Lanka. Two other larval parasites have been reported to occur locally (Wickramasinghe, 1979). Overall though, the larval parasitism is low mainly due to the protected habitat of the larva.

Only one pupal parasite of the yellow stem borer is known to occur locally (Wickramasinghe, 1979).

In China, ducks and chicken have been used to mop the larval populations but this practice may cause some damage to the crop.

Resistant Varieties:

The use of host plant resistance as a method to control yellow stem borer has hitherto not been possible. In general, the indica varieties are

more susceptible than the japonica varieties . In Sri Lanka, some of the local varieties viz. Kaluheenati have been found to be less susceptible (Fernando, 1964). Some other varieties that show promise are also known to occur here at present (Senadhira et al. 1960). Even elsewhere only varieties with low to moderate resistance are known (Wickramasinghe, 1980).

Cultural Control:

Clean cultivation viz. removal of stubble either by burning, by ploughing or a combination of these two is an adequate method to keep stemborers under control where only one crop of short duration is grown. Due to the monophagous habit of this pest, crop rotation and closed growing seasons are bound to keep it at bay. In Sri Lanka however, these practices are not feasible due to the presence of ratoon crop and volunteer plants particularly in the boggy tracts (Fernando, 1964). Although higher plant density has been reported to have a controlling effect the Department of Agriculture does not endorse this practice. The planting date has little bearing as a control measure because this pest is not known to follow the same cycle of adult emergence in each year.

Other Control Methods:

Among these methods are the removal of egg masses and the use of light traps to catch the adults. The former is slow and labour intensive while the latter is not efficient; these practices might become useful in small scale cultivation and in an integrated management program.

Chemical Control:

Earlier studies have shown that diazinon, rogor and sumithion are among the insecticides that give good control of the first brood of yellow stemborer but not of the second brood. The timing of insecticidal spray is critical in view of the high degree of egg parasitism and the migratory habits of the different instars of larvae.

The current recommendation by the Department of Agriculture (Anon, 1981) is as follows: If water can be drained, broadcast to moist soil either carbofuran three percent granules at the rate of 17-22 kg/ha (15-20 lbs/ac) or diazinon five percent granules at the same rate. If drought prevails and the soil is dry, spray one of the following: Monocrotophos 60 percent emulsifiable concentrate (EC) at the rate of

520-725 ml per ha (8-11 fl.oz./ac); endosulfan 35 percent EC at the rate of 980-1260 ml/ha (14-18 fl.oz./ac); chlorpyrifos 20 percent EC at the rate of 1050-2100 ml/ha (15-30 fl.oz./ac).

In stemborer affected areas it is advisable to treat the nurseries 5-7 days after sowing. The field could be treated first at maximum tillering and again a few days after panicle initiation.

These recommendations are also applicable for the control of pink stemborer also. The repeated use of the insecticides is bound to result in the development of resistance by the insect. As early as in 1964, Fernando reported on the possible resistance to insecticides by the yellow stemborer larvae.

9. Rice Leaf-and Plant hoppers

The rice plant is known to be inhabited by around 50 species of leafhoppers and planthoppers. Generally the leafhoppers are among the most serious insect pest of our rice. Since the 1960s these insects have become significant pests of rice cultivated in this country. In 1965, a serious outbreak of brown planthopper, Nilaparvata lugens (Stal.)

in Ampara district affected 16,000 ha of which 2,800 were devastated. Since then this pest has reached epidemic proportions in several rice growing districts particularly those located in the dry zone. In Maha season of 1967, a serious outbreak of the White-backed planthopper, Sogatella furcifera (Horvath) was reported from Ibbagamuwa in Kurunegala district. Some taxonomic details and the status of leaf and planthoppers known to occur in Sri Lanka are given in Table II. Their common names are based on their colour and body markings but do not necessarily reflect the part of the plant attacked.

These insects belong to the order Homoptera which is characterized by the presence of a segmented, beaklike mouthcone arising ventrally from the posterior end of the head and uniformly thickened wings.

DAMAGE

The leafhoppers attack the leaves of young rice plants and the leaves as well as the basal parts of full grown plants (Pathak 1970). The white-backed planthopper is generally found during early growth stages of the rice plant. The brown planthopper prefers the basal part of

the plant at a mature stage of growth (Anon. 1970).

TABLE 11. LEAFHOPPERS AND PLANTHOPPERS KNOWN TO AFFECT RICE GROWN IN SRI LANKA

Family	Common name	Status as a pest	Scientific name	Synonyms
Cicadellidae (=Jassidae)	Green leaf-hopper	minor hopper	<u>Nephotettix</u> Ishihara	<u>N. bipunctatus</u> <u>impicticeps</u>
	Zig-zig winged leaf-hopper	minor	<u>Inazuma</u> Motschulsky	<u>Deltoccephalus</u> <u>cephalus</u> <u>cephalis</u>
	-	minor	<u>Tettigoniella</u> <u>spectro</u> Distant	-
	-	rare	<u>Recilia</u>	

Family	Common name	Status as a pest	Scientific name	Synonyms
		rare	<u>dorsalis</u> <u>Thia</u> <u>subrufa</u>	-
Delphaci- <u>Del-</u> <u>dae</u>	plant- hopper	Brown serious	very <u>ata</u> <u>lugens</u> (Stal.)	<u>Nilapar</u> <u>phax</u> <u>lugens</u> Stal. <u>D.sor-</u> <u>desoen</u> Motshu- lsky <u>D.ory-</u> <u>zae</u> Matsumu- ra <u>D. orac-</u> <u>vix</u> Kirkalóy <u>D.parys-</u> <u>atis</u> Kirkalóy <u>Delpha-</u> <u>codes</u> <u>anóreisa</u> Muir <u>D.parys</u> <u>atis</u> Muir

Family	Common name	Status as a pest	Scientific name	Synonyms
				<u>Dicranotropis</u>
				<u>andrei</u>
				Kirkaldy
				<u>Hikora</u>
				<u>formosa</u>
				Matsumura
				<u>Kalpa</u>
				<u>aculeata</u>
				Distant
				<u>Liburia</u>
				<u>oryzae</u>
				Matsumura
				<u>L. sorde-</u>
				<u>scens</u>
				Mehchar
				<u>N. greeni</u>
				Distant
				<u>N. sorde-</u>
				<u>scens</u>
		<u>cens</u>		Kuwayama
	White	Poten	<u>Sogate-</u>	<u>Sogata</u>
	backed	tially	<u>lla</u>	<u>furcifera</u>
	plant	serious	<u>furci-</u>	<u>Delphaco-</u>
	hopper		<u>fera</u>	<u>des</u>
			(Horva-	<u>furcifera</u>
			th)	

The leaf and planthoppers cause direct damage to the plant by sucking the sap. In addition they may secrete toxins and transmit pathogenic viruses (Table 3).

In general, hopper attacks cause the loss of plant vigour, affect tillering and increase the number of unfilled grains (Pathak 1971). The leafhopper attacked plants have white to yellow streaks on leaves and die-back of leaves occur when the attack is severe (Anon. 1968a). The brownhopper attacks, when severe, are characterized by "hopper-burn", the drying-off of plants due to intensive sucking by this insect. The first sign of hopper-burn is the yellowing of older leaf-blades. This extends progressively to all above ground parts until all these turn brown and die. This is probably due to the reduction in the rate of translocation of photosynthate to the root system which drains the phloem sap, reduces photosynthesis, causes proteolysis and results in the accumulation of degraded products (Sogawa and Cheng 1979).

Both leaf - and planthoppers attack the vegetative phase of the rice plant. Although the phenology of attack varies among these

TABLE III. LEAF AND PLANTHOPPERS AS VECTORS OF VIRUSES CAUSING DISEASES IN RICE

Pest Organism	Disease	Symptoms
Green Leaf hopper	Yellow dwarf	Stunted growth; profuse tillering; leaves turn from green to greenish yellow or yellow
Zig-zag winged leafhopper	Orange leaf	Leaves turn brilliant orange especially in young plants; poor tillering; leaf blade rolls inwards from leaf-tip down, withers and turns dirty brown
Brown planthopper	Grassy stunt	Stunted growth; profuse tillering; leaves become pale green with misty spots.

insect pests, they are described together due to the other similarities.

The amount of yield loss due to hopper damage varies according to the stage of development of the plant at the time of the attack and the number of insects per hill. Ten brown planthoppers per hill are considered to cause economic losses in yield.

LIFE HISTORY

The leaf and planthoppers undergo incomplete metamorphosis. The egg stage is followed by several nymphal stages and the adult.

Green Leafhopper

Egg: The eggs are found in the leaf sheaths. These are found in masses of 8-16 eggs. The egg is narrow and cylindrical with a long cap. The micropylar end is protruding from the leaf tissue. The average dimensions of the egg are 0.97 x 0.22 mm. The eggs hatch in about six days.

Nymphs: There are five stadia. The nymphal stage lasts 16-18 days.

Adult: The adult has a submarginal black band on the vertex. The wings are green with black spots. The female (average length 5.3 mm) is slightly larger than the male (average length 4.00 mm).

Zig-zag Winged Leafhopper

Egg: The eggs are laid in rows within the leaf-sheath. The average dimensions are 1.2x 0.3 mm. These hatch in 7-9 days.

Nymphs: There are five stadia. They vary in size from 1.0-3.0 mm. They are yellowish brown and complete the development in 16-18 days.

Adult: The adult is characterized by the presence of a brown zig-zag pattern (W) on the white forewings. The female is (average length 4.0 mm) slightly larger than the male (average length 3.5 mm).

Brown Planthopper

The life history of brown planthopper is illustrated in Fig. 9.

Egg: The eggs are usually found on the tissues of the lower part of the plant but may

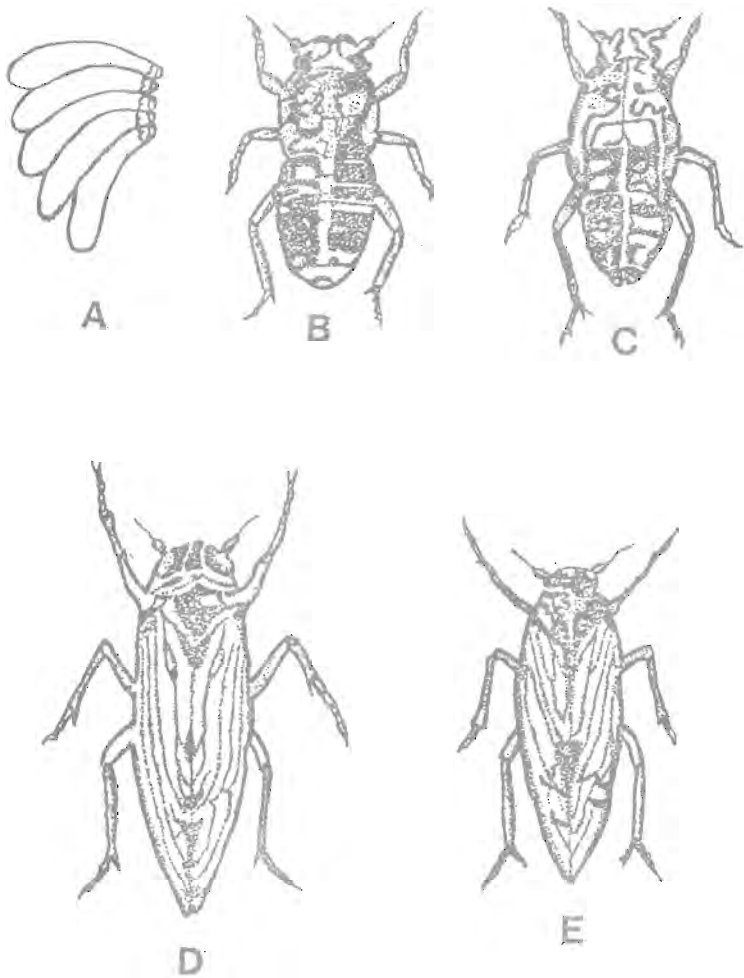


Fig. 9. Brown plant hopper, Nilaparvata lugens

- A. Egg mass
- B. First instar
- C. Fifth instar
- D. Female
- E. Male

also be found on leaf blades. They are laid in batches with their anterior ends glued together, much like a comb of bananas. The egg is white and transparent. The shape and the dimensions of the egg depends on the stage of growth of the rice plant. The eggs hatch in 7-11 days depending on the environmental conditions (Mochida and Okada 1979).

Nymphs: The nymphs are usually found on the lower part of the plant. When the level of population is high they might occur on the other parts of the plant as well. The nymph is dark brown. The first stadium is 0.6 mm but by the fifth and the final stadium may reach 2.0 mm. The fourth and fifth stadia are normally found near the base of the plant. the different stadia could be distinguished by their body size and the shape of the meso- and metanota. The length of the nymphal period (10-15 days) depends on temperature, cultivar and the morphological form of the adult (the brachypterous forms develop faster).

Adult: The adult female (average length 3.9 mm) is slightly smaller than the male (average length 4.6 mm). The body colour of the adults varies from light to dark brown.

Two morphs i.e. brachypterous and macropterous forms, are found. Relatively higher proportion of macropterous i.e. full-winged, form occurs when the population density is high and the quality of food is low.

The female is capable of laying up to 1400 eggs during her life span.

White-Backed Planthopper

The life cycle of white-backed planthopper is shown in Fig. 10.

Egg: The eggs are laid in masses in the leaf sheaths. The egg is narrow and has a long cap. The period of incubation is about six days.

Nymphs: The nymphs are pale to light brown. They vary from 0.6-2.00 mm in length depending on the stage of development. The development of the nymphs takes 11-12 days.

Adult: The adult could be recognized by its distinct vertex, uniformly hyaline forewings with dark veins and the presence of a conspicuous black dot at about the middle of the posterior edge where the forewings come

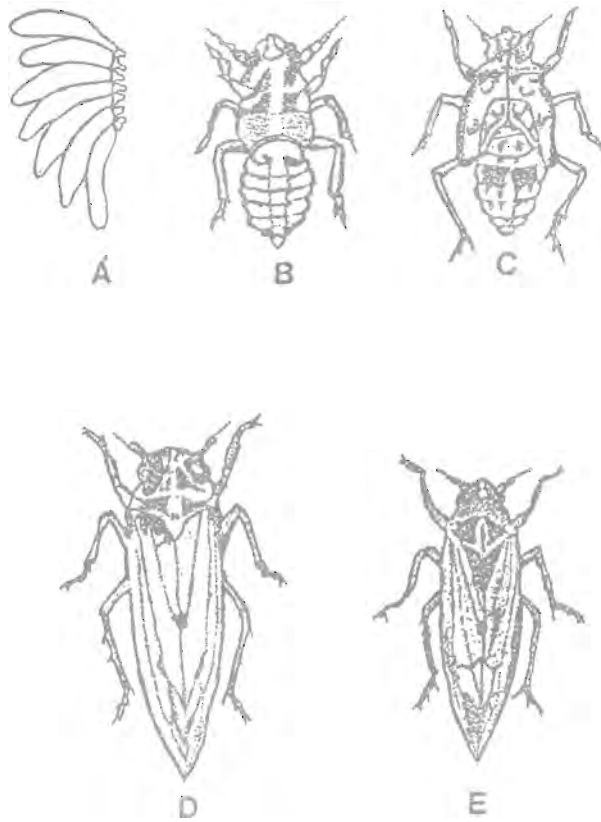


Fig. 10. White backed plant hopper - Sogatella furcifera

- A. Egg mass
- B. First instar
- C. Fifth instar
- D. Female
- E. Male

together. The pronotum is pale yellow and the rest of the body is black. The adult is 3.00 mm long on the average. The brachypterous females are normally found near the base of the plant while the males and the macropterous females are located near the crown.

ECOLOGY

The alternate hosts of the brown planthopper include: Eleusine coracora, Leersia hexandra, L. japonica, Saccharum officinarum, Zea mays, Zizania latifolia, and Z. longifolia (Dyck et al. 1979). Grist and Lever (1964) list six alternate hosts of white-backed planthopper and fifteen of green leafhopper. Towards the end of the growing season, white-backed planthoppers are found on the weeds in the fields (Otake et al. 1976).

The use of a sweep net is a convenient and a quick method of sampling brown planthoppers but this overestimates the number of adults. The yellow pan trap, though used effectively in Japan, did not give satisfactory catches of planthoppers in Sri Lanka (Wickremasinghe 1976) Dyck et al. (1979) reviewed the various methods including use of upright sticky boards, visual counts, aspirators and light traps to sample brown planthoppers.

In general, the hopper populations increase very fast. The population usually has one peak; little before the middle of the season in the case of the white-backed planthopper and in the latter half of the season in brown planthopper. However this was not observed in Sri Lanka (Otake et al. 1979). Locally, these authors found a relatively high population density of the late nymphal stadia and females of brown planthopper from mid-July to mid-August. The sex ratio of brown planthopper remained 1:1 until the final stage of the population was reached. In white-backed planthopper the highest population was observed 54 days after transplanting. This lasted for 14 days and then decreased steadily (Otake et al. 1976).

CONTROL

Biological: Otake et al. (1976) reported several parasites of brown planthopper in Sri Lanka. Among these are some Oryniids, Elechids, Pipunculids, and Nematodes. Although the degree of parasitism was considerable (up to 40 percent) some times, these parasites were neither persistent nor regulative. Elsewhere strepsipterans have been recorded as parasites of brown planthopper (Dyck et al. 1979).

The most noteworthy of the local predators of brown planthopper is the mirid bug, Cyrtorhinus lividipennis, particularly in the endemic areas (Wickramasinghe 1980). Among other predators are spiders, beetles and ducks (Dyck et al. 1979). Several fungi are reported to be entomophagous on brown planthopper but these are less important than the predators.

The white-backed planthopper is also regulated by parasites belonging to orders Diptera and Strepsiptera. The most important among its five known egg parasites is the hymenopteran, Anagrus optoblis which is also known to parasitise brown planthopper eggs. A species of Dorilors is known to regulate populations of green leafhopper in Sri Lanka (Wickramasinghe, 1980).

Resistant Varieties: hitherto the resistance to local biotypes of brown planthopper has been limited to crosses involving Ptb 33 variety. The basis of this resistance is a combination of tolerance of damage and a degree of antibiosis which results in lowering the hatchability of eggs and an increase in tendency towards maleness (Wickramasinghe, 1980). In addition Pathak (1970) reported lower body weight, slower growth,

underdeveloped ovaries and smaller number of eggs laid as consequences of this antibiosis. The local variety Bg 279-2 is resistant to brown planthopper and has other desirable characteristics viz: high yield (Senadhira et al. 1980). Among the other local varieties which have shown brown planthopper resistance are Suduru-samba. So far no varieties resistant to the local biotype of white-backed planthopper are known.

Cultural: Among the cultural practice that could be used to control brown planthopper is the use of optimal plant density. In Bg 34-6, a local variety, 15 cm (6.0") was found to be the optimal spacing to keep the brown planthopper populations low while obtaining a good yield (Wickramasinghe 1980). The removal of alternate hosts and the use of light traps to attract adults are the other measures that could be used to keep this pest at bay (Anon. 1970).

Chemical: The broadcasting of granules is superior to seed treatment, placement of these granules in the furrows or seedlings sowing. For maximum efficiency, the application of the insecticide should be at maximum nymphal populations although this is not possible with

overlapping generations or continuous planting, among the insecticides that control brown planthopper are earbaryl and diazinon (Wickramasinghe 1980).

The current recommendation by the Department of Agriculture (Anon. 1981) is the application of carbofuran 3 percent granules at the rate of 22 kg/ha. The rice field is to be drained of water before the application of the granules. Where water cannot be drained, use of any one of the following as a spray is recommended. BPMC 50 percent emulsifiable concentrate (EC) (1.41 L/ha); MIPC 50 percent wettable powder (WP) (2.25 kg/ha), Propoxur 20 percent EC (1.0 L/ha). The insecticides should be diluted to 222 L/ha and the application should be repeated ten days after, if the pest continues to spread. Several anti-feedants and growth-suppressants of brown planthopper are known but these are still at an experimental stage (Heinrichs 1979).

The control of other leaf and planthoppers is similar to the above.

10. Rice Pentatomid bug, Scotinophora lurida (Burm.)

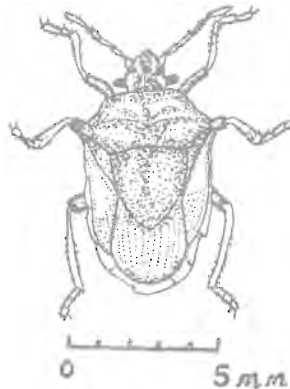


Fig. 11 Black paddy bug., Scotinophora sp. adult

This bug was a major pest of rice grown in Sri Lanka in the 1950s. Localized severe outbreaks of this pest have been reported from Walawe in 1940 and again in 1953 (wickramasinghe 1976). It was a major pest in Southern areas of Sri Lanka. Sporadic outbreaks have been reported from Minneriya, Gkkampitiya and Pclonnaruwa.

This bug is a hemipteran which belongs to the family Pentatomidae. This family is characterized by the presence of a triangular scutellum which reaches at least the membranous

portion of the forewing and a five-segmented antenna. The opening of the gland, which produces a characteristic smell, is near the hind coxa. It is commonly called the paddy pentatomid bug or Japanese black rice bug. The local strain bears many similarities to the Japanese strain but undergoes three to four generations per crop-year unlike the Japanese counterpart. There are differences in the symptomatology between the two strains viz. the incidence and distribution of feeding lesions (Fernando 1960).

DAMAGE

This is mainly an early to mid-season pest of rice. De Alwis (1941) reported that the pentatomid bug begins to feed on rice plants which are three weeks old. The plant is most susceptible up to 8 weeks from planting but occasional attack may continue up to harvesting time. This insect is also known to attack rice earheads at the milky stage (Anon. 1960).

The damage is caused by nymphs and adults which suck the sap from the plants. There are reports of salivary toxins but these have not been elucidated (Wickremasinghe 1978). De

Alwis (1941) claimed that the feeding is confined to the stems but this is not quite likely; reports of these bugs feeding on earheads are available.

The major symptoms are the death of the growing shoots of the seedlings and the appearance of whitish lesions on mature leaves. These lesions are frequently associated with necrosis and browning of a variable part of the leaf from its tip backwards. The damage to earheads results in reducing the grains to shrivelled remnants (Anon. 1960). The feeding damage sets back the growth and if the bugs on a given plant exceed a limit, the plant may die.

LIFE HISTORY

The following account of the life history is based on De Alwis (1941) and Fernando (1960a and 1960b).

Egg:

The eggs are usually laid in two or three (and rarely four) parallel rows either on leaves of grasses or of rice. The eggs on adjacent rows alternate with each other. Each row may contain up to 13 eggs. The egg is 1.0x0.75 mm,

barrel-shaped and pale green when laid. With development the eggs turn pink. The incubation period is six days at 75 percent relative humidity and 25 - 28⁰C.

Nymphs:

There are five stadia. The first stadium is about one mm long and is roughly circular in shape. The head is dark brown with black eyes and pale brown antennae. The thorax is dark brown with pale brown legs. The brown abdomen has fine black spots and three dark brown transverse bands mid-dorsally. At 75 percent relative humidity and 25 - 28⁰C it takes five days to complete development.

The other stadia are yellowish brown with black markings. They differ from each other in body length (this increases from 2.5 mm in second stadium to 8.0 mm in the fifth), colour of the head, antennae, eyes, thorax, legs and the abdomen. At the relative humidity and temperature range given above, the duration of second through fifth instar are nine, and twelve days respectively (Fernando 1960a). The wing-buobs are visible in the last stadium only.

Adult:

The adult is dark brownish black to black. It has a shield like process. It is 8.0-10.0 mm long and 5.0 - 5.5 mm broad, broadly ovate with a slightly convex head. The antennae are six-segmented and are half as long as the body. The rostrum is four-jointed and reaches up to the posterior coxae. There are two lateral ocelli. The black thorax has a scutellum which narrows behind. Each leg bears a black femur and a three-jointed tarsus. There is no sexual dimorphism. The adult life span is about ten months.

ECOLOGY

These bugs are known to exist on wild grasses growing in and around the paddy fields. In the laboratory they have been reared on Guinea and Napier grasses. During unfavourable seasons they aestivate under stubble or in soil. They become gregarious when rice is in fallow. Fernando (1960b) reported that the adults move on to the Yala crop in April/May, aestivate between growing seasons and attack the Maha crop in October/November.

They avoid strong sunlight and are usually found at the base of the plant near the water level. They are active early in the mornings and in late evenings when most of the feeding is done. They need to feed for about a week before copulation leading to oviposition in about ten days. The adults usually die after oviposition (De Alwis 1941).

CONTROL

Biological:

Among the natural enemies known to exist locally are some unspecified and rare predaceous bugs (De Alwis, 1941) and an effective parasitic cecilonid wasp, Telenomus tryptus. This latter had 89 percent parasitism in some fields (De Alwis, 1941) and 30-36 percent parasitism was recorded over a three year period in an insecticide sprayed field (Fernando 1960b). This bug is also attacked by a fungus Metarrhizium anisophae during its aestivation.

There is no information available on rice varieties resistant to this pest.

Cultural:

The clean up of grassy weeds growing in and around the paddy fields is an effective way to keep the rice pentatomid population down. The ploughing of the stubble could destroy the aestivating population. Early in the cropping season, the flooding of the field for 3-6 hours after adding kerosine oil, effectively drowns the nymphs. Then fresh water has to be let in. Among other cultural measures are to increase the plant spacing, grow a small patch to be used as a trap crop and hand collection as suggested by De Alwis (1941).

Chemical:

The current recommendation by the Department of Agriculture, (Anon 1981) is given below:

As soon as the insects appear on the crop, either dust with BHC ten

percent dust at the rate of 22-35 kg/ha. or,

Apply fenthion 50 percent emulsifiable concentrate at the rate of 1.4-2.1 L/ha. or,

Trichlorphon 80 percent wetttable powder at the rate of 0.56 - 1.12 kg/ha and repeat after a week, if necessary.

11. Mole Cricket, Gryllotalpa africana Beauvois

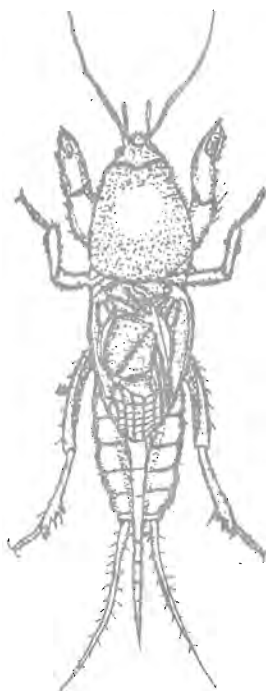


Fig. 12 Mole cricket, Gryllotalpa africana, adult.

This insect is a sporadic pest of rice grown in Sri Lanka. It is known to cause occasional outbreaks depending on environmental conditions. It belongs to the family Gryllotalpidae in Order Orthoptera.

DAMAGE

The adults burrow into soil and may damage the subterranean parts of rice plants. The damage is usually localized and it ceases after the fields are flooded. The upland rice is more susceptible to attack.

LIFE HISTORY

The eggs are laid in hardened cells within soil. Each cell contains 30-50 eggs which may take 15-40 days to hatch. The nymphal stage lasts 15-20 days. The adult (Fig. 12) is light brown, 25-35 mm long and has large forelegs modified for burrowing into soil (Pathak 1970).

CONTROL

Controlling of this insect is only rarely necessary. This could be achieved by flooding the fields, light trapping of adults and use of a bait consisting of one part sodium

flurosilicate : one part brown sugar : ten parts of rice bran mixed into a paste.

III. Insect Pests Attacking Rice in Reproductive Phase

12. Paddy bug, Leptocoriza varicornis (F)

INTRODUCTION

The paddy bug was reported to be the most serious insect pest of rice grown in this country in the early part of this century (Hutson 1930). While the status of some other pests have changed since, paddy bug continues to cause extensive damage. A loss of 10-40 percent of the yield due to this pest is not uncommon and a severe paddy bug attack may result in complete crop failure (Fernando et al 1957).

This bug belongs to the family Coreidae in the order Hemiptera. This family is characterized by the presence of a four segmented antenna inserted towards the top of the head and an

elongated body with a relatively small scutellum. This insect has been commonly called the paddyfly (Hutson 1931) and rice bug (Pathak 1970). Leptocoriza varicornis (F) has also been recorded as L. florida Guer. and L. acuta Thunb (Grist and Lever 1969).

This insect is widely distributed in all the rice growing districts of our country (Fernando 1964). It is in particular a problem in the rice grown under the major irrigation schemes (Wickramasinghe 1978).

Damage

The paddy bug migrates to paddy as soon as the flowering begins and attacks any soft or milky grain (Fernando et al. 1957). The milky stage which is usually 7-10 days in duration, is the most susceptible stage of growth (Wickramasinghe 1978). Although the young succulent leaves and shoots have reportedly been attacked (Anon. 1970) it is more likely that the paddy bug feeds on the seeds of wild grasses during off season.

These bugs feed actively during the mornings and evenings. The damage is done both by the nymphs and the adults which pierce and suck the contents of the milky grain. Usually the proboscis is inserted at the place where the glumes meet. The affected grain first turns yellow and later becomes brown with a diffused dark spot formed at the point of insertion of stylets. The attack results either in half-filled or empty grains. Besides this the damage is also recognized by erect panicles indicating empty grains. These bugs emanate a characteristic unpleasant odour. With a severe infestation even the straw develops an off flavour making it unsuitable as an animal feed (Pathak 1970).

The damage is more severe when plenty of moisture is available either due to even rainfall or due to irrigation.

LIFE HISTORY

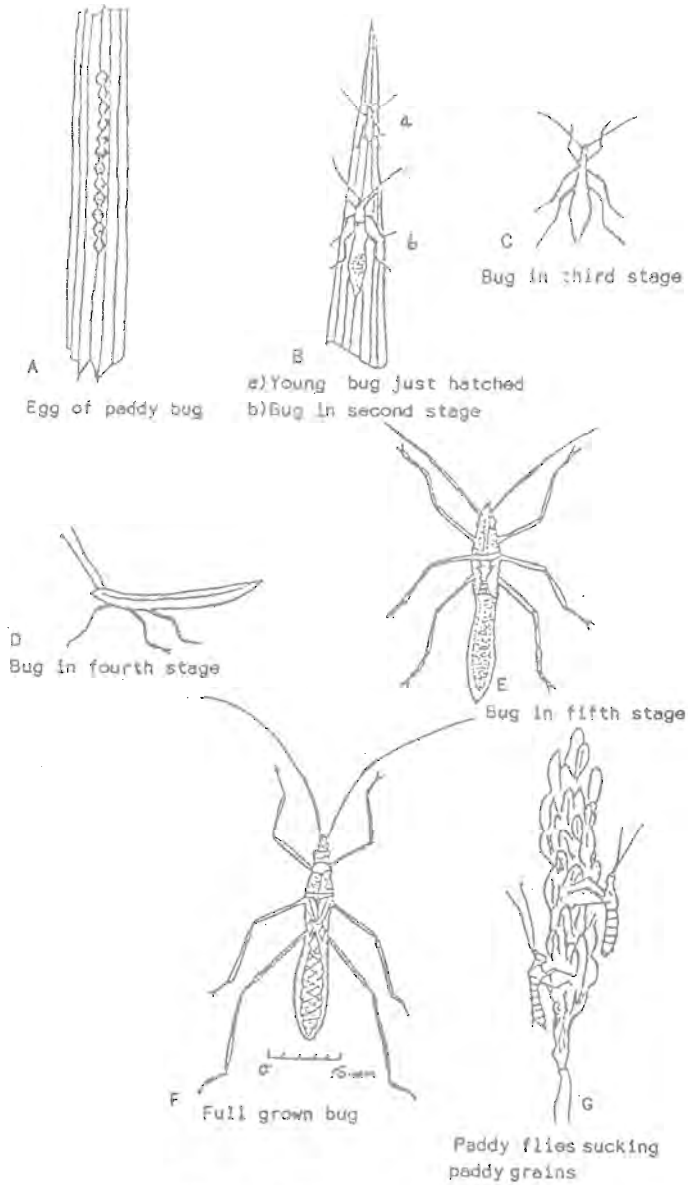


Fig. 13 Paddy bug, Leptocoris sp.

These insects undergo an incomplete metamorphosis. The following description is based on Pathak (1970) and Anon. (1970).

Egg: The eggs are laid on the upper surface of the leaf blade. Usually they are found in a row but occasionally along two rows. Each row contains 10 - 12 eggs glued to the leaf surface.

The egg is creamy white and boat-shaped with a slightly flattened top. The average length of an egg is two mm. With development the egg becomes dark reddish brown and black, to appear like a seed. The eggs hatch in 5 - 8 days.

Nymphs: There are five nymphal stadia. The first stadium is yellowish green and 1.5 mm long, on the average. After each moult the colour changes and the size increases eventually resulting in a brown coloured fifth stadium with an average length of 12.5 mm. This development is completed in 17-27 days depending on the environmental conditions.

Adult: The adult is a long slender bug (Fig. 13) 14-17 mm long. It is olive brown above and green underneath. The adult may live up to 14 weeks. The adult female lays 100-300 eggs.

ECOLOGY

Among the alternate hosts of this insects are several graminaceous weeds viz. Echinochloa crusgali, E. colonum, Panicum repens, P. miharis, Cyperus polystachys (Wickremasinghe) and several cereal crops including Eleusine corccana (finger millet), Paspalum scrobiculatum (amu), and Sefaria italica(tanahal) (Huston 1930). Various legumes viz. cowpea, greengram, several species of rattlepod and Amaranthus, are reported to harbour the paddy bug and these need authentication.

Warm weather, overcast skies and frequent drizzles are among the climatic factors that favour rapid build-up of the populations of paddy bug (Pathak 1970). Enormous populations of this insect result when the flowering in rice is unequal and prolonged either due to staggered planting of the same variety or due to simultaneous planting of varieties flowering at different times (Wickramasinghe 1976).

CONTROLBiological:

Several natural enemies of paddy bug are known to exist locally. Hutson (1930) reported that an unspecified egg parasite was found in small numbers in Anurachapura area. In addition several predaceous bugs were also found by him. Grist and Lever (1969) reported the presence of the following predators from India and Sri Lanka (Ceylon): Asopus malabaricus F., Enagorus sordidatus Stal., Rhinocerus fuscipes and Irantha sp. However, birds are not known to feed on the rice bug. Overall though the natural enemies are of little help to keep the population down if other conditions are conducive for a rapid build-up.

Host plant resistance:

Hitherto no rice varieties with resistance to this pest are available.

Cultural:

Having a closed growing season and growing a rice variety with uniform maturity in a given tract of rice should be effective in minimising the damage done by this pest (Fernando et al., 1957). Among the mechanical devices used by the local farmers are the use of either winnows or ropes coated with the latex of the jak fruit. Hutson (1930) reported that the former is more effective. Nets could be used to catch the bugs which later could be destroyed. The use of improvised light traps i.e. kerosine oil lamp hung over a basin containing water and a film of kerosine, is another way of destroying the adults of this insect (Pathak 1970).

The elimination of graminaceous weeds from paddies and levees, before these plants flower, should help to check the rice bug populations. It is possible to use a strip of early maturing rice as a trap crop.

Chemical:

Earlier gamma BHC was recommended for the control of this pest but since then the bug has been found to become resistant to this

insecticide (Fernando et al. 1957). The current recommendation by the Department of Agriculture (Anon. 1981) is to use the following:

Two percent carbofuran dust at the rate of 17-22 kg/ha before grain hardens and to repeat in three days, if necessary.

Spraying of quinalphos 25 percent EC at 1.4-2.0 L/ha.

Diazinon 40 percent EC at the rate of 1.0-1.65 L/ha or

Fenthion 50 percent EC at the rate of 1.4-2.1 L/ha.

(EC = emulsifiable concentrate).

IV. Other Minor Field Insect Pests of Paddy

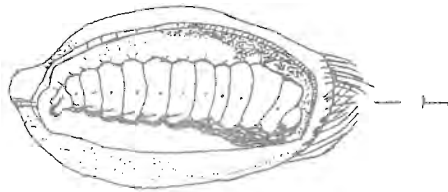
In the 1930s Borolia venalba was recorded as a pest of locally grown rice (Anon. 1938). During the 1960s, the paddy hesperid, Parnara baoa Moore and P.mathias Fabricius, were considered to be caterpillar pests of importance (Fernando 1964). The leafhopper, Tettigoniella spectra Distant, was also

considered as an important pest of rice during this period. Two other leafhoppers attacking rice, i.e. Ricilia dorsalis and Thia subrufa were also first recorded in the 1960s (Wickramasinghe 1978).

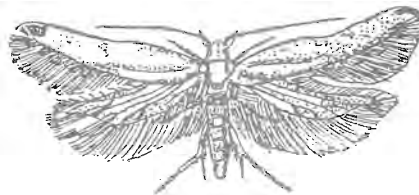
Among the other minor insect pests recorded from Sri Lanka during the last couple of decades are the leaf beetles, Leptispa pygmaea Baly and Dicladispa armigera (= Hispa armigera).

V. Insect Pests of Stored Paddy

13. Angoumois grain moth, Sitotroga Cerealella
(Oliv.)



A



B

Fig. 14 Angoumois grain moth, Sitotroga cerealella

A. Mature larva

B. Adult

This is a moth belonging to the family Gelechiidae in the order Lepidoptera. This family is characterized by having long narrow wings ending in a fringe of hair. The anal vein is absent and the outer margin of the hindwing is usually concave.

This is a cosmopolitan pest which was earlier known as the grey rice moth.

DAMAGE

The damage is done by the larvae. They feed on the endosperm leaving only the outer husk by the time of pupation. Usually the damage is confined to the peripheral layers of paddy.

LIFE HISTORY

The eggs are laid on the surface of the grain either singly or in clusters. The eggs are 0.5 mm long on the average. They are translucent white at the beginning but gradually turn pink with development.

The larval and pupal stages are spent inside the grain.

The adult is a small moth. It is 5-7 mm in length. The moth is pale brown and has one or two small black dots on the forewing (Anon. 1970). The apex of the wing is pointed and has a long fringe of hairs.

CONTROL

There is no information on the biological control agents of this pest. Fernando (1959) reported that the rice variety MAS 24 was resistant to this pest. The proper drying (less than ten percent moisture) and clean storage in insect proof containers are among the cultural control methods. Early harvesting is also a good preventive measure. The Department of Agriculture (Anon. 1981) recommends the spraying of storage bags with methyl pirimiphos (25 ml in ten L of water).

Other Arthropod Pests of Rice

Rice field Crab, Ceylonensis paratheplusa herbst

INTRODUCTION

The rice field crab is a nuisance in some paddy growing areas. In the 1950s sporadic outbreaks of this crustacean have been reported.

This belongs to Gecarinidae, a family of land crabs in the order Malacostraca.

DAMAGE

The damage done by this crustacean is mostly indirect because their furrows either allow direct draining of water from the "liyaddas" or weaken the levees resulting in breaches especially in hill districts. Some of these apparently nibble the bases of rice seedlings (Anon. 1960). This could be a problem especially in transplanted paddy. Their presence could be detected by the furrows which are usually vertical with a rim of mud at the opening.

CONTROL

The natural enemies viz. rats, birds of prey and paddy field heron, Ardeola gravis, help to keep the population of field crabs low. It is possible to trap the crabs by using earthenware

pots baited with fried brans moistened to form balls. The crabs were very susceptible to pesticides at the beginning but soon developed resistance (Fernando 1964) to some. The current recommendation by the Department of Agriculture (Anon. 1981) is to use any one of the following pesticides. Quinalphos 25 percent EC; Diazinon 40 percent EC; Fenthion 50 percent EC; BPMC 50 percent EC. Twenty eight ml (one fl. oz.) of the insecticide is to be mixed with 5-9 L of water and 56 ml (two ml fl. oz.) of the mixture should be poured into each furrow.

VI. Vertebrate pests of rice

14. Paddy field mole rat, Bandicoota bengalensis (Gray)

INTRODUCTION

The paddy field mole rat, Bandicoota bengalensis (Gray), has been a major pest of paddy grown in Sri Lanka in the 1950s. It continues to cause significant damage to rice crops (Wickremasinghe 1970). Up to ten percent of a crop may be lost as a result of this damage (Grist and Lever 1969) although no reliable crop loss estimates are available locally.

This mammalian pest of rice is a rodent characterised by the presence of ever-growing chiesel-like incisors, lack of canines and slender clavicles. It was earlier known either as Gunomys gracilis or G. kok (Gray) Wehring but since then has been recognized as a subspecies of Bandicoota bengalensis (Gray). It is commonly called the field mole rat, or lesser bandicoot (Anon. 1970).

DAMAGE

The plants are most susceptible when they are in "heen bandi" stage but also at the mature earhead stage (Anon. 1960). In other countries the rats reportedly feed on newly sown paddy as well as on young tillers (Anon. 1970).

The field mole rat can directly damage the crop by feeding on it. They feed on the basal part of the plants at "heen bandi". A single rat could destroy up to 100 stems per day. They also cut the mature earheads and either feed on the seeds or store these in their burrows. The eventually results in uneven ripening. This indirect damage is done by the extensive burrows in the levees which may breach and damage the crop.

The rat holes are an indication of their presence in the fields. The rats usually feed in patches, leaving at least a metre wide around. The scanty appearance of the centre of the centre of the field with the withering plants with their bases gnawed seen on closer observation is a symptom of rat damage.

LIFE HISTORY

The adult is a relatively large rodent reaching a length of 25 cm. Fernando et al. (1967) reported that B. bengalensis shows marked increase in reproductive activity after feeding on developing earheads. The female could become gravid before the first litter is fully weaned thus resulting in a second litter before harvest.

ECOLOGY

The usual colonizing habit of B. bengalensis is within the levees. The ramifying burrows are found from panicle initiation stage to early part of the post harvest season. They continue to stay within burrows tending their young after feeding on the developing earheads (Fernando et al. 1967). The rats are also known to feed upon the seeds of many other plants including the graminaceous weeds which

abound the rice fields.

CONTROL

The known natural enemies are the snakes which feed upon the young as well as adults. Some of the rapturous birds may occasionally feed upon them. The destruction of the natural enemies as a result of the use of insecticides is considered to be one of the reasons for the upsurge of rodent activity in the paddy fields (Fernando et al. 1967).

Earlier the use of the phosphides which released the quick acting fumigant phosphene was recommended. This method controlled rats for several years, when it was carried out systematically from panicle stage for two consecutive seasons (Fernando et al. 1967). However use of phosphide, unless done carefully, could be dangerous and needs closer technical supervision. Later the use of anticoagulants was recommended.

The baiting begins two weeks after transplanting and at the rate of 25 stations per ha to be increased later to 40 per ha at maximum tillering and stopped at harvest.

The current recommendation by the Department of Agriculture (Anon. 1981) is to use the Coumarin type rodenticide mixed with broken maize/sorghum at the rate of 1:19. This is used with 40 baiting locations/ha from transplanting to grain filling. Pre-baiting with the grains for 6-7 days is preferred where possible and baits have to be renewed every 3-4 days and should be prevented from getting wet.

VII. Integrated management of the insect pests of rice grown in Sri Lanka

The need for an integrated approach to manage the pest problems in agroecosystems is universally accepted now. Wickramasinghe (1978) highlighted the need for an integrated approach to manage the insect pests of rice in Sri Lanka. The concept of integrated pest management is based on the study of the agroecosystem concerned and regular monitoring of the pests to determine whether their populations approach levels known to cause economic losses in yield i.e. economic threshold levels. The current economic thresholds of some of the major insect pests of locally grown rice are shown in Table IV.

The use of improved rice varieties with proven resistance to major insect pests is an important first step in an integrated pest management programme. At present rice varieties viz. Bg 400-1 and Bg 276-5 with resistance to gallmidge are locally available. For those insects which are well adapted to the rice plant eg. brown planthopper, the use of resistant varieties cannot be a major control strategy because of the presence of several biotypes of this insect. Even in this case, 3-3 1/2 month varieties could be used, where possible, to avoid the pest damage which is mainly caused by the third generation of this insect. It is also imperative to select rice varieties which mature at about the same time. This combined with the avoidance of staggered planting in a given tract of rice could minimize the damage done by the paddy bug.

The preservation of the natural enemy complex of the insect pests of rice is another sound pest management tactic. The key natural enemies for each pest has to be identified (e.g. egg parasitoids of the rice stem borers) and any agronomic practice that is harmful to these natural enemies should be avoided. In particular, when the pesticides are applied any

effect detrimental to the natural enemies should be minimized. Indeed, where monitoring of the pest population reveals the presence of an adequate number of effective natural enemies pesticides should not be used.

For some of the pests with no other known effective control methods and under certain conditions where economic yield losses are imminent in the absence of an immediate remedy, the use of pesticides is the only tool available to manage the rice pests. However,

TABLE IV. ECONOMIC THRESHOLDS PRESENTLY ADAPTED FOR SOME INSECT PESTS OF RICE GROWN IN SRI LANKA(after Nair, 1982)

Pest	Field Condition	Threshold
Brown plant		Nursery or early
hopper	tillering	five/hill
	After maximum	6-10/hill
	tillering	
	If virus disease	one/tiller or
	is present	1-2/hill

Gallmidge Nursery or early tillering with galls	5-10 percent of centre tillers
Green Leaf disease One adult per hopper is present Otherwise	If virus hill 10/hill
Leaf-roller One damaged Leaf/hill	-
Paodybug -	Two bugs/m ²
Stem-borers Two moths or tillering masses/m ² Maximum tillering or panicle initia- tion two egg masses/m ² Maha-bundi or flowering masses/m ²	Nursery or early two egg Five percent dead hearts or two moths or two moths or two egg
Whorl maggot One damaged leaf/hill	-

there pesticides should always be applied on a need basis (i.e. where the sampling indicates an increasing pest population at the economic threshold level) and not on a calendar basis. The use of broad-spectrum insecticides should, wherever possible, be avoided; at least these should be used in an ecologically selective manner, viz. using granular formulation so that the non-target organisms are not affected; timing of the insecticide applications to coincide with the most vulnerable stage of the pest or the most susceptible stage of the crop; restricting the use of pesticides to some areas e.g. nurseries.

In addition to the above, several cultural and agronomic practices could be used with advantage to bring down the levels of pest populations.

Nurseries should be prepared, where possible, to obtain pest free planting material. These should be monitored to detect any incidence of pests and pesticides have to be used to keep the plants pest free. Only the healthy plants should be used and the infested ones should be destroyed.

During land preparation, deep ploughing of the field could destroy the pests that are known to inhabit the weeds and stubble. Plastering of the levees could help to reduce the field crab and mole rat populations.

Transplanting at the recommended spacing eg. 15 x 15 cm for Bg 34-6 in the case of brown plant hopper, could be used to reduce pest populations. However, transplanted rice could be under water stress and this might make the plant more susceptible to thrips; it is also known that transplanted rice is more susceptible to the whorl-maggot. Both stem borers and gall midge in endemic areas would be more widely dispersed under transplanted conditions (Wickramasinghe 1978).

Where possible, the water levels in the field should be adjusted to keep the pest populations low. Manipulation of the water level could be used effectively to control plant hoppers, stem fly and swarming caterpillar populations. Having sufficient water could help to minimize thrips attack on the seedlings. Mole crickets could be destroyed by flooding the fields. On the other hand, the rice caseworm could be controlled by draining the fields.

Weed control, either by slashing or by clean weeding will keep some pest populations eg. brown planthopper, gallmidge and paddybug, low. The weeds, particularly the graminaceous ones, need to be destroyed before flowering because paddy bug is known to thrive on these seeds prior to invading the rice fields.

Throughout the growing seasons, the farmer should be vigilant to detect indications of a build up of insect pests; count of egg masses, use of light traps eg. kerosine lamp to monitor insects and the actual counts as in the case of planthopper, could all be used for this purpose. At the same time attention has to be paid to the occurrence of the natural enemies of insect pests.

Harvesting and threshing should be done as soon as the crop is mature. This will minimize the damage done by birds and the incidence of storage insect pests which may infest the mature seeds in the field. Early harvesting will prevent the occurrence of volunteer plants which in turn can harbour insects between growing season.

Burning the stubble after the harvest will help to destroy the insect pests that occur in the base of the plant. Deep ploughing, where feasible, is an alternative to burning the stubble.

Either staggered or continuous cropping should be avoided. Having a crop-free period would help to minimize the carrying-over of the pests between seasons. Where possible, crop rotation should be resorted to and this again will help to keep the pest populations low.

Cleaning and proper drying (to less than ten percent moisture content) before storages will make the seeds unattractive to storage insect pests. The storage area and containers should be insect proof and kept clean and dry to discourage build-up of storage insect pest populations.

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