INSECT PESTS AND THEIR ARTHROPOD NATURAL ENEMIES IN A PADDY FIELD ECOSYSTEM

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ABSTRACT

A research project is currently in progress at Bathalagoda to assess the biological diversity in a paddy field ecosystem. This paper reports the insect pests of paddy and their arthropod predators and parasitoids present during the different phases of the paddy field and growth stages of the paddy plant and in relation to the use of biocides. Insects on vegetation were sampled using a sweep net, a quadrate, a Blower vac suction device and a light trap, while aquatic insects were sampled using a dipper.

A total of 43 species of pest insects belonging to 20 families and 7 orders, 94 species of arthropod predators belonging to 34 families and 8 orders together with 27 species of insect parasitoids in 12 families and 2 orders were recorded during four consecutive paddy cultivation cycles. The pest insects were dominated by Hemipteran bugs (18 species in 6 families) followed by Lepidopterans (7 species in 4 families), Orthopterans (6 species in 2 families), Coleopterans (6 species, 2 families), Dipterans (4 species, 4 families), Thysanopterans (1 species in 1 families) and Hymenopterans (1 species in 1 families). The predatory arthropods were dominated by 48 species of spiders in 11 families followed by Coleopterans (14 species in 6 families), Hemipterans (11 species in 8 families), Odonates (11 species in 3 families), Hymenopterans (5 species in 1 families), Orthopterans (3 species in 2 families), Dermapterans (1 species in 1 family) and Phasmids (1 species). The insect parasitoids collected consisted of Hymenopterans (25 species, 10 families) and Dipterans (2 species in 1 family). Sampling at 2 week intervals during a paddy cycle indicated that the vegetative stage of the plant harboured the most number of pests, while the grain ripening stage harboured more predators. Application of biocides affected both pests and predators and the latter more drastically.

INTRODUCTION

Paddy fields are unique in that they are a man-made semi-aquatic ecosystem maintained for the cultivation of rice. During a single paddy cultivation cycle, a paddy field goes through three major ecological phases; aquatic, semi-aquatic and a terrestrial dry phase. Thus a paddy field constitutes a heterogeneous habitat inhabited by a variety of organisms.

In Sri Lanka, about 780,000 ha. of land, at present is under paddy cultivation under rainfed or irrigated conditions (Panabokke, 1996). The long history of paddy cultivation in this country maintained a stable relationship between insect pests and their natural enemies, until the green revolution. Following the green revolution in the mid 1960s, and with the introduction of high yielding rice varieties that needed high fertiliser and biocide inputs, the natural balance that once existed in the paddy ecosystem was upset. With the advent of synthetic fertiliser and broad- spectrum biocides the natural phenomena that managed insect pests were affected. This resulted in the breeding of pest resistant rice varieties and use of chemical insecticides as primary agents of pest control.

However, the indiscriminate use of insecticides has led to the destruction of natural enemies and has enabled pests to develop resistance resulting in the resurgence of several primary and secondary pest species (Smith, 1994). These together with other disadvantages of pesticide use such as increased costs and environmental hazards have led agricultural scientists to explore alternative techniques to minimise pest impact, while simultaneously maintaining the integrity of the ecosystem. A comprehensive knowledge of the ecology of paddy field ecosystems is an important prerequisite to develop natural pest control strategies. However, information on ecology and diversity of the paddy field ecosystems in Sri Lanka is scanty. Much of the previous and present work related to rice field organisms of Sri Lanka focuses on paddy pests on which there is a wealth of information. Preliminary information on other faunal groups including soil and aquatic organisms of paddy fields has been gathered by Weerakoon (1957) , Weerakoon and Samarasinghe (1958) and Fernando (1977). A comprehensive study on the biodiversity and water quality in an irrigated paddy field ecosystem is now in progress at Bathalagoda.

This paper reports aspects of composition and abundance of rice insect pests and their arthropod natural enemies at the different growth stages of the paddy plant and the ecological phases of the paddy field, in relation to agrochemical use.

MATERIALS AND METHODS

The study was carried out in an irrigated paddy field (0.5 ha in extent) located at Bathalagoda (Intermediate zone), where sampling was carried out from November, 1995 to September, 1997. Four paddy cultivation cycles were studied. Standard agronomic practices of land preparation, transplanting of 21 day old seedlings at 25x25 cm spacing, with fertiliser applications at three stages; basal, maximum tillering and panicle initiation, and pesticides applications at the nursery stage and during pest outbreaks, was carried out at the study site.

Sampling

Four sampling devices; a circular quadrate, a sweep net, a Blower vac suction device and a light trap were used to sample insects and spiders on aerial/vegetation (rice plants and the weeds), while aquatic insects in the paddy field water were sampled using a dipper.

Quadrate sampling: A circular quadrate (65 cm diameter and area 0.3 m^2) made of plastic tubing, enclosing 7-10 hills was placed randomly at 10 sites in the field proper. All insects and spiders seen within the quadrate were collected and recorded. Using this method, paddy plants were sampled at fortnightly intervals.

Sweep net sampling: Using a standard sweep net, 100 sweeps were made discontinuously by walking along the field bunds to cover a distance of approximately 100 m. Insects and spiders caught in the sweep net were immobilised and brought into the laboratory. The paddy field weeds were sampled in this manner at fortnightly intervals.

Blower vac sampling: A plastic circular enclosure (50 cm diameter, 57 cm height) covering 6-8 hills was placed at 10 random sites in the field proper. All the animals within the enclosure were sucked up using the suction device and transferred into vials containing 70% alcohol. Sampling using this device was carried out at fortnightly intervals.

Light trap sampling: A nocturnal light trap (60 W bulb) was operated a few distance away from the field and the insects collected were examined at weekly intervals.

Aquatic dip sampling: Aquatic insects were sampled using a standard aluminium dipper (400 ml). Dip samples were collected from 10 random sites (3 dips per site) in the field proper and the samples were fixed in 5% formalin and brought into laboratory.

In the laboratory the samples were sorted and the insects and spiders present were identified and counted under a binocular microscope (10 x 9) and recorded on standard data sheets. The insects and spiders were provisionally identified up to the lowest possible taxon using keys available for South-East Asia (Barrion and Litsinger, 1994) and using reference collections at the Department of Zoology, University of Peradeniya and Rice Research and Development Institute at Bathalagoda. Certain identifications were confirmed by relevant authorities.

Data Analysis

Temporal patterns of the abundance of insect pests and their arthropod natural enemies were compared using mean numbers per sample. Temporal patterns of the species richness of the above groups were compared using S- the total number of species in each community per sampling day, as the index of species richness (Ludwig and Reynolds, 1988).

RESULTS AND DISCUSSION

Table I shows the mean number and the range of arthropod taxa collected using the different methods of sampling.

Table I. Arthropod species and the mean number of individuals collected per sampling day using the different methods

Sampling method	Sampling days	Pests		Predators		Parasitoids	
		spp.	Mean/day (Range)	spp.	Mean/day (Range)	spp.	Mean/day (Range)
Quadrates (3 cycles)	27	34	8.7 (2 - 27)	51	15.3 (3 - 38)	02	<1
Sweep net (2 cycles)	20	37	43.2 (1 - 252)	61	30.6 (4 - 113)	11	6.9 (1 - 20)
Blower Vac (1 cycle)	09	39	33.3 (6-77)	64	49.2 (7-137)	22	11.4 (2 - 29)
Light trap (2 cycles)	39	19	46.7 (1 - 142)	14	24.8 (1 - 272)	04	<1
Aquatic- dip samples (4 cycles)	24	03	<1	17	24.6 (8 - 41)	–	–

The results indicate that the Blower vac suction device collected the most number of species and individuals belonging to the three arthropod groups. Although the sweep net collections too contained a relatively large number of arthropod species and individuals, this method of sampling was used to sample the field bunds only and not the field proper, due to practical reasons. The light trap gathered many species of nocturnal pests and predators, but was biased towards insects attracted to light. The aquatic dip samples contained many aquatic predatory species, including bugs, beetles and dragonfly larvae.

A list of the taxonomic groups representing the insect pests and their arthropod predators and parasitoids, collected during four cultivation cycles, using the above sampling methods, is given in Table II.

Table II. Arthropod taxa collected during the study

TAXON	PESTS	PREDATORS	PARASITOIDS
Class - Insecta Lepidoptera 4 Fam, 7 spp.	4 Fam, 7 spp.		
Hemiptera 13 Fam, 29 spp.	6 Fam, 18 spp	8 Fam. 11 spp.	
Coleoptera 8 Fam., 20 spp.	2 Fam. , 6 spp.	6 Fam. ,14 spp.	
Orthoptera 5 Fam., 10 spp.	2 Fam., 6 spp.	3 Fam., 4 spp.	
Diptera 6 Fam., 6 spp.	4 Fam., 4 spp.		2 Fam., 2 spp.
Hymenoptera 11 Fam., 31 spp.	1 Fam., 1spp.	1 Fam., 5 spp.	10 Fam., 25 spp.
Thysanoptera 1 Fam., 1 spp.	1 Fam., 1 spp.		
Dermaptera 1 Fam., 1 spp.		1 Fam., 1 spp.	
Odonata 3 Fam., 10spp.		3 Fam., 10 spp.	
Phasmida 1 Fam., 1 spp.		1 Fam., 1 spp.	
Class - Arachnida Araneae 11 Fam., 48 spp.		11 Fam., 48 spp.	
Total Composition 64 Fam., 164 spp.	Families: 20 Species: 43	Families: 34 Species: 94	Families: 12 Species: 27

Fam: Families spp.: Species

SPECIES RICHNESS

A total of 43 species of insect pests belonging to 20 families, 94 species of arthropod predators belonging to 34 families, together with 27 species of insect parasitoids in 12 families were recorded. The arthropod natural enemies were richer in species in relation to the insect pests by a ratio of 3 :1. The species richness of insect pests and their natural enemies increased gradually with the maturity of the rice plant and decreased with the harvest of the crop and commencement of the fallow period (Figure 1).

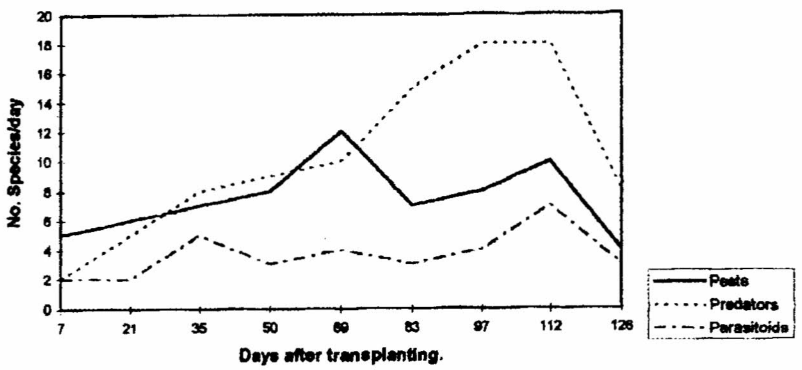


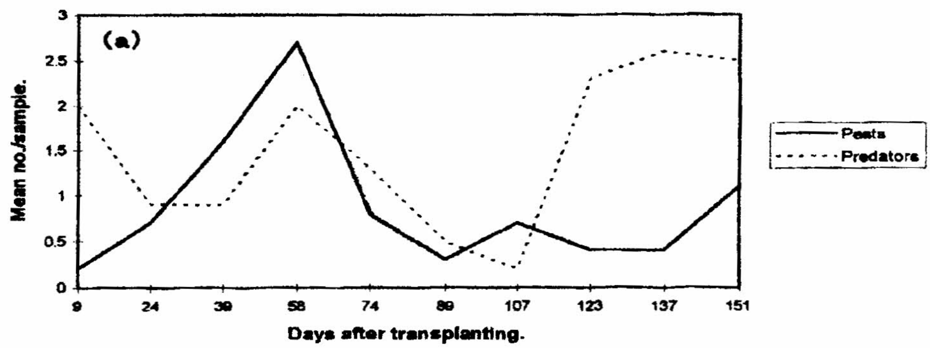
Fig. 1. Temporal pattern in species richness of insect pests and their arthropod predators and parasitoids (Yala cycle - April- Sept. '97)

Dominant Taxa

The pest insects were dominated by the sap sucking hemipterans that were represented by 18 species in 6 families. Among them, the plant hoppers (Homoptera: Delphacidae), leafhoppers (F. Cicadellidae) and the heteropteran bug (F. Alydidae), *Leptocorisa oratorius* were found to be the most common pest species. The predatory arthropods were dominated by numerous species of spiders (Araneae: 48 species in 11 families) followed by Coleopterans and Heteropterans. The spiders occupied different strata of the rice plant, and included both sedentary web-spinners (*Tetragnatha spp.* and *Araneus spp.)* and cursorial hunters (*Pardosa spp.* and *Oxyopes spp.)* . The common predatory Coleopterans included *Micraspis spp.* (F. Carabidae) *Ophionea nigrofasciata* (F.Carabidae) and *Paederus spp.* (F. Staphylinidae). The major Heteropteran predators were *Cyrtorhinus lividipennis* Reuter (F. Miridae) and *Microvelia douglasi* (F. Veliidae). These predatory taxa are known to be important polyphagous predators of sap sucking Delphacids and Cicadellids (Ooi and Shepard, 1994). This trend was clearly evident from the work of Heong , Aquino and Barrion (1991), where significant positive correlations were obtained for the abundance of Homopteran pests with spiders, *C.lividipennis* and Veliids. The insect parasitoids consisted largely of Hymenopterans which included 25 species in 12 families.

Abundance Patterns

Figure 2 (a and b) shows the abundance of insect pests and their arthropod predators in the field proper (quadrate samples) and bunds (sweep net samples) during the Maha cycle (October - March 1996/1997). Biocides were applied on different days after transplanting (DAT), on three occasions; namely at the nursery stage (insecticide), 19 days after transplanting (weedicide) and at 89 DAT (insecticide) . As indicated in Figure 2a, the pests in the field proper reached a peak level at 58 DAT, while their arthropod predators reached peak levels at 9, 58 and 137 DAT. A similar trend was observed for the pests and predators when the bunds were sampled (Figure 2b). The predators were found to be more drastically affected than the pest due to the application of weedicides and insecticides, at 19 and 89 DAT respectively. The abundance of predators greatly increased during the grain ripening stage of the rice plant which is accompanied by the terrestrial dry phase of the paddy field. This was due to the appearance of Carabid and Staphylinid beetles, ants and minute spiders (Theridids and Linyphiids) which colonised the soil cracks. Partial slashing of weeds in the bunds, at 81 DAT, reduced the abundance of pests drastically while predators were less affected and later became more abundant in the bunds (Figure 2b).



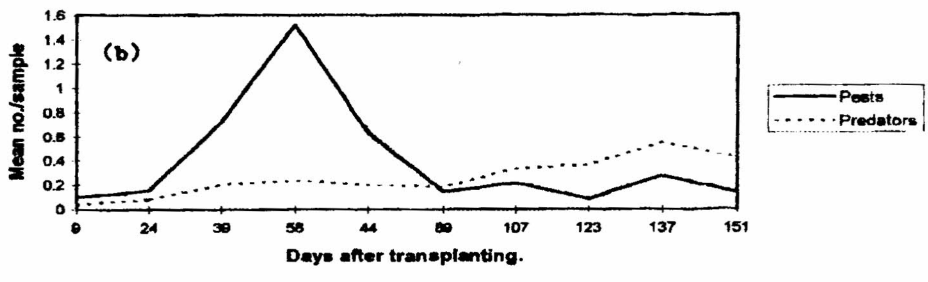


Fig: 2
Abundance of insect pests and their arthropod predators *during Maha cycle* (Oct 96' - Mar' 97, biocides applied at 03 stages).
(a)-Field proper (Quadrate samples)
(b)-Field bunds (Sweep net samples)

Figure 3 (a and b) shows the abundance of insect pests and their arthropod predators and parasitoids in the field proper (Blower vac samples) and bunds (sweep net samples), during the Yala cycle (April- September 1997) where insecticides were applied only during the nursery stage. The pests in the field proper (Figure 3a) reached a peak level at 69 DAT, while their arthropod predators and parasitoids reached peak levels at 35 DAT (vegetative stage) and at 112 DAT (ripening stage). Intense slashing of weeds in the bunds at 60 DAT drastically reduced the abundance of pests as well as their natural enemies (Figure 3b). As observed in the previous cycle, the predatory arthropods became more abundant towards the latter part of the cultivation cycle. Although an insecticide was applied only during the nursery stage of this cycle, a stable relationship has been maintained between insect pests and their arthropod natural enemies. Similar results had been obtained by Heong , Aquino and Barrion (1991) who studied the arthropod community structure of five rice fields in the Phillipines, where no pesticides had been used.

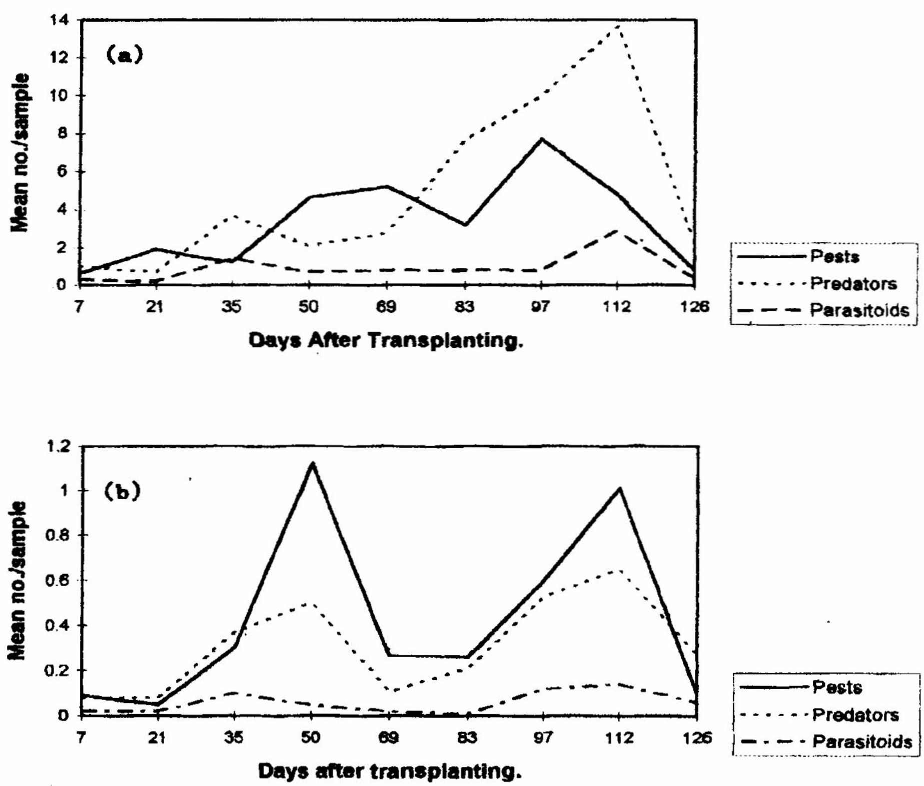


Fig. 3 Abundance of insect pests and their arthropod predators and parasitoids during Yala cycle (April-Sept'97, insecticides applied only to nursery)
(a) Field proper (Blower-vac sampling)
(b) Field bunds (Sweep net sampling)

CONCLUSIONS

The study on paddy field pests and their arthropod natural enemies, reflects the gradual fluctuations in their numbers in relation to the growth stage of the rice plant and the phase of the field, as well as the drastic fluctuatuations in relation to biocide use. The results infer that with minimal biocide applications, a stable relationship is maintained between the insect pests and their arthropod natural enemies. This could be further enhanced by the manipulation of weed communities through partial slashing of the weed cover on bunds and by the presence of weeds in the field proper during the fallow period. Such areas as well as other non -rice habitats in the vicinity (thickets and marshes) can sustain a reservoir of natural enemies during successive cultivation cycles. Natural biological control which maintains the diversity and the integrity of this man made ecosystem should be considered as a prime center for the application of safe and effective integrated pest management strategies. The importance of biodiversity in the dynamics and the management of insect pests of rice has been clearly highlighted by Way and Heong (1994).

ACKNOWLEDGEMENTS

The work reported in this publication forms a part of a larger study funded by the Natural Resources, Energy and Science Authority (NARESA) of Sri Lanka. The authors acknowledge Dr. L. Nugaliyadde of RRDI, Bathalagoda for providing facilities for field work and Dr.T.Hidaka, IPM Expert/JICA, for making available the Blower vac suction device for the study. Field assistance provided by Mr. Thushara Weerasinghe is greatly appreciated. Encouragement by Prof. F.P.Amerasinghe, Dept. of Zoology, University of Peradeniya, throughout this study is gratefully acknowledged.

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