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IMPACT OF PALAYAMANAN FIELDS ON CONSERVATION BIOLOGICAL CONTROL IN RICE-BASED CROPPING SYSTEM

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ABSTRACT

Palayamanan is a farming system that highlights the purposive integration of various farming components such as rice and other crops, livestock, fish and recycling so that nothing is wasted; everything in the farm is a precious resource ((PhilRice, 2005). A two-year study was conducted to determine the impact of Palayamanan field on conservation biological control that potentiates the possibility of Palayamanan field to serve as refuge to beneficial organisms which can provide sustainable Integrated Pest Management (IPM) in areas with large rice monoculture. Sampling of insect pests and beneficial organisms through different sampling devices and techniques and at varying crop growth stages in the Crop Protection Division (CPD) rice field, Palayamanan rice field and vegetable area of Palayamanan was conducted. Prey enrichment method was also used to evaluate the extent of mortality caused by parasitoids on eggs of the brown planthopper (BPH).

Results in 2011 dry and wet seasons showed that densities of rice leafhoppers and planthoppers were relatively low in Palayamanan rice field compared to those in rice monoculture in the Crop Protection Division (CPD) field. Dense populations of beneficial organisms and incidence of BPH egg parasitism were recorded during the dry season of 2012 and wet seasons of 2011 and 2012 in the Palayamanan rice field. Parasitism of BPH eggs was highest in the Palayamanan vegetable area which indicated that parasitoids of BPHcolonized this area to feed on honey and pollen on flowers of vegetable plants. The area serves as refuge for these beneficial organisms from the rice field.

Key words: conservation biological control, ecological engineering, integrated pest management, Palayamanan, rice-based farming systems

INTRODUCTION

Palayamanan, an integrated farming system (crops, livestock and aquaculture), could provide an ecological engineering (EE) approach to manage insect pests in rice-based farming systems. Ecological engineering approaches to managing insect pests on agricultural crops are new in Asia with little research in this area. Ecological engineering is a set of human activities that modifies the environment according to ecological principles. It is a useful conceptual framework for considering the practice of habitat manipulation for arthropod pest management. The main goal is the use of cultural techniques such as planting flowering plants as source of nectar and pollen for parasitoids to enhance biological control (Gurr et al., 2004). Recently, LEGATO (2011) described ecological engineering as the development of strategies to maximize ecosystem services through improving biodiversity to provide refuge, food and breeding places for parasitoids, predators and pollinators. The ecological engineering approach is applicable in most rice ecosystems in the Philippines and throughout tropical Asia. However, most farmers still apply preventive insecticide applications resulting in higher production costs and danger to human health and the environment. Initial results of our study (Arida and Punzal, 2006 unpublished) at the Central Experiment Station (CES) of the Philippine Rice Research Institute (PhilRice), on movement and colonization of beneficial organisms, showed that predators and parasitoids of rice stemborer and rice brown planthopper [*Nilaparvata lugens* (Stål)] eggs tend to colonize in non-rice habitats during fallow periods. Because there is crop diversity in Palayamanan, it is likely that the area serves as refuge for beneficial organisms. This provides a sustainable Integrated Pest Management (IPM) in surrounding areas with large rice monoculture by providing food and breeding places to predators and parasitoids. Sustainable IPM means fewer or less inputs by farmers and reduced hazards to humans and the environment. The objective of this study was to determine the impact of Palayamanan fields on conservation biological control and as an approach for a sustainable IPM program in rice-based farming systems.

An important principle in IPM is maximizing natural control (Heong et al., 1991). This is the utilization of naturally occurring beneficial organisms like predators, parasitoids and microorganisms in managing pests. There are rich communities of beneficial organisms (natural enemies) in the rice ecosystem in the absence of toxic pesticides, and a list of helpful insects, spiders and pathogens in the rice ecosystem was reported earlier (Shepard et al., 1987). Their importance in the regulation of major insect pests of rice has been demonstrated in numerous cases (Arida and Shepard, 1985). These organisms form the core of IPM program in rice (Settle et al., 1996) and results of most studies suggested that pest management for much of tropical rice must be based on natural control (utilizing beneficial organisms), rarely supplemented by insecticides (Way and Heong, 1994). It is now evident that in order to achieve sustainable pest management in rice and rice-based ecosystems, there is a need to enhance an important ecosystem service, the naturally occurring biological control (Settle et al., 1996). Conservation of beneficial organisms requires sufficient habitat biodiversity at the landscape level. Many of the beneficial organisms, like generalist predators, have long life cycles and have limited capacities to move long distances, while most pest species are winged and have high migratory capacities.

Results of studies through laboratory and field experiments showed that *Micraspis crocea* (Mulsant), *Anaxipha longipennis* (Serville), *Metioche vittaticolis* (Stål) and *Conocephalus longipennis* (Haan) are efficient predators of rice insect pests (Rubia et al., 1988). This group of generalist predators is commonly found in the rice field during the late vegetative and reproductive stages of crop growth. The combined effect of parasitoids and predators was reported to have significant impact on the mortalities of eggs of yellow stemborer, *Scirpophaga incertulas* (Walker) (Shepard and Arida, 1986) and rice leaf folders *Cnaphalocrocis patnalis* (Bradley) (=*Marasmia patnalis* Bradley) and *Cnaphalocrocis medinalis* (Guenée) (Arida and Shepard, 1990). Conservation of beneficial organisms is one of the foundations that led to the success in rice IPM in most parts of Asia. However, movement and colonization of beneficial organisms as affected by crop establishment method, cropping patterns and the role of non-rice habitats surrounding the rice field, is not well understood. The non-rice habitats around rice fields are suspected to serve as important refuge to natural enemies (especially generalist predators) during rice fallow period. These habitats must surely be recognized as potentially very important, particularly for off-season continuity of some natural enemies (Way and Heong, 1994). The movement and colonization of beneficial organisms are important factors that should be well-understood for the development of a sustainable IPM program in rice-based farming systems.

MATERIALS AND METHODS

The study was conducted at the CES, PhilRice, Maligaya, Science City of Muñoz, Nueva Ecija Province in Central Luzon, Philippines. The fields were set up in the Crop Protection Division (CPD) plot and in the Palayamanan field during 2011 and 2012 dry and wet seasons. The CPD rice field is 500 meters away from the Palayamanan field. Agronomic practices and other important farm operations were recorded in all the fields monitored. The devices used during field sampling of arthropods were Blower-vac suction machine (Arida and Heong, 1992), sweep net (SN), yellow sticky board trap (YSBT) and yellow pan trap (YPT). Arthropod sampling was conducted during the tillering, maximum tillering and milking stages of plant growth. The prey enrichment method (Parker, 1971) was used to determine levels of brown planthopper (BPH) egg parasitism in the Palayamanan rice field, CPD rice field and in the vegetable area of the Palayamanan. Thirty day-old potted plants of a BPH susceptible variety bearing eggs were exposed in each field to parasitoids in the field. Potted plants were collected after 72 hours and brought to the greenhouse for observation on the number of parasitoid emergence and BPH nymphs. The plants were later dissected in the laboratory to record the number of parasitoids and BPH eggs that failed to hatch. Percent egg parasitism was calculated based on total number of parasitoids and BPH nymphs recorded. The plot size of each field measured 1,000m^2.

RESULTS AND DISCUSSION

Population Density of Insect Pests and Their Natural Enemies

Movement and colonization of the different arthropod groups varied through seasons. During the 2011 dry season, population densities of parasitoids and predators outnumbered rice planthoppers and leafhoppers. However, during the wet season, rice planthoppers and leafhoppers (mainly *Nephotettix* spp.) rapidly increased in number as compared to beneficial organisms. The number of beneficial organisms was higher in the Palayamanan fields, except for parasitoids during the dry season (Fig. 1). In addition, the different arthropods were more abundant and more diverse in the Palayamanan rice field relative to those in the CPD rice monoculture field. Similar results were obtained during the 2012 dry and wet seasons when populations of rice hoppers were higher in plots far from, compared to those in rice fields inside the

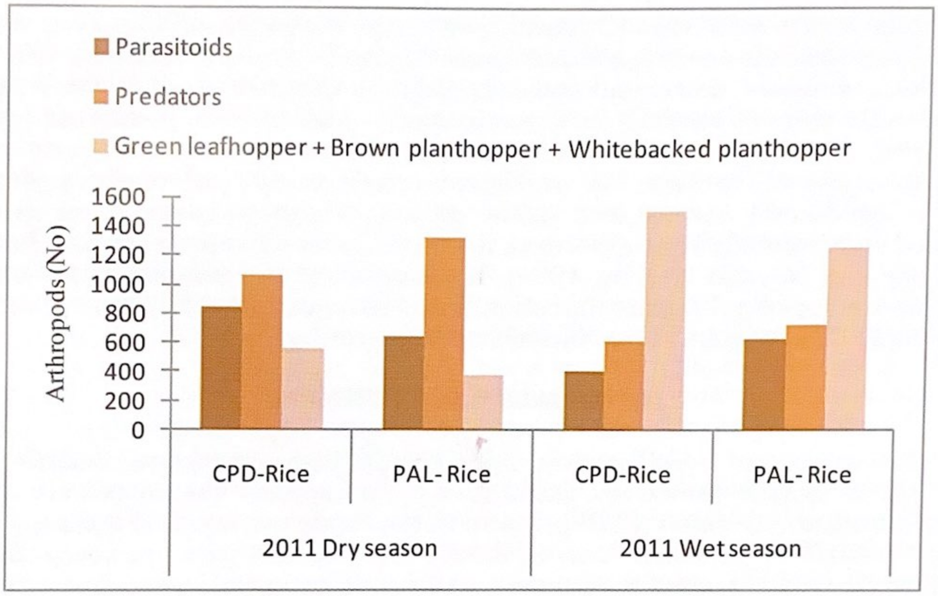

Figure 1. Population of important arthropods collected at different crop growth stages using sweep net and blow-vac suction machine. PhilRice CES. 2011 Dry season and Wet seasons. Legend: CPD - Crop Protection Division; Pal - Palayamanan.

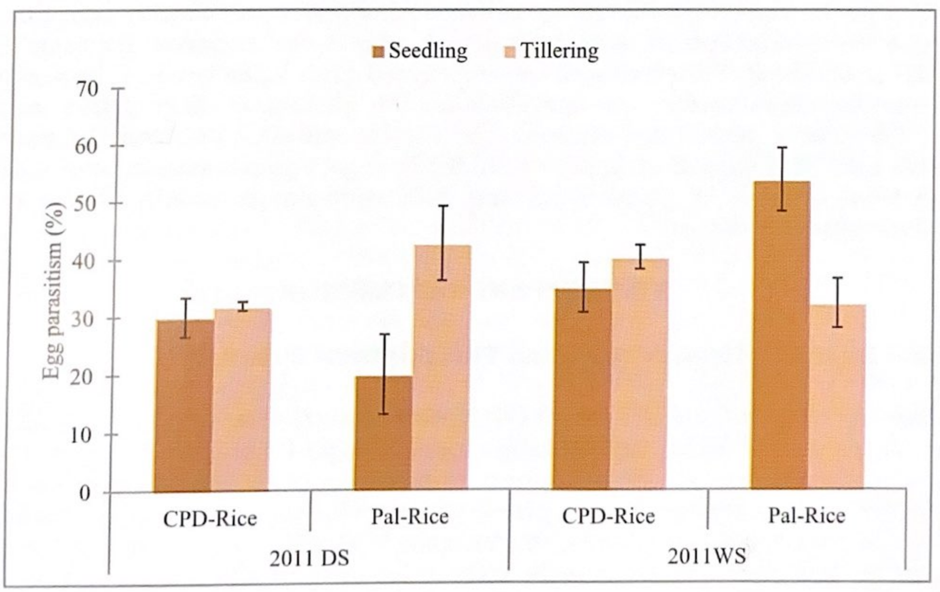

Figure 2. Percent parasitism (mean ± SD) of brown planthopper eggs recorded at seedling and tillering crop growth stages. CES, 2011 Dry and Wet seasons. Legend: CPD - Crop Protection Division; Pal - Palayamanan.

Palayamanan. Catches of predators using the different sampling devices showed that their populations were numerically higher in the rice monoculture than in Palayamanan area. However, the difference was not statistically significant (t-Test .05). This was likely due to the lower population densities of prey in the Palayamanan area as shown by the low number of planthoppers and leafhoppers (Fig. 3). Degree of damage due to stemborers was lower in the Palayamanan rice field compared to that in rice monoculture in both seasons. However, the level of damage was less than 2% whitehead in both fields. Most of the parasitoids were collected in the yellow board trap in both fields. However, peak population of parasitoids was collected during the booting stage in CPD rice, while it was at the tillering stage in the Palayamanan rice. This was attributed to the availability of sources of food in the Palayamanan rice, being close to an area with flowering plants like flowering weeds and vegetables. Their presence resulted in the early colonization of the parasitoids that could help suppress early population of insect pests in the rice field. The most common parasitoids were *Gonatocerus* sp., *Anagrus* sp., *Oligosita* sp., *Telenomus* sp., *Tetrastichus* sp., *Itoplectis* sp., *Cardiochiles* sp., *Temelucha* sp. and *Xanthopimpla* sp. Most of these species of parasitoids attack the eggs of rice hoppers, and stemborer and larvae of rice leaf folder. Higher number of predators were collected by sweep net, compared to blow-vac suction machine. Highest population densities of predators were found during the milking stage of the rice crop in both fields. The most common predators were several species of spiders, namely, *Pardosa pseudoannulata* (Bösenberg & Strand), *Tetragnatha maxillosa* Thorell, *Araneus inustus* (L. Koch.), *Callitrichia formosana* Oi [=*Atypena formosana* (Oi)] and *Oxyopes* sp. Other recorded predators were the coccinelid beetle *M. crocea*, long horned grasshopper *C. longipennis*, the mirid bug *Cyrtorhinus lividipennis* Reuter, and predatory crickets *A. longipennis and M. vittaticollis.* Damseflies and dragonflies were also recorded in high numbers in both fields during the study.

BPH Egg Parasitism by Prey Enrichment Method

The degree of parasitism of brown planthopper eggs was consistently higher in the Palayamanan rice field than in CPD rice monoculture field. The highest recorded parasitism of brown planthopper eggs was 48% in 2011 (Fig. 2) and more than 60% egg parasitism during the 2012 dry season (Fig. 4). Since both fields in the study were not sprayed with any insecticide, the differences in levels of BPH egg parasitism was not significant.

In general, results showed that movement and colonization of the different arthropod populations varied through seasons and across arthropod functional groups. During the 2011 dry and wet seasons, population densities of parasitoids and predators outnumbered those of rice planthoppers and leafhoppers. However, during the wet season, planthoppers rapidly increased and outnumbered parasitoids and predators. During the dry season, the (non-major pest) arthropod population was high and more diverse in the Palayamanan rice field relative to that in the CPD rice monoculture field. The combined level of parasitism of brown planthopper eggs during the seedling and tillering stages was recorded to be higher in Palayamanan rice field than in CPD rice monoculture field.

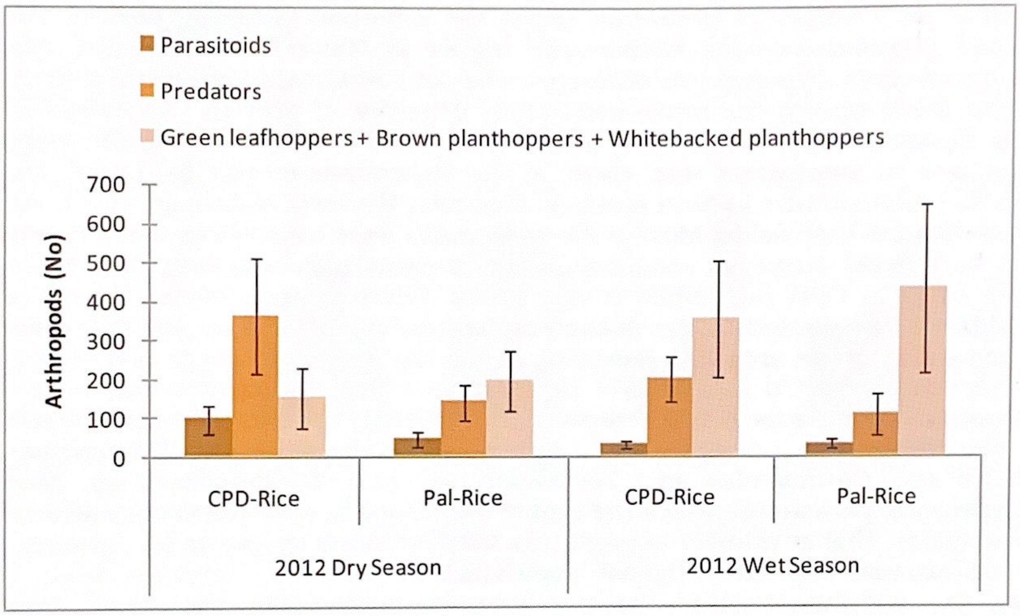

Figure 3. Populations (mean ± SD) of important arthropods in the two rice fields. CES, 2012 Dry and Wet seasons. Legend: CPD - Crop Protection Division; Pal - Palayamanan.

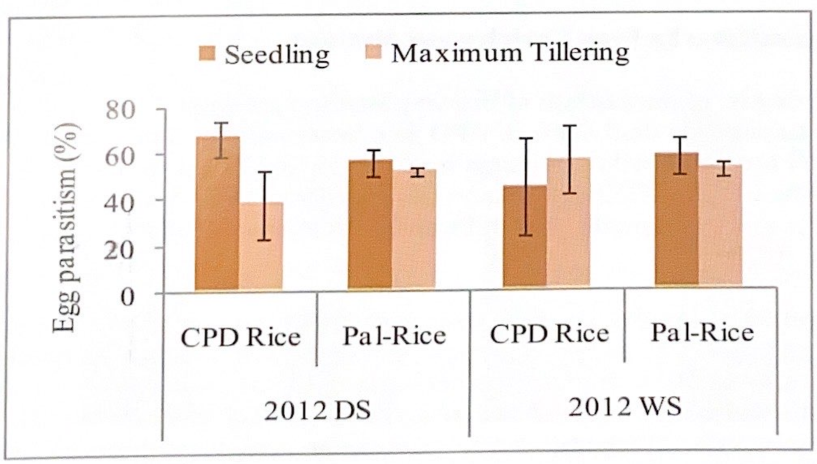

Figure 4. Parasitism (mean ± SD) of brown planthopper eggs recorded at different stages of crop growth. CES, 2012 Dry and Wet seasons. Legend: CPD - Crop Protection Division; Pal - Palayamanan.

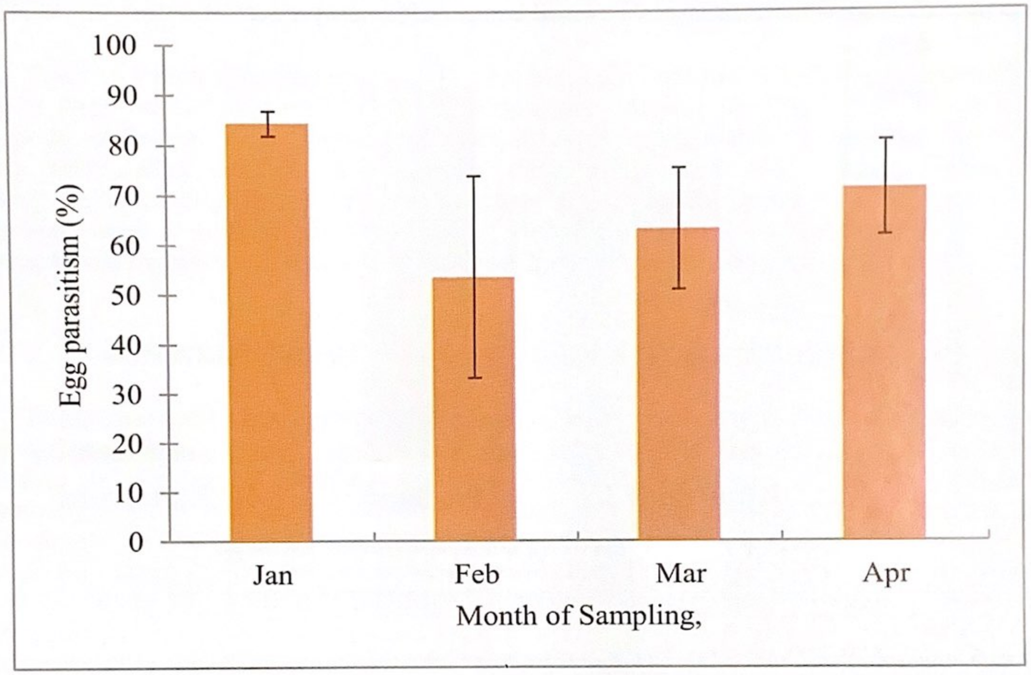

Figure 5. Parasitism (mean ± SD) of brown planthopper eggs exposed in the Palayamanan area planted with different kinds of vegetables. CES 2012 Dry season.

Damage due to stemborers was also low in both fields in both seasons and no significant diffrences were recorded. Recorded damage (% whiteheads) was less than 2% in both fields. Among the beneficial organisms recorded were parasitoids in the family Ichneumonidae (Hymenoptera), and predators under the families Miridae (Hemiptera), Salticidae (Araneae), Coccinellidae (Coleoptera), and other Araneae.*C. longipennis*, an important predator of stemborer eggs, was recorded in high numbers during the reproductive stage of the crop. Most of these beneficial organisms are known to be predators of rice hoppers that are commonly found in the field.

Parasitism of BPH Eggs in the Palayamanan Vegetable Area

The number of BPH eggs attacked by parasitoids in exposed potted plants bearing BPH eggs ranged from 55 to 85% monthly (Fig 5). The high incidence of BPH egg parasitism could be attributed to the presence of flowering plants in the Palayamanan where adult parasitoids feed on honey and nectar. The most common egg parasitoids collected were *Anagrus* sp. and *Gonatocerus* sp. This demonstrated that the Palayamanan vegetable field is an important place for the conservation of beneficial organisms in rice-based cropping systems.

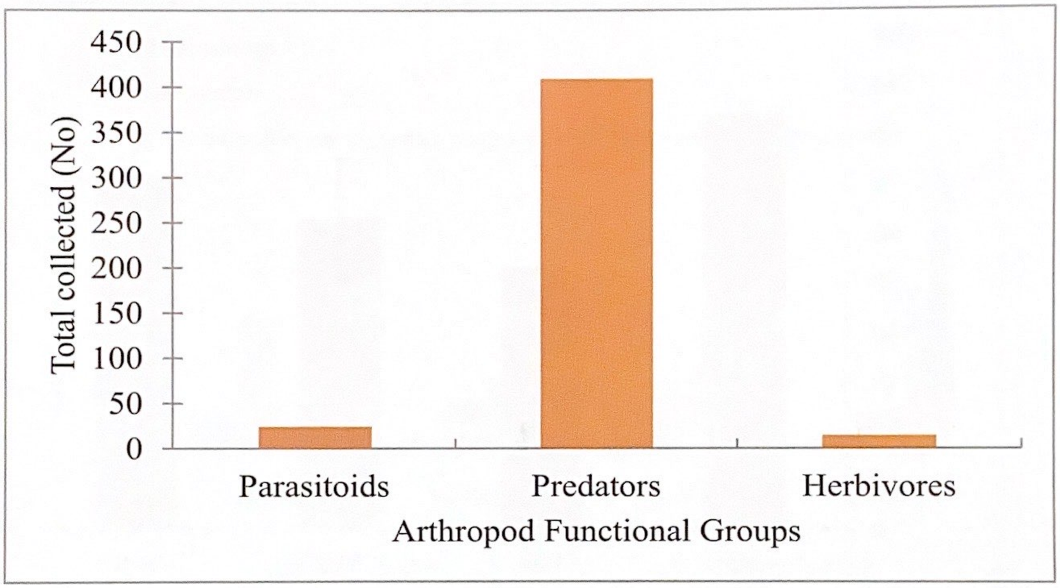

Figure 6. Important arthropod functional groups collected from the vegetable area of Palayamanan area using different sampling devices. CES, 2011 Wet season.

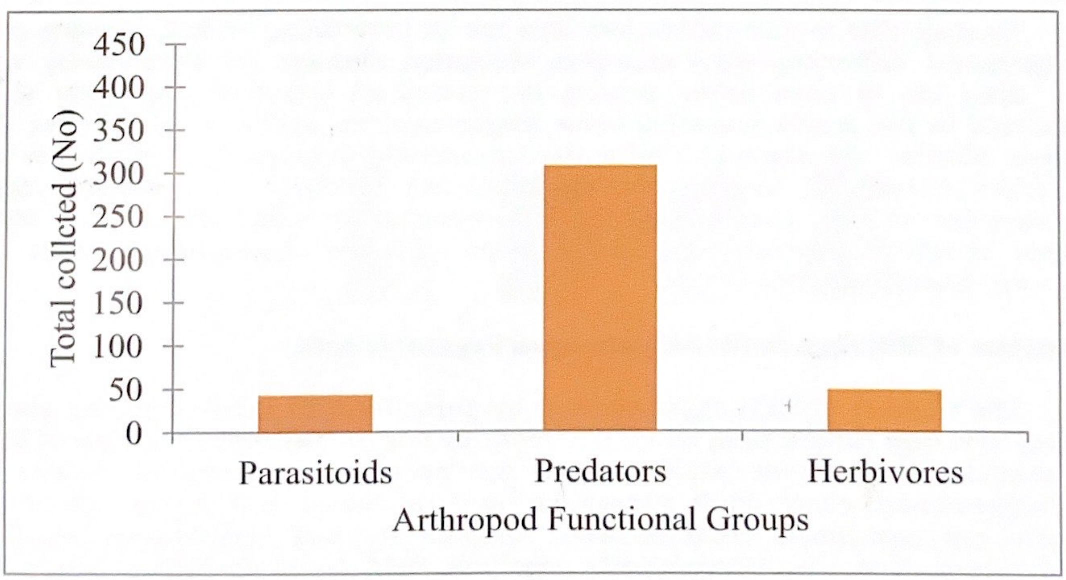

Figure 7. Important arthropod functional groups collected using different sampling devices in vegetable area of Palayamanan area. CES, 2012 Dry season.

Population Density of the Natural Enemies in the Palayamanan Vegetable Area

The numbers of arthropods collected through various sampling devices during the 2011 wet season and 2012 dry season are shown in Figs. 6-7. Most of the arthropods collected were predators, which were composed of several species of spiders, coccinellid beetles, damselflies, dragonflies and mirid bugs. Parasitoids collected were mostly those attacking eggs of rice leafhoppers and planthoppers, stemborers and other defoliators. Other beneficial species collected consisted of hymenopteran parasitoids that attack larvae of stemborers and rice leaf folders.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Palayamanan, an integrated farming system (crops, livestock and aquaculture), was investigated if it could provide an ideal area for the conservation of beneficial organisms in rice-based farming systems. Sampling of insect pests and beneficial organisms through different sampling devices and techniques and at varying crop growth stages in the Crop Protection Division (CPD) rice field, Palayamanan rice field and vegetable area of Palayamanan was conducted. Prey enrichment method was also used to evaluate the level of mortality caused by parasitoids on eggs of the brown planthopper.

Higher populations of beneficial organisms was recorded in the rice field in Palayamanan than in CPD rice field. This was attributed to the proximity of the field to the area with high vegetation diversity that includes several kinds of flowering vegetables and weeds that serve as sources of food and refugia for beneficial organisms. In addition, the Palayamanan vegetable field serves as refuge for beneficial organisms as shown by the number of predators and parasitoids recorded and percent parasitism of BPH eggs. Therefore, in addition to increasing the income of farmers from rice, other crops, livestock and other sources in the Palayamanan, the area provided a place for the conservation of beneficial organisms for a sustainable insect pest management in rice and rice-based ecosystems.

The vegetables planted in the Palayamanan provided food and shelter to beneficial organisms found in rice fields. In addition, other fields close to the area also benefited as shown by the number of beneficial organisms in the CPD rice field, which was 500 m away. Further studies should be conducted to determine which of the vegetables and flowering weeds in the area contributed most to the conservation of these beneficial organisms.

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