Research article

Diversity of Arthropod Natural Enemy Species in Intensive Monsoon Rice Growing Area, Nay Pyi Taw, Myanmar

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Abstract This study was conducted to investigate the species diversity of arthropod natural enemy species structure in intensive monsoon rice cultivation areas during 2018. The study site is Kyee Inn village, Pyinmana Township, Myanmar, and over 550 ha. Data collected from (300 m x 300 m) grid pattern and 56 grid points (G) using a D-Vac vacuum suction-machine. This study identified eight orders, 30 families, 57 genera, and 28 arthropod natural enemy species. The highest species richness occurred in Order Hymenoptera, followed by Order Coleoptera and Order Hemiptera. The diversity of natural enemy was varied widely with different grid points. The recorded equitability (evenness) was equally abundant in most grid points, but some have high single-species dominance. The highest number of *Cyrtorhinus lividipennis* (Order Hemiptera) found in G18, even though G18 displayed a medium diversity index and low equitability. The population of *Cyrtorhinus lividipennis* was higher than other species in all grid points. It may due to food sources are abundant during the growing season. Fortunately, we observed many natural enemy species, and it should conserve for natural balance to maintain the pest population.

Keywords natural enemy community, species diversity, equitability, intensive monsoon rice

INTRODUCTION

Rice (*Oryza* spp.) is the most important and widely cultivated crop globally. It is the staple crop for more than 60 percent of the world population. Rice is a dietary staple throughout all Myanmar. In Myanmar, paddy sown total area is 7.28 million hectares (monsoon and summer rice), and rice production is 28.32 million metric tons (MOAI, 2014). Arthropods are the most diverse and dominant constituent of biodiversity in terrestrial ecosystems. It is the largest animal phylum constituting about 85% of all known animals in the world (Odegaard, 2000).

In agricultural fields where pesticide use is minimized, crop production commonly depends on natural controls provided by a pest's natural enemies. These have an important role in regulating pest populations (Barbosa, 1998). The importance of natural enemies is particularly highlighted when a pest resurgence takes place (Dent, 2000). Indiscriminate use of agrochemicals, such as insecticides, harms these natural enemies and causes a loss in such beneficial organisms' biodiversity. Agro-biodiversity performs several ecosystem services (Dudely et al., 2005).

The biodiversity of beneficial natural enemies may be a pivotal resource to improve productivity and sustainability in agriculture (Schmitz, 2007). The arthropods, natural enemies of rice insect pests, include a wide range of predators and parasitoids such as carabid beetles, aquatic and terrestrial predatory bugs, and dragonflies. Parasitoids include many hymenopteran wasp species and some dipteran flies (Bambaradeniya and Amerasinghe, 2003). Beneficial insects provide regulating ecosystem services to agriculture such as pollination and the natural regulation of plant pests

(Getanjaly, 2015). Although most of the farmers are familiar with some rice insect pests in Myanmar, they don't know the important role of arthropod natural enemies and are not familiar absolutely. Thus, it is crucial to study the species richness of natural enemies in their habitat and conserve them to improve biological control.

OBJECTIVE

This research investigates the species richness and diversity of natural enemies on monsoon rice to support farmers' valuable information.

METHODOLOGY

Study Site

The study was conducted in 56 farmers' fields during the monsoon rice season at Kyee Inn village, Pyinmana Township, Nay Pyi Taw, which lies between 19°70'66"-19°72'62" N and 96°22'43"-96°25'73" E from July to November 2018. The sampled area is 2.4 Km wide by 3.9 Km long (550 ha). The Manawthukha rice variety is grown in the study fields using farmers' usual practices.

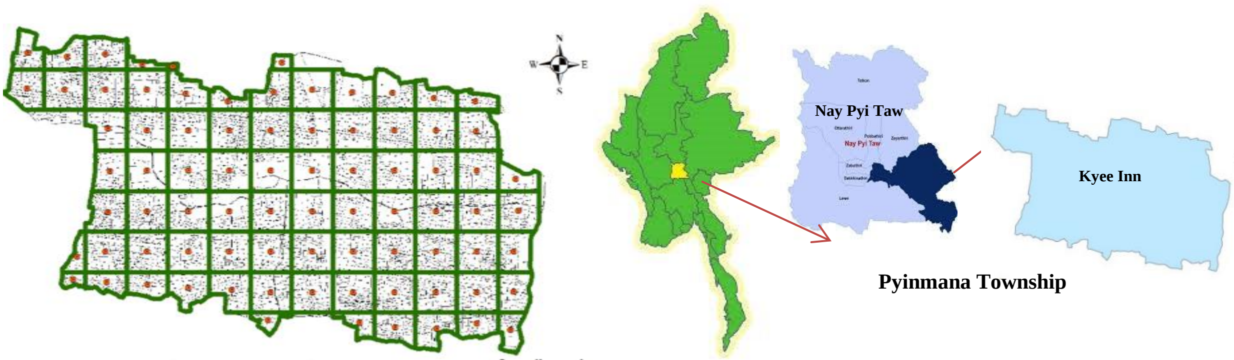


Fig. 1 Study areas at Kyee Inn Village, Pyinmana Township, Myanmar

Species Sampling

Arthropod natural enemies were collected on a 300 m by 300 m grid pattern, resulting in 56 grid points started at 20 days after sowing until harvest time. Five samples were taken at random from each rice field. All samples were collected near the center of the plot, at least 5m from the edge, to reduce edge effects using D- Vac Vacuum Insect Net - Hand Carry Model 122S (made by Rincon – Vitova Insectaries). The collection from 4-5 hills of rice plant after sowing, but only 2-3 hills after the rice plant reached maximum tillering at the fortnightly interval. Sampling duration was fixed at 1 to 2 min, depending on the rice's growth stage, and each sampling repeated three times. All samples inside the enclosure were collected and transferred to plastic bottles containing ethyl acetate with cotton wool, with species identification conducted in the laboratory for identification. All the collected samples were stored in 90% methylated spirit.

Identification of Species

Species identification was made in the JICA-ELB1 Laboratory, Department of Entomology and Zoology, Yezin Agricultural University. All the collected samples were stored in 90% methylated spirit. Morphospecies identification was made by using the textbooks of Insects of Australia (CSIRO, 1970), Manual of Nearctic Diptera, Volume 1, 2, 3 (McAlpine et al., 1981), and Pests of rice and their natural enemies in Peninsular Malaysia (Vreden and Ahmadzabidi, 1986) with OLYMPUS SZ 61 camera attached microscope (10x × 45x).

Data Analysis

The abundance and species richness of arthropod natural enemies were measured by the Shannon-Wiener function (Krebs, 1978). Shannon-Wiener function was used to measure the index of species diversity by the following formula:

$$H = -\sum_{i=1}^{S} (P_i)\,(log_2 P_i)$$

Where;
H = index of species diversity or information content of sample (bits/individual)
S = number of species
P_i = proportion of total sample belong to i^{th} species (Krebs, 1978)
More even or equitable distribution among species will also increase species diversity measured by the Shannon-Wiener function (Krebs, 1978). Equitability (evenness) measured in;

$$E = H/H_{max}$$

Where;
E = equitability (range 0 – 1)
H = observed species diversity
H_{max} = maximum species diversity = $log_2 S$

RESULTS AND DISCUSSION

Species Diversity and Abundance of Natural Enemy Species

There were eight orders, 30 families, 57 genera, 28 species identified in this study (Table 1). The observed arthropod orders are Araneae, Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Odonata, and Orthoptera. In 2014, 44 species from seven orders of natural enemy species were observed in Nyaungbingyisu, Nay Pyi Taw (Khin Ngu War Thant, 2016). May Thet Hlaing (2017) surveyed 118 species in Nyaungbingyisu (Pobbathiri Township), 62 species in Kyarku, Dekkhinathiri Township, and 105 species Zalaung, Oattarathiri Township, and 103 species in Yezin Agricultural University Campus. Hurlbert et al., (1989) found that the numbers of species and individuals and the diversities and evenness values were distinctly different according to habitat, type of field, and rice growth stage. The criterion used by (Rahayu et al., 2006) holds that species biodiversity is high when the value is greater than 3, a medium between 1 and 3, and low when less than 1. In our study, high diversity index occurs at 11 grid points and a medium at 44 grid points. The remaining grid points displayed a low level of diversity. Therefore, the overall species diversity index was considered in the medium criterion (Fig. 2.a, b).

Alatalo (1981) devised an index of species abundance (evenness or equitability) typically on a scale ranging from near 0, indicating low evenness or high single-species dominance, to 1, which means an equal abundance of all species, or maximum evenness. According to the results, the recorded equitability (evenness) of 19 grid points show a low index of evenness, while 37 grid points are approaching equal abundance (≥ 0.5) (Fig. 3.a, b). According to the results, the recorded equitability (evenness) of most grid points in the study area was nearly equally abundant, and some are high single-species dominant. The highest diversity index (3.44) is in G31 and the most evenness (0.82) in G32 (Fig. 2.b and Fig. 3.b).

On the other hand, the lowest diversity index (0.99) and least equitability (0.22) occurs in G46 (Fig 2.b and Fig 3.b). Therefore, the diversity of natural enemy species varied widely according to different grid points due to adjacent habitats, cropping patterns of the area, farmers' practices such as irrigation, pesticides, fertilizers, and pests.

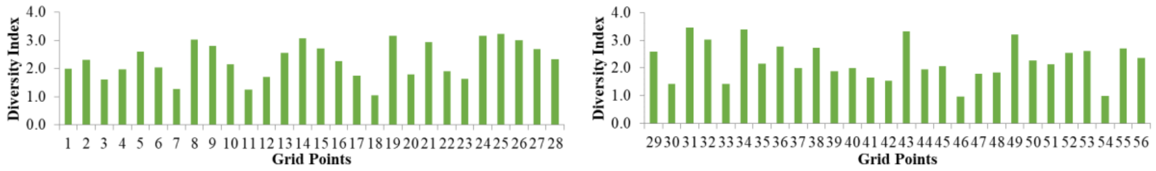
Table 1 Recorded natural enemy species from the study area, Kyee Inn Village, Pyinmana Township, 2018

No.	Order	Family	Genus	Species	Mean	SE (±)
1.	Araneae	Tetragnathidae	*Tetragnatha*	*maxillosa*	18.29	4.83
2.	Araneae	Araneidae	*Araneus*	sp.	8.60	3.46
3.	Araneae	Oxyopidae	*Oxyopes*	sp.	3.40	3.16
4.	Araneae	Linyphiidae	*Atypena*	*formosana*	3.20	3.20
5.	Araneae	Lycosidae	*Hippasa*	sp.	2.40	1.29
6.	Araneae	Lycosidae	*Trochosa*	sp.	0.67	0.49
7.	Araneae	Lycosidae	*Lycosa*	sp.	0.43	0.43
8.	Coleoptera	Staphylinidae	*Bledius*	*filipes*	12.40	12.40
9.	Coleoptera	Coccinellidae	*Micraspis*	*crocea*	1.57	1.41
10.	Coleoptera	Anthicidae	*Anthicus*	sp.	1.33	0.72
11.	Coleoptera	Staphylinidae	*Paederus*	*riparius*	1.33	0.88
12.	Coleoptera	Carabidae	*Bembidion*	sp.	1.00	1.00
13.	Coleoptera	Carabidae	*Casnoidea*	*indica*	0.71	0.47
14.	Coleoptera	Coccinellidae	*Harmonia*	*octomaculata*	0.50	0.50
15.	Coleoptera	Coccinellidae	*Menochilus*	*sexmaculatus*	0.40	0.24
16.	Coleoptera	Carabidae	*Clivina*	*fossor*	0.33	0.33
17.	Coleoptera	Carabidae	*Ophionea*	*nigrofasciata*	0.33	0.21
18.	Coleoptera	Carabidae	*Eucolliuris*	*fuscipennis*	0.20	0.20
19.	Coleoptera	Staphylinidae	*Lathrobium*	sp.	0.20	0.20
20.	Coleoptera	Carabidae	*Anillus*	sp.	0.17	0.17
21.	Coleoptera	Carabidae	*Anoplogenius*	sp.	0.17	0.17
22.	Coleoptera	Hydrophilidae	*Berosus*	sp.	0.14	0.14
23.	Coleoptera	Staphylinidae	*Stenus*	sp.	0.14	0.14
24.	Dermaptera	Anisolabididae	*Euborellia*	*annulipes*	1.00	1.00
25.	Dermaptera	Forficulidae	*Doru*	sp.	0.29	0.18
26.	Diptera	Pipunculidae	*Tornosvaryella*	*oryzaetora*	2.57	1.93
27.	Hemiptera	Miridae	*Cyrtorhinus*	*lividipennis*	199.20	133.46
28.	Hemiptera	Veliidae	*Microvelia*	*douglasi*	3.00	1.90
29.	Hemiptera	Pentatomidae	*Zicrona*	sp.	0.71	0.71
30.	Hemiptera	Reduviidae	*Polytoxus*	*fuscoviftatus*	0.50	0.50
31.	Hemiptera	Mesoveliidae	*Mesovelia*	*vittigera*	0.43	0.43
32.	Hemiptera	Reduviidae	*Peregrinator*	*biannulipes*	0.33	0.33
33.	Hemiptera	Reduviidae	*Rhynocoris*	sp.	0.20	0.20
34.	Hemiptera	Reduviidae	*Zelus*	sp.	0.14	0.14
35.	Hymenoptera	Dryinidae	*Aphelopus*	sp.	15.60	15.35
36.	Hymenoptera	Eulophidae	*Elasmus*	sp.	15.00	11.66
37.	Hymenoptera	Dryinidae	*Gonatopus*	*zealandicus*	7.14	4.72
38.	Hymenoptera	Braconidae	*Bracon*	sp.	7.00	5.05
39.	Hymenoptera	Pteromalidae	*Trichomalopsis*	sp.	4.43	2.36
40.	Hymenoptera	Formicidae	*Dorymyrmex*	sp.	4.40	4.15
41.	Hymenoptera	Eulophidae	*Tetrastichus*	sp.	3.67	2.08
42.	Hymenoptera	Formicidae	*Myrmecocystus*	*mexicanus*	3.00	3.00
43.	Hymenoptera	Eurytomidae	*Eurytoma*	sp.	1.17	1.17
44.	Hymenoptera	Diapriidae	*Trichopria*	*basalis*	1.00	0.82
45.	Hymenoptera	Platygastridae	*Macroteleia*	sp.	0.57	0.20
46.	Hymenoptera	Diapriidae	*Trichopria*	*drosophilae*	0.50	0.34
47.	Hymenoptera	Braconidae	*Phanerotoma*	sp.	0.40	0.40
48.	Hymenoptera	Formicidae	*Leptothorax*	sp.	0.33	0.33
49.	Hymenoptera	Formicidae	*Pheidole*	sp.	0.29	0.29
50.	Hymenoptera	Formicidae	*Lasius*	sp.	0.20	0.20
51.	Hymenoptera	Formicidae	*Manica*	sp.	0.20	0.20
52.	Hymenoptera	Halictidae			0.20	0.20
53.	Hymenoptera	Ichneumonidae	*Charops*	*brachypterum*	0.20	0.20
54.	Hymenoptera	Braconidae	*Spathius*	sp.	0.17	0.17
55.	Hymenoptera	Formicidae	*Solenopsis*	sp.	0.17	0.17
56.	Hymenoptera	Ichneumonidae	*Xanthopimpla*	*flavolineata*	0.17	0.17

Table 1 (contd.)

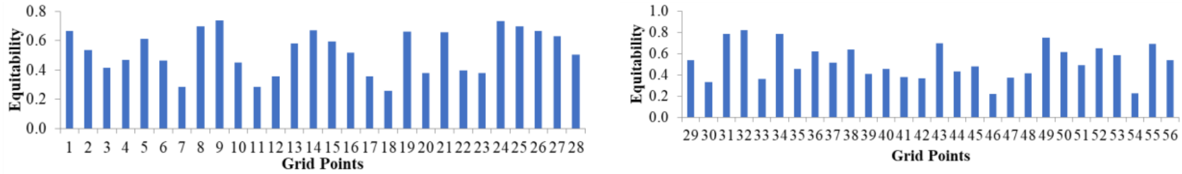
No.	Order	Family	Genus	Species	Mean	SE (±)
57.	Odonata	Coenagrionidae	*Agriocnemis*	*pygmaea*	5.50	5.50
58.	Odonata	Coenagrionidae	*Agriocnemis*	*femina*	3.29	2.65
59.	Orthoptera	Gryllidae	*Anaxipha*	*longipennis*	3.17	1.40
60.	Orthoptera	Gryllidae	*Metioche*	*vittaticollis*	0.17	0.17

These results were consistent with the finding of several authors have concluded that the abundance and diversity of predators and parasitoids within a field are closely related to the nature of the vegetation surrounding the field (Hopper, 1989). There is wide acceptance of the importance of vegetation surrounding the field margins as the reservoirs of crop pests' natural enemies.



(a) (b)

Fig. 2 Diversity index of natural enemies on rice during monsoon season in study area (a) grid points 1 to 28 (b) grid points 29 to 56



(a) (b)

Fig. 3 Equitability in distribution of natural enemies on rice during monsoon season in study area (a) grid points 1 to 28 (b) grid points 29 to 56

The highest species richness of natural enemies occurs in the Order Hymenoptera, which includes ten families, 20 genera and six species identified. The second highest species richness from Order Coleoptera consists of five families, 16 genera and nine identified species. Order Hemiptera has the third-highest species richness includes five families, eight genera and five identified species.

In Order Araneae, family Tetragnathidae, the highest mean number of *Tetragnatha maxillosa* (18.29 ± 4.83 individual) occurs at G10. *Tetragnatha maxillosa* is a spider species that is very active during the night and preys upon brown planthopper (*Nilaparvata lugens*), leafhopper (*Nephotetteix* sp.), and some other insect pest species (Betz and Tscharntke, 2017). Spiders are used as a biological control agent of rice pests instead of chemicals (Khan, 2013). In Coleoptera, the highest mean number of *Bledius filipes* (12.40 ± 12.40 individual) from the family Staphylinidae occurs in G16. It might feed on algae and detritus (Mark, 2006). The mean number of *Anthicus* sp. (1.33 ± 0.72 individual) from family Anthicidae occurs in G43. Ant-like flower beetles are mainly saprophagous, some species being predaceous or anthophilous (feeding on flowers) (Telnov, 2008). Insects are directly beneficial to humans by producing honey, silk, wax, and other products. Indirectly, they are important as pollinators of crops, natural enemies of pests, scavengers, and food for other creatures (Hoffmann and Frodsham, 1993). Under Order Dermaptera, the highest mean number of *Euborellia annulipes* (1.00 ± 1.00 individual) from the family Anisolabididae is observed in G56. In Order Diptera, the highest mean number of *Tornosvaryella oryzaetora* (2.57 ± 1.93 individual) from the family Pipunculidae is in G22. In Order Hemiptera, the highest mean number of *Cyrtorhinus lividipennis* (199.20 ± 133.46 individual) belongs to the family Miridae in G18. Predators are mainly from Order Heteroptera include *Cyrtorhinus lividipennis* (Miridae) and *Microvelia douglasi* (Veliidae), being the most abundant species (Heong et al., 1991).

Under Order Hymenoptera, the highest mean number of *Aphelopus* sp. (15.60 ± 15.35 individual) belongs to the family Dryinidae and occurs in G7. Noyes (2008) reported that several species of Eulophidae are important in biocontrol programs throughout the world. Hymenoptera is the most important insect order due to many insect species that are potential pollinators and parasitoids. Its ecological specialist species are also being used widely for habitat quality assessment (Trevis, 1996). In Order Odonata, the highest mean number of *Agriocnemis pygmaea* (5.50 ± 5.50 individual) belong to the family Coenagrionidae and occur at G43. In Order Orthoptera, the highest mean number of *Anaxipha longipennis* (3.17 ± 1.40 individual) belongs to the family Gryllidae from G29. Among them, the observed dominant rice natural enemy species is *Cyrtorhinus lividipennis* belonging to Order Hemiptera. This result was consistent with the finding of Heong et al., (1990), who stated that the mirid bug *Cyrtorhinus lividipennis* was found to predate on the eggs and nymphs of both leafhoppers and planthoppers, preferring mainly BPH eggs. The population density of *Cyrtorhinus lividipennis* increase in the abundance of the BPH and WBPH. Brown planthopper and Whiteback planthopper provide a broader range of food sources for an extended period during the growing season.

CONCLUSION

This study indicates that, arthropod natural enemy species diversity is medium in most of the grid points for the study period. Sample results yielded eight orders, 30 families, 57 genera, and 28 species of arthropod natural enemies in the study. According to the results, the observed species diversity index was considered in the medium criterion. The recorded equitability (evenness) of most grid points was nearly equally abundant, and some are high single-species dominance. The population of *Cyrtorhinus lividipennis* was higher than other species in all grid points. Therefore, the diversity of natural enemy species varied widely according to different grid points due to adjacent habitats, cropping patterns of the area, farmers' practices such as irrigation, pesticides, fertilizers, and pests. Therefore, it may be assumed that the Brown planthopper and Whiteback planthopper populations are abundant in this and previous year and found vegetation near the field in this study area. Brown planthopper and Whiteback planthopper provide a wider range of food sources for an extended period during the growing season. Some insects such as *Bledius filipes*, *Anthicus* sp., *Berosus* sp. from Order Coleoptera and *Manica* sp. from Order Hymenoptera are found as beneficial insects because of vegetation near the field. Proper identification and understanding of natural enemies, as well as beneficial insects, is the first step in implementing biological control and enhancing pollination activity. Therefore, Natural enemies and beneficial insects in rice fields play an important role in agriculture. Suppose we create a better environment for natural enemies by using non-chemical control methods at different rice growth stages. In that case, many natural enemies may suppress pest populations, which may benefit the farmers. The present study's findings may help provide valuable information for farmers to improve biological control techniques. Additionally, further studies should be undertaken to establish the abundance and different natural enemies present in this area.

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