Diversity of Insect Pest and Predator Species in Monsoon and Summer Rice Fields of Taungoo Environs, Myanmar

San San Oo1*, Khin Myat Hmwe1, Nyo Nyo Aung1, Aye Aye Su1, Khin Khin Soe1, Tin Lay Mon1, Khin Mar Lwin2, May Myat Thu3, Thin Thin Soe2, Myat Lwin Htwe2

1Zoology Department, University of Yangon, Yangon, Myanmar
2Zoology Department, Kyaing Tong University, Kyaing Tong, Myanmar
3Zoology Department, Dagon University, Yangon, Myanmar
Email: *sansanooyu@gmail.com

Abstract

Paddy fields are natural and artificial wetland ecosystems that supply rice for the people and provide the wildlife especially insect diversity of different functional aspects. A total of 71 insect species belonging to 40 families under eight orders were observed during the study period. Among the 71 insect species, 18 species of beetles, nine species of bugs, eight species of dragonfly, five species of butterflies, four species of leafhoppers, plant hoppers and moths, three borer and spiders, two crickets, one species of skippers, grass hopper, hispa, ant, weevil, hairy caterpillar, leaf roller, katydid, thrips, maggot and water boatmen were recorded in the study sites. Total of 41 species of pests, 18 species of predators and 12 species of beneficial species (they function as pollinating the flowering plants in the paddy field wetland ecosystem) were recorded in the study sites. In the monsoon season, the 41 species of pest species, 18 species of predator species and 12 species of beneficial species were recorded from monsoon rice field. According to Shannon Evenness value ($H'/S = -0.01256$), the data showed that the insect species recorded from the one habitat was not the similar to another. In summer paddy fields, 36 species of pest species, 16 species of predator species and 9 species of beneficial species were recorded. Total arthropod insect species were recorded 61 species from the dry rice fields. According to Shannon Evenness value ($H'/S = -0.000120$), the data showed that the insect species recorded from the one habitat was not the similar to another. Population growth and duration of life cycle of insects is mainly dominated by the temperature, the duration of life cycle is shorter in the high temperature than in the low temperature.
1. Introduction

The insects play an important role in the paddy field ecosystem functioning as pests and their counter action of predator insects. The insects are the highest diversity among about 90% or more of global living species exist on earth planet. Most insects are destructive, vectors and predators. Among them, the pest species destroyed the plant species especially agricultural crops.

Insects are responsible for two major forms of damage to crops. These include aphids, whiteflies and scaled insects. Rice (Oryza sativa) is the staple food of over half of the world’s population. Annual world rice production is approximately 460 million tons grown on more than 145 million hectare (ha). Over 90% of the world’s rice is grown in Asia. The government has accorded the highest priority on the rice sector because of its crucial role in food security, economic and political importance to the country [1].

Myanmar is an agricultural country, having over 8 million hectares of paddy land, all are growing monsoon rice and in some of these fields where there is irrigating by the dams, the summer rice are growing. Monsoon rice occupies the largest portion of the rice area 80% and summer rice is 20%. There are about 70 rice varieties have been collected in Myanmar (IRRI), all have particular characters possessing good and bad. Twenty-eight varieties of these are widely grown by farmers. Rice varieties vary in characteristics such as grain length, thickness, color and aroma. The incidents of the pests are dependent on the varieties of rice species [2].

Insects are major constraint to rice production. Most of the rice plant parts are vulnerable by the insects feeding throughout the growing season from the time of sowing to the harvesting. Both the mature and immature stages of insects injure rice plants by chewing leaf and root tissues, boring and tunneling into stems, or sucking fluid sap from stems and grains. The injury from feeding of insects leads to damage showing symptoms of skeletonized and defoliated leaves, dead hearts, whiteheads, stunted and wilted plants and unfilled or picky grains. Ultimately insect damage affects the plant physiology leading to reduction in measurable yield, utility or economic return [3]. As the insect pests cause damage to rice plants and are one of the reasons of total annual yield loss of rice, it is important to study the rice insect pests, especially their seasonal abundance and incidence, to evaluate the control measures. Notable works on the rice field insect pests are those of Alam [4] [5]. The entomologists of BRRI initiated systematic surveys of rice field insect pests throughout Bangladesh dividing Bangladesh into several agro-ecological zones and collected rice insect pests from dif-
ferent crops, seasons and growth stages of the rice plants [6]-[11].

The arthropod community in rice fields includes rice pests, their natural ene-
mies (predators and parasitoids) and other non-rice pest insects that inhabit or visit the vegetation. Over 800 species of arthropod community in rice ecosystem have been reported worldwide. The composition of the arthropod communities in the rice ecosystem is mainly influenced by the rice plants [10].

Irrigated rice fields are agronomically managed wetland ecosystems with a high degree of environmental heterogeneity operating on a short temporal scale, harbour a rich and varied fauna [11]. The fauna is dominated by micro (bacteria), meso (insects) and macro invertebrates (especially arthropods) inhabiting the soil, water and vegetation sub-habitats of the rice fields. The terrestrial arthropod community in rice fields consists mainly of insects and spiders (terrestrial invertebrates). The different communities of terrestrial arthropods in the rice field include rice pests, their natural enemies (predators and parasitoids) and other non-rice pest insects that inhabit or visit the vegetation which are collectively known as beneficial insects although spiders are under the class Insecta [6].

The cultivation of rice in Myanmar varies according to seasonal changes and the availability of water supply. It is grown extensively throughout the country in three seasons. There are mainly two rice growing seasons, dry season rice and monsoon rice. The dry and humid climate of Myanmar is conductive to the pro-
liferation of insect pests. The two rice crops grown under diverse ecological con-
tions are attacked throughout the growing periods by a number of insect pests of the 70 species of rice insect species recorded in Myanmar, 40 - 43 species have been found to be more damaging. The magnitude of damage varies in seasons, years and locations.

The climate condition of Taungoo environs was moist humid in monsoon season (a range of temperature of between 32.5˚C and 39˚C; that of humidity of 84.5 - 96 mm and rainfall with 103 cm) and hot dry in summer season (range of temperature between 22.5˚C and 33˚C; that of humidity of 41.5 - 63.0 mm) according to Department of Meteorology and Hydrology, Taungoo Township. The rice fields in Myanmar have diverse ecological conditions and presence of rice field insect pests is expected to be variable. But no attempt has been made to study the rice field insect pests in the Taungoo of Bago Region. The present study was aimed to prepare a list of rice field insect pests, their abundance and incidence on different stages of rice plants and in different growing seasons. This study was to access the abundance category, dominant index, Shannon index diversity of the paddy field ecosystem, and to compare the two ecosystems of monsoon and summer rice fields from Taungoo area of Myanmar.

2. Materials and Methods

2.1. Study Area and Study Period

Taungoo Township is located in upper part of Bago Region, eastern part of Mid-
dle Yoma Mountain range and close to lower boundary of Mandalay Region. It
is one high species diversity region. Soil types and weather condition is favorable condition for the growing paddy and other varieties of crops including peas and beans. Four paddy fields with an area of one hectare each from villages of Taungoo Township were selected as follows: Study site 1: around Nat Sin Gon village (N 18°59'31.40" and E 96°17'40.15"); Study site II: Along the road sides of Saba Oo village (N 18°56'23.04" and E 96°17'53.80"); Study site III: Nyaung kaing village (N 18°58'53.49" and E 96°15'54.77"); Study site IV: Htain Kone Pin village (N 18°57'17.87" and E 96°18'29.21"). The study period lasted from July, 2017 to May, 2018 (Figure 1).

2.2. Sample Collection

Five transect lines were designated evenly apart each other. Five sampling plots were located on each transect line. The insect specimens from all survey sites from both seasons of monsoon and summer were weekly collected during the time from 7:00 am to 5:00 pm. During the day time, insect net were also used by sweeping the net. The nocturnal insects were also collected using light traps, light traps were set out each corners of the paddy field and one was at the centre of the field. The collected specimens were soaked out into different insect groups as butterflies, beetles, etc. and they were identified down into species levels depending into taxonomic and morphological characters. Those species were categorized as pests, predators and beneficial groups depending on the infestation and predation during the observation time and the confirmed with the references.

2.3. Data Analysis

Two parameters to access the insect diversity and Relative abundance of the recorded species were calculated. The Shannon index and Evenness formula were used for the assessment of insect species diversity as follows (Stiling, 1999) [12].

Figure 1. Map of Taungoo environs showing the four study site.
Equation 1

\[ H' = \sum P_i \ln P_i \]

\( H' = \ln H/S \)

\[ P_i = \frac{\text{No. of insect species}}{\text{Total No. of all bird species}} \times 100 \]

where, \( \ln = \text{Log Normal}, \)
\( S = \text{Total numbers of species}. \)

Relative abundance of monthly occurrence was also calculated based on each species. The calculation was followed after Kumar and Sivaperuman (2005) [13].

Equation 2

\[ \text{Relative abundance} = \frac{\text{Total No. of particular species}}{\text{Total No. of all species}} \times 100 \]

The range of index value for the Abundance categories were determined as

- Rare Species = (0.1 - 2.0)
- Common = (6.1 - 8.0)
- Uncommon = (2.1 - 4.0)
- Abundant = (8.1 - above)
- Frequent = (4.1 - 6.0)

2.4. Identification

Identification was followed after Bingham (1905) [14], Bingham (1907) [15], Talbot (1939) [16], Kinyon (2004) [17].

3. Results and Discussion

The paddy field ecosystem was composted of a total of 71 insect species belonging to 40 families under nine orders with the three spider species. Among the 71 insect species, 18 species of beetles, nine species of bugs, eight species of dragonfly, five species of butterflies, four species of leafhoppers, plant hoppers and moths, three borer and spiders, two crickets, one species of skippers, grass hopper, hispa, ant, weevil, hairy caterpillar, leaf roller, katydid, thrips, maggots and water boatmen were recorded in the study sites (Table 1). Hence, those paddy fields were functioning ecosystem and healthy community and participate in every tropic level of these ecosystems. The insects are small animals functioning in various tropic levels. As a biodiversity conservation point of view, these paddy fields were sustainable ecosystem (Table 1 and Table 2).

The paddy field ecosystem was highly diverse insect species and spiders inhabiting 71 species representing 40 families in the monsoon rice plantation and 32 families in summer rice growing season (Table 2 and Figure 2). The species numbers under nine orders, Order Coleoptera, Diptera, Hemiptera, Orthoptera, Hymenoptera, Lepidoptera, Odonata, Thysamoptera and Arachnidae decreased in summer while it was more or less similar in both paddy growing seasons. The insect species numbers and its relative abundance was higher because they didn’t applied the pesticides for this research and the surrounding paddy fields usually control the pest insects as chemical control. This area is also not far to the deciduous forest of Middle Yoma mountain range.
Table 1. Collected insect species from the paddy fields of Taungoo township.

| ORDER/FAMILY   | No. | Scientific Name               | Common Name               | Habit  |
|----------------|-----|--------------------------------|---------------------------|--------|
| I. COLEOPTERA  |     |                                |                           |        |
| Anobiidae      | 1   | *Xestobium rufovillosum*       | Deathwatch beetle         | Pest   |
| Bostrichidae   | 2   | *Heterobostrychus aequalis*    | Oriental wood borer       | Beneficial |
| Carabidae      | 3   | *Harpalus rufigipes*           | Strawberry seed beetle    | Pest   |
| Coccinellidae  | 4   | *Micraspis discolor*           | Lady bug beetle           | Predator |
| Chrysomelidae  | 5   | *Aulocophora foveicollis*      | Red pumpkin beetle        | Pest   |
|                | 6   | *Aulocophora nigripennis*      | Leaf beetle               | Pest   |
|                | 7   | *Cassoda flaveola*             | Pale tortoise beetle      | Pest   |
|                | 8   | *Gastrophyraatrocyanea*        | Leaf bee                  | Pest   |
|                | 9   | *Hoplasaenideacapitata*        | Leaf beetle               | Pest   |
|                | 10  | *Monolepta australis*          | Red shouldered leaf beetle| Pest   |
|                | 11  | *Dicladispa armigera*          | Rice hispa                | Pest   |
| Curtulionidae  | 12  | *Sitophilus oryzae*            | Weevil                    | Pest   |
| Dermentidae    | 13  | *Anthrenus sp.*                | Carpet beetle             | Beneficial |
| Hydrophilidae  | 14  | *Hydrophilus triangularis*     | Water scavenger beetle    | Beneficial |
| Scaravaeidae   | 15  | *Heteronychus lioderes*        | Scarab beetle             | Pest   |
|                | 16  | *Phyllophaga sp.*              | May beetle                | Pest   |
| Staphylinidae  | 17  | *Paederus dermatis*            | Rove beetle               | Predator |
|                | 18  | *Xylodromus sp.*               | Rove beetle               | Predator |
| II. DIPTERA    |     |                                |                           |        |
| Ephydridae     | 19  | *Hydrellia philippina*         | Whorl maggot              | Pest   |
| III. HEMIPTER  |     |                                |                           |        |
| Alydidae       | 20  | *Stenocoris sp.*               | Rice bug                  | Pest   |
|                | 21  | *Leptocoris oratorius*         | Rice water bug            | Pest   |
| Cicadellidae   | 22  | *Cofana spectra*               | White leafhopper           | Pest   |
|                | 23  | *Empoasca fabae*               | Leafhopper                 | Pest   |
|                | 24  | *Nephotettix virescens*        | Leafhopper                 | Pest   |
|                | 25  | *Recilia dorsalis*             | Zigzag leafhopper white backed plant | Pest |
|                | 26  | *Nephotettix nilripictus*      | Hopper                    | Pest   |
| Corixidae      | 27  | *Corixa punctata*              | Water boatmen             | Beneficial |
| Delphacidae    | 28  | *Nilaparvata lugens*           | Brown plant hopper         | Pest   |
|                | 29  | *Delphacodes sp.*              | Brown plant hopper         | Pest   |
|                | 30  | *Sogatella furcifera*          | Plant hopper               | Pest   |
| Dictyopharidae | 31  | *Rhynochomitra microchirina*   | Green plant hopper         | Pest   |
| Miridae        | 32  | *Phytocoirs sp.*               | Bug                        | Beneficial |
| Lygaeidae      | 33  | *Scolopostethus pictus*        | Bug                        | Beneficial |
| Cydnidae       | 34  | *Pangaeus bilineatus*          | Burrowing bug              | Pest   |
| Pentatomoidae  | 35  | *Scotinopharaco arctica*       | Black bug                  | Pest   |
Continued

| Insect Order          | Family        | Genus                      | Species                        | Predator/Pest Status |
|-----------------------|---------------|----------------------------|--------------------------------|----------------------|
| Pyorrhocoroidae       | 36.           | Dysdercus cingulatus       | Red cotton bug Assassin        | Beneficial           |
| Reduviidae            | 37.           | Sirthanea dimidiate        | Dansel bug                     | Pest                 |
| Pentatomidae          | 38.           | Nezara viridula            | Green Stink Bug                | Pest                 |
| IV. HYMENOPTERA       |               |                            |                                |                      |
| Formicidae            | 39.           | Solenopsis geminate        | Alate queen ant                | Predator             |
| V. ORTHOPTERA         |               |                            |                                |                      |
| Acrididae             | 40.           | Oxya chinensis             | Rice grasshopper               | Pest                 |
| Grylidae              | 41.           | Gryllus texensis           | Field cricket                  | Pest                 |
| 42.                   | Anaxipha sp.  |                            | Field cricket                  | Predator             |
| Tettigoniidae         | 43.           | Conocephalus fasciatus     | Katydid                        | Predator             |
| V. LEPIDOPTERA        |               |                            |                                |                      |
| Crambidae             | 44.           | Scirpophaga praelata       | Moth                           | Pest                 |
| 45.                   | S. praelata    |                            | Stem borer                     | Pest                 |
| 46.                   | Marassmia exigua |                           | Rice leaf roller dark-headed   | Pest                 |
| 47.                   | Chilo polychrysus |                         | Striped borer                  | Pest                 |
| 48.                   | Chilo suppressalis |                        | Striped rice stem borer        | Pest                 |
| Erebidae              | 49.           | Cretonotos gangis          | Hairy caterpillar               | Pest                 |
| 50.                   | Laelia coenosa |                            | Moth                           | Pest                 |
| 51.                   | Orygia sp.    |                            | Tussock moth                   | Pest                 |
| Hersperiididae        | 52.           | Pelopidas mathias          | Rice skipper                   | Pest                 |
| Sphingidae            | 53.           | Theretra shendurneensis    | Moth                           | Pest                 |
| Nymphalidae           | 54.           | Danaus chrysippus          | Butterfly                      | Beneficial           |
| 55.                   | Junonia almanac |                           | Butterfly                      | Beneficial           |
| 56.                   | Junonia atlites |                          | Butterfly                      | Beneficial           |
| 57.                   | Melanteristida ismene |                       | Rice butterfly                 | Beneficial           |
| Pieridae              | 58.           | Eurema hecabe              | Butterfly                      | Beneficial           |
| 59.                   | Cnaphalocrocis medinalis |                  | Rice leaf folder               | Pest                 |
| VII. ODONATA          |               |                            |                                |                      |
| Libellulidae          | 60.           | Acisoma panorpoides        | Dragonfly                      | Predator             |
| 61.                   | Brachythemis contaminate |               | Dragonfly                      | Predator             |
| 62.                   | Crocothemis erythraea |                        | Dragonfly                      | Predator             |
| 63.                   | Diplacodes nebulosa  |                        | Dragonfly                      | Predator             |
| 64.                   | Diplacodes trivalis |                        | Dragonfly                      | Predator             |
| 65.                   | Neurothemistulla tallia |                        | Dragonfly                      | Predator             |
| 66.                   | Orthetrum sabina |                            | Dragonfly                      | Predator             |
| 67.                   | Trithemis kirbyi kirbyi |                        | Dragonfly                      | Predator             |
| VIII. THYSANOPTERA    |               |                            |                                |                      |
| Thripidae             | 68.           | Stenchaetothrips biformis  | Rice thrips                    | Pest                 |
| XI. ARANEAE           |               |                            |                                |                      |
| Araneidae             | 69.           | Argiope ctenulate          | Orb-weaver spider              | Predator             |
| Agelenidae            | 70.           | Tegenaria sp.              | Spider                         | Predator             |
| Nesticidae            | 71.           | Nesticus cellulanus        | Spider                         | Predator             |
Table 2. Species composition in different families of insects and spiders from the paddy fields.

| Sr. No. | Order       | Monsoon season | Summer season |
|---------|-------------|----------------|---------------|
|         | No. of Family | No. of Species | No. of Family | No. of Species |
| 1       | Coleoptera  | 10             | 9             | 15            |
| 2       | Diptera     | 1              | 1             | 1             |
| 3       | Hemiptera   | 13             | 8             | 15            |
| 4       | Hymenoptera | 1              | 0             | 0             |
| 5       | Orthoptera  | 3              | 2             | 2             |
| 6       | Lepidoptera | 7              | 7             | 16            |
| 7       | Odonata     | 1              | 1             | 8             |
| 8       | Thysanoptera| 1              | 1             | 1             |
| 9       | Aracnidae   | 3              | 3             | 3             |
| Total   | 40          | 71             | 32            | 61            |

Figure 2. Species composition of family level of arthropod insect species in Taungoo environs.

In the study area of paddy field ecosystem, as relative abundance categories, most species are rare species in both monsoon (55 species) and summer (51 species) the uncommon species category was 12 species in Monsoon rice and 16 species in summer rice fields. No common species was assessed in both seasons. Actually, the spiders are not included in the insect group, here we assessed the abundance categories included with the spider species. However, this paddy field was well and sustainable ecosystem (Table 3 and Figure 3).

As a agricultural aspect, In the study area of paddy field ecosystem, three growing seasons of the species number and individual numbers of insects and spiders were observed to varied in monsoon and summer rice growing seasons. During the monsoon season, the same numbers of species (69 species) was observed in
Table 3. Abundant category of recorded insect species in the study areas.

| Abundance category | No. of species Monsoon | No. of species in Summer |
|--------------------|------------------------|--------------------------|
| Rare               | 55                     | 51                       |
| Uncommon           | 12                     | 16                       |
| Common             | 0                      | 0                        |
| Frequent           | 2                      | 2                        |
| Abundance          | 1                      | 1                        |
| Total species      | 70                     | 70                       |

Figure 3. Abundant category of recorded insect species in the study areas.

Three growing stages although particular species was found to vary with growing stages (Table 4). Total number and individual numbers of each and all observed species were logically difference in the growing stages. The different types of pest insects, such as stem borers, leaf folders, grain eaters were found with respective growing stages. Consequently, insect predator relationships between pests and carnivorous species were found to commonly specific.

According to the assessment on the Shannan species diversity index, the value was distinctly higher in monsoon season ($H' = 4.52E-02$, with $E = 6.46E-04$) than in summer season ($H' = 2.5482$, with $E = 0.0364$) respectively (Table 5). The typical values are generally between 1.5 and 3.5 in most ecological studies, the index is rarely greater than 4 according to the internet assessed. Hence, the paddy fields in the Taungoo environs were highly diverse and still healthy ecosystem.

4. Conclusion

Paddy field ecosystem located in Taungoo environs is highly diverse and still healthy ecosystem inhabiting a total of 71 insect species belonging to 40 families under eight orders, including 18 species of beetles, nine species of bugs, eight species of dragonfly, five species of butterflies, four species of leafhoppers, plant hoppers and moths, three borer and spiders, two crickets, one species of skippers, grass hopper, hispa, ant, weevil, hairy caterpillar, leaf roller, katydid, thrips,
Table 4. Comparison of insect species in different growing stages and seasons.

| Growing stage | Monsoon Rice field | Rice field | Summer | Rice field |
|---------------|--------------------|------------|--------|------------|
|               | No. of species | No. of individuals | No. of species | No. of individuals |
| Plantation    | 69               | 7349        | 59     | 7166       |
| Flowering     | 69               | 17,517      | 63     | 10,116     |
| Ripening      | 69               | 11,113      | 61     | 3521       |
| Total numbers | 35,978           | 20,803      |

Table 5. Comparative diversity value of summer and Moon son of Taungoo environ.

| Scientific name       | Summer Rice | PhnP | Moon Son Rice | PhnP |
|-----------------------|-------------|------|---------------|------|
| 1. Xestobium rufovillosum | 55          | 0    | 400           | 1.310E−05 |
| 2. Heterobostrychus aequalis | 5           | −3.22E−05 | 136           | −1.390E−05 |
| 3. Harpalus rufipes    | 135         | −1.04E−02 | 171           | −1.681E−05 |
| 4. Micraspis discolor  | 110         | −7.39E−03 | 327           | −7.930E−06 |
| 5. Aulocophora foveicollis | 99         | −6.18E−03 | 214           | −1.836E−05 |
| 6. Aulocophora nigripennis | 92         | −5.48E−03 | 215           | −1.839E−05 |
| 7. Cassidaflaveola     | 175         | −1.58E−02 | 252           | −1.747E−05 |
| 8. Gastrophysa artiodactyla | 289     | −3.46E−02 | 986           | 7.571E−04 |
| 9. Hoplaeaideicapitata | 0           | 0.00E+00 | 361           | 3.020E−07 |
| 10. Monolepta australis | 0           | 0.00E+00 | 164           | −1.633E−05 |
| 11. Dicladispa armigera | 103        | −6.61E−03 | 238           | −1.807E−05 |
| 12. Caulophilus armiger | 11         | −1.33E−04 | 219           | −1.838E−05 |
| 13. Anthrenus sp.      | 0           | 0.00E+00 | 273           | −1.589E−05 |
| 14. Hydrophilus inquedula | 426       | −6.09E−02 | 1153          | 1.196E−03 |
| 15. Heteronychus spinodes | 320       | −4.03E−02 | 214           | −1.836E−05 |
| 16. Phylophaga sp.     | 215         | −2.19E−02 | 190           | −1.779E−05 |
| 17. Paederus dermatitis | 0          | 0.00E+00 | 487           | 5.552E−05 |
| 18. Xylodromus sp.     | 205         | −2.03E−02 | 183           | −1.749E−05 |
| 19. Stenocoris sp.     | 337         | −4.35E−02 | 390           | 9.518E−06 |
| 20. Leptocoris aequalis | 551        | −8.60E−02 | 219           | −1.838E−05 |
| 21. Cofoa spectra      | 187         | −1.76E−02 | 252           | −1.747E−05 |
| 22. Empoasca fabae     | 208         | −2.08E−02 | 301           | −1.246E−05 |
| 23. Nephotettix virescens | 15         | −2.31E−04 | 315           | −1.020E−05 |
| 24. Recilia dorsalis zigzag | 15       | −2.31E−04 | 35            | −2.205E−06 |
| 25. Corixapunctata     | 0           | 0.00E+00 | 325           | −8.323E−06 |
| 26. Rhynchomitramicro rhina | 395    | −5.47E−02 | 817           | 4.228E−04 |
| 27. Phytocoris sp.     | 144         | −1.15E−02 | 259           | −1.705E−05 |
| 28. Scolopostethus pictus | 2144      | −3.18E−02 | 1945          | 4.933E−03 |
| 29. Pangaebulbifera    | 15          | −2.31E−04 | 340           | −5.090E−06 |
| 30. Scotinophara aequalis | 12        | −1.52E−04 | 280           | −1.520E−05 |
| 31. Dysdercus cingulatus | 271       | −3.14E−02 | 307           | −1.158E−05 |
| 32. Sirithe neadimidiata | 445       | −6.46E−02 | 196           | −1.801E−05 |
### Continued

| Common Name                        | Abundance | Density | Shannon Weiner Index | Evenness |
|------------------------------------|-----------|---------|----------------------|----------|
| Nephotettix nigropictus            | 368       | 532     | $-4.94E-02$          | 8.549E−05|
| Nezara viridula                    | 0         | 155     | 0.00E+00             | −1.563E−05|
| Sogatella furcifera                | 82        | 193     | $-4.51E-03$          | −1.793E−05|
| Solenopsis geminata                | 0         | 539     | 0.00E+00             | 9.067E−05|
| Oxya chinensis                     | 245       | 245     | $-2.69E-02$          | −1.781E−05|
| Gryllustexensis                    | 350       | 211     | $-4.60E-02$          | −1.837E−05|
| Anaxiphasp                         | 0         | 1       | 0.00E+00             | −4.546E−09|
| Conocophalus fasciatus             | 245       | 280     | $-2.69E-02$          | −1.520E−05|
| Scirphlagas praelata               | 255       | 413     | $-2.86E-02$          | 1.818E−05|
| Scirphlagas intertulus             | 198       | 82      | $-1.93E-02$          | −7.683E−06|
| Marasmi exigua                     | 264       | 772     | $-3.01E-02$          | 3.518E−04|
| Creatonotogangis                   | 209       | 182     | $-2.10E-02$          | −1.743E−05|
| Laeliacoena                         | 149       | 137     | $-1.22E-02$          | −1.399E−05|
| Orygiasp                           | 424       | 350     | $-6.05E-02$          | −2.650E−06|
| Hydrelia philippina                | 243       | 77      | $-2.66E-02$          | −7.063E−06|
| Pelopidas mathias                  | 708       | 323     | $-1.16E-01$          | −8.705E−06|
| Theretras benduraneensis           | 590       | 383     | $-9.37E-02$          | 7.139E−06|
| Danaus chrysippus                  | 589       | 278     | $-9.35E-02$          | −1.540E−05|
| Junonia almana                     | 730       | 768     | $-1.20E-01$          | 3.454E−04|
| Junonia attilites                  | 435       | 232     | $-6.26E-02$          | −1.825E−05|
| Melanitis Ida ismene               | 336       | 144     | $-4.33E-02$          | −1.467E−05|
| Euremahence                         | 458       | 257     | $-6.72E-02$          | −1.714E−05|
| Chilo polychrysus                  | 1111      | 521     | $-1.73E-01$          | 7.759E−05|
| Chilo suppressalis                 | 1015      | 477     | $-1.64E-01$          | 4.957E−05|
| Cnaphalocrocis medinalis           | 255       | 123     | $-2.86E-02$          | −1.254E−05|
| Acisomapanoroides                  | 19        | 102     | $-3.52E-04$          | −1.013E−05|
| Brachythemis contaminata           | 85        | 69      | $-4.78E-03$          | −6.073E−06|
| Crocothemiserythraea               | 120       | 1985    | $-8.54E-03$          | 5.199E−03|
| Diplacodes nebulosa                | 372       | 1011    | $-5.02E-02$          | 8.157E−04|
| Diplacodes trivalis                | 446       | 797     | $-6.49E-02$          | 3.901E−04|
| Neurothemisullatia                 | 418       | 937     | $-5.93E-02$          | 6.491E−04|
| Orthetrum sabina                   | 808       | 819     | $-1.34E-01$          | 4.265E−04|
| Trithemis kirbykirbyi              | 287       | 1112    | $-3.42E-02$          | 1.078E−03|
| Argiopectenulata                   | 323       | 1574    | $-4.09E-02$          | 2.825E−03|
| Argiopectenulata                   | 449       | 1048    | $-6.54E-02$          | 9.070E−04|
| Tegenaria sp.                      | 463       | 1457    | $-6.83E-02$          | 2.294E−03|
| Nesticus cellulanus                | 332       | 935     | $-4.26E-02$          | 6.450E−04|
| Nilaparvata lugens                 | 170       | 776     | $-1.51E-02$          | 3.58E−04|
| Stenchaetothrips biformis          | 0         | 3517    | 0                    | 0.0217787407|
| **Total**                          | 21228     | 35,978  | $-2.50E+00$          | 0.04520|

**Shannon Weiner index value**  
\[ H' = \sum P_i \ln P_i \]

**Shannon Evenness index value**  
\[ E = H'/S \]

| Common Name                        | Abundance | Density | Shannon Weiner Index | Evenness |
|------------------------------------|-----------|---------|----------------------|----------|
| *Stenchaetothrips biformis*        | 0         | 3517    | 0                    | 0.0217787407|

**Shannon Weiner index value**  
\[ H' = \sum P_i \ln P_i \]

**Shannon Evenness index value**  
\[ E = H'/S \]

**Total** 21228 −2.50E+00 35,978 0.04520

Shannon Weiner index value  
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**Total** 21228 −2.50E+00 35,978 0.04520
maggot and water boatmen. 41 species of pest species, 18 species of predator species and 12 species of beneficial species were recorded from monsoon rice field. According to abundance category, rare species was highest (55 species) which follows uncommon species (12 species), frequent (2 species) and abundance (one species). It could be assumed as balance ecosystem. Among three growing stages, insect was collected the most in flowering stage and the lowest was in the plantation stage. In the comparison of monsoon and summer season, the most species and individual numbers were recorded in monsoon season.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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