Species Diversity of Arthropods in Intensive Rice-Ecosystem of Nay Pyi Taw Council Area

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Abstract

In order to measure the diversity of insect pests and natural enemies in riceecosystem, the present study was conducted in Nay Pyi Taw Council Area (Pobbathiri, Dekkhinathiri, Ottarathiri and Zeyyarthiri Townships) from August to December 2015. From this study, 118 species of 11 orders in Nyaungbingyisu (Pobbathiri Township), 62 species of 10 orders in Kyarku (Dekkhinathiri Township), 105 species of 9 orders in Zalaung (Ottarathiri Township) and 103 species of 11 orders in YAU Campus (Zeyarthiri Township) were observed during the study period. Shannon-Wiener function was used to measure the index of species diversity. According to the calculation of Shannon-Wiener function, species diversity and equitability were more abundant in Nyaungbingyisu and YAU Campus than the other two locations. For insect pest species, the highest population was observed in family Thripidae (*Stenchaetothrips biformis*) of order Thysanoptera in Kyarku among all locations. As for natural enemy species, the most abundant population was found in family Corixidae of order Hemiptera in Zalaung Village among the study areas.

Key words: Diversity, insect pests, natural enemies, different locations, rice ecosystem

Introduction

Rice is an essential crop provided as staple food for the populations of South and South East Asia. Myanmar is the world's seventh-largest rice producing country (Thiha 2014). Rice is the country's most important crop and is grown on over 8 million hectares, or more than half of its arable land (GRiSP 2013).Since rice is the major crop for both food security and economy of the country, yield is the most important constraint for increased rice production.

As one of the important factors, to improve higher rice productions; it is needed to protect the damage by insect pests. All of plant parts are attacked by insect pests at all growth stages (Mikkelsen and Datta 1991). Pest and disease problems are major constraints for increasing rice production (Dale 1994).

Almost 20 insects are considered as rice pests of economic importance that include stem borers, gall midge, grain-sucking bugs, defoliators (lepidopterans) and vectors like leafhoppers and planthoppers that cause direct damages and transmit various diseases (Pathak and Khan 1994). Most of rice plant parts are exposed to pest attack from period of sowing till harvest. Insects damage plant parts by chewing plant tissues, boring into stems or sucking fluid saps from stem and grains. Damages caused by insects disturb physiology of plants and result in lower crop yield (Nasiruddin and Roy 2012).

The natural arthropod enemies of rice insect pest include a wide range of predators and parasitoids that are important biological agents. Predators include a variety of spider, and insects such as carabid beetles, aquatic and terrestrial predatory bugs and dragonflies. Parasitoids include many species of hymenopteran wasps and a few dipteran flies (Bambaradeniya and Amerasinghe 2003). Predators and parasitoids can provide long-term regulation of pest species provided proper management practices are followed to make the environment conducive to furthering their abundance and efficiency in target agro-ecosystems (Opender and Dhaliwal 2003).

Uses of chemical inputs such as pesticides have increased agricultural production and productivity. Continuous use of chemical inputs such as pesticides have resulted in damage to the environment, caused human ill health, negatively impacted on agricultural production and reduced agricultural sustainability. Fauna and flora have been adversely affected. The decimation of beneficial agricultural predators of pests has led to the proliferation of several pests and diseases. This can occur because the pesticides have eliminated the beneficial predators of pests. As pesticide use increases, with frequent overuse and misuse, problems with insect pests, diseases and weeds also increase. For example, heavy insecticide applications often precede the outbreaks of rice brown planthopper. Therefore, it is imperative to find ways to protect them from extinction. An entomophage park is an interesting approach to conserving the biodiversity of natural enemies (Yasuda*et al*., 2001).

Determining the natural enemies and biodiversity of rice fields is the first step to success in biological control and IPPM (Integrated Production and Pest Management) programs (Ghahari *et al.,* 2008). Biodiversity plays significant role in maintaining a sustainable agronomic systems. In order to gain productive results, it is necessary to conserve diversity in agricultural systems. Practices like overuse of pesticides; monoculture, grazing, poor farming techniques etc. are posing threats to biodiversity associated with rice farming system (Asghar *et al.,* 2013).

Biodiversity refers to species richness and abundance, genetic variability between and within populations, ecosystems and community diversity. Species richness and diversity are essential ingredients of biodiversity (Ananthakrishnan 2010). Species diversity is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species' abundances. Species diversity is one component of the concept of biodiversity (Purvis and Hector 2000).

Recently, biodiversity in agricultural land has received growing attention because it plays a significant role in agro-ecosystem function (Dudley *et al*., 2005; Jarvis *et al*., 2007). For example, rice paddies are the habitats for diverse parasitoids and arthropod predators, which are important natural enemies of rice pests (Ueno 2010). Such beneficial organisms serve agro-ecosystem function regulating pest populations (Barbosa 1998; Hajek, 2004). In agricultural fields where pesticide use is minimized, crop production commonly depends on natural control provided by natural enemies because they have an important role in regulating pest populations (Barbosa 1998; Hajek 2004), highlighted when the resurgence of pests takes place (Pimentel 1997; Dent, 2000). Indiscriminate use of agro-chemicals such as insecticides harms natural enemies and causes the loss of biodiversity of such beneficial organisms.

Intensive farming practices encourage increased production without examining its long term consequences, such as degradation of soil, contamination of groundwater by agro-chemicals and declining of biodiversity at all levels (Abbas *et al*., 2013a). Hence, researchers all over the world are striving to conserve biodiversity as it stabilizes the balance among organisms of different functional groups (predator-prey) in an ecosystem (Power and Flecker 2000). Therefore, the main objective of the present study was to measure abundance of insect pests and their natural enemies in intensive rice-ecosystem of Nay Pyi Taw Council.

Materials and Methods

Study Area

Research was conducted in the selected rice fields at Nay Pyi Taw Council Area. Four locations were selected, one place from Nyaungbingyisu Village in Pobbathiri Township; one from Kyarku Village in Dekkhinathiri Township; one from Zalaung Village in Ottarathiri Township and one fromYAU Campus, Yezin Agricultural University in Zeyarthiri Township. Research was implemented from August to December 2015.

Collection of Arthropods

Light trap (Minnesota trap) with fluorescent tube was used to collect the nocturnal insect pests and natural enemies. Light trap was placed on the corner of each experimental field at weekly interval from the time of seedling to until harvest. One light trap was set up for each location and covered for 2 acres of rice field. The light was switched on at dark (6:00 pm - 6:00 am). The insects trapped in the jar were collected the next morning.

Yellow pan trap was mounted on stand at approximately the same height of vegetation or just below the canopy level. Yellow pan trap was used to attract small diurnal insects. This trapping method used small pans filled with a mixture of water and liquid detergent. The pans were placed on the ground in conspicuous places in the morning. At the end of the day, the water was strained through a fine sieve and the specimens were collected. A 500 ml bowl was used and cut holes near top of bowl and covered with mesh. The first bowl was placed in the vegetation bordering the crop/ on the bund at field edge and the others in a diagonal manner and at distances of Zero, then at 1m, 2m, 4m, 8m, 16m, etc. into the center of the paddy field. Each bowl was covered with a coarse wire mesh to prevent scavenging of insects by birds. The bowls were left out for 48 hrs at a time of weekly interval throughout the rice-growing season. An aquarium net or fine sieve was used to collect the insects and placed in >90% methylated spirit.

Pitfall traps was used for studies on surface dwellers such as spider, Collembola, centipedes, ants and beetles, especially Carabidae, The plastic containers (8 cm top width, 10 cm depth) sunken in the ground and half-filled with alcohol. A total of 24 pitfall traps/acre was set up for each location. The traps were arranged in square grids with 20m between traps to avoid the "digging in" effect. Opaque plastic lids were fixed to prevent birds and small animals from feeding on the insects. Each "sample" containing insects caught in one pitfall trap was collected during 7 days of continuous trapping.

Yellow sticky traps were used for population monitoring of many pests. Three yellow sticky traps per acre were mounted on wooden stakes to be just above the crop canopy with 5 meters distance between traps installed at the center of the rice field and near the rice bund, and collected after 24 hr. All types of data were recorded at weekly starting from seedling to harvesting.

Identification of Arthropods

The collected insect specimens were carried to the JICA-ELB1 Laboratory, Department of Entomology and Zoology, Yezin Agricultural University for further identification. All insects were identified to the families, subfamilies and genus level as far as possible by using keys outline from the textbooks of Insect of Australia (CSIRO 1970), Manual of Nearctic Diptera, Volume 1, 2, 3 (McAlpine 1981), Pest of rice and their natural enemies in Peninsular Malaysia (Vreden and Ahmadzabidi 1986), Friends of Rice Farmers (Shepard *et al.*, 1987) and Rice IPM Volume 1 and the internet websites (http://www. Kerbtier.de. Die Käferfauna Deutschlands von Christoph Benisch © 2007-2012).

Data Analysis

Shannon-Wiener function was used to measure the index of species diversity. Index of species diversity can be measured 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
s = number of species
P_i = proportion of total sample belonging to i^{th} species

A more even or equitable distribution among species will also increase species diversity measured by Shannon-Wiener function. Equitability can be measured in;

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

Where,

E = equitability

H = observed species diversity

H_{max} = maximum species diversity = $\log_2 S$

Results and Discussion

Species Diversity of Arthropod Species in Nyaungbingyisu, Kyarku, Zalaung and YAU Campus during August to December 2015

According to the Shannon-Wiener functions, 80 families from 12 orders such as Araneae, Blattodea, Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Odonata, Orthroptera and Thysanoptera were recorded in different (locations) fields during the rainy season (August to December).

Species index and equitability of arthropod species for four different locations were 4.90 and 0.71 in Nyaungbingyisu, 3.47and 0.58 in Kyarku, 3.48 and 0.52 in Zalaung and 4.80 and 0.72 in YAUCampus respectively (Figure 1). Therefore, species diversity and equitability were more abundant in Nyaungbingyisu and YAU Campus than other two locations.

The criteria used by Rahayu *et al.,* (2006) described that an organism species biodiversity is considered high when the value is > 3, medium when the value is between 1-3, and low when the value is < 1.Therefore, the diversity index of arthropods species in different four locations was included in high criterion. Smith and Wilson (1996) stated that evenness indices standardize abundance and range from near zero when most individuals belong to a few species, to close to 1, when species are nearly equally abundant.According to the results, we recorded that equitability (evenness) of Nyaungbingyisu and YAU Campus were nearly equally abundant among others.

In this study, 11 orders of arthropods species in Nyaungbingyisu and YAU Campus, 10 orders in Kyarku and 9 orders in Zalaung were recorded in the rice fields. The most abundant population of order in different four locations was found in order Hemiptera (945.1 ± 649.4 individual) in Zalaung. The second highest population was observed in order Coleoptera (668.1±351.2 individual) in YAU Campus respectively (Figure 2). Zin Mar and Phyoe Tha Zin (2013) found that Hemiptera was the most abundant order of the phytophagous guild while most of predators were from Coleoptera.

In Araneae, 2 families in Nyaungbingyisu and YAU Campus, 3 families in Kyarku and Zalaung Villages were observed from the study area (Figure 9). As for the pest species, one family from order Blattodea recorded from the selected locations. In Coleoptera, 12 different families from Nyaungbingyisu and Kyarku Villages, 19 families from Zalaung Village and 18 families from YAU Campus were observed (Figure 6, 10). Twelve families of order Diptera from Nyaungbingyisu, 5 families from Kyarku, 7 families from Zalaung and 6 families from YAU Campus were during the study period (Figure 7). Although 2 families of order Dermaptera from Nyaungbingyisu and 1 family from YAU Campus were found, however, this species was not observed in Kyarku and Zalaung Village (Figure 9). In Hemiptera, 17 different families from Nyaungbingyisu, 12 families from Kyarku, 18 different families from Zalaung and YAU Campus were recorded during the study period (Figure 5, 11).

The key order for the biodiversity conservation is the Hymenoptera; 5 families from Nyaungbingyisu, 3 families from Kyarku, 7 families from Zalaung and 6 families fromYAU Campus were observed. Other important pest order Lepidoptera; 3 families from Nyaungbingyisu and YAU Campus, 2 families from Kyarku and 3 families from Zalaung were found during the study period (Figure 4). One family from order Mantodea was observed in Nyaungbingyisu and YAU Campus as well as one family from order Thysanoptera was found in Kyarku Village (Figure 4, 13). Moreover, 3 families from order Odonata in Nyaungbingyisu, one family from Kyarku, Zalaung and YAU Campus were recorded (Figure 13). In Orthroptera, 5 families from Nyaungbingyisu and Zalaung Village and 4 families from Kyarku and YAU Campus were occurred (Figure 4, 13).

Species Diversity of Rice Insect Pests Species in Nyaungbingyisu, Kyarku, Zalaung and YAU Campus during August to December 2015

During the study period, 43 families from 7 ordersof insect pest species were recorded from four different locations. The diversity index of pest species in Nyaungbingyisu, Kyarku, Zalaung and YAU Campus were 3.7, 1.47, 3.61 and 4.33 respectively and equitability were 0.62, 0.3, 0.62 and 0.77 respectively (Figure 3).

In Nyaungbingyisu, one pest family of Blattodea, 7 families of Coleoptera, 12 families of Diptera, 11 families of Hemiptera, 3 families of Lepidoptera and Orthroptera were observed during the study period. Among these families, the family Delphacidae (*Nilaparvata lugens* and *Sogatella furcifera*) was found as the highest mean population (50.2 $\pm$ 17.6 individuals) (Figure 6) and then, the family Ceratopogonidae of order Diptera was occurred as the second highest population (49.2 $\pm$ 43.7 individuals) (Figure 7).

In Kyarku Village, 1 family of Blattodea, 5 families of Coleoptera, Diptera and Hemiptera, 2 families of Lepidoptera, 3 families of Orthroptera and 1 family of Thysanoptera were recorded during the study period. Among the families, the highest population was observed in family Thripidae (*Stenchaetothrips biformis*) (133.3 $\pm$ 108.4 indiviudals) of order Thysanoptera (Figure 4). Like Nyaungbingyisu, the second highest population was found in family Ceratopogonidae (13.6 $\pm$ 9 individuals) of order Diptera (Figure 7).

Similarly, 1 family of Blattodea, 9 families of Coleoptera, 7 families of Diptera, 11 families of Hemiptera, 4 families of Lepidoptera and 3 families of Orthroptera were observed in Zalaung Village. In this study area, family Cicadellidae (*Nephotettix*spp.) was the highest population (104 ± 65.3 individuals) among the recorded families and family Delphacidae was recorded as the second highest population (59.3 ± 25 individuals) (Figure 6).

In YAU Campus, 1 family of Blattodea, 9 families of Coleoptera, 6 families of Diptera, 11 families of Hemiptera, 3 families of Lepidoptera and 2 families of Orthroptera were found during the study period. Among these families, family Tenebrionidae of order Coleoptera was recorded as the highest population (48 ± 33.9 individuals) and the second highest population was family Scarabaeidae (32 ± 13.4 individuals) of order Coleoptera (Figure 5).

Moreover, Figure 4showed that the mean population number of different insect pest families of order Blattodea, Lepidoptera, Orthroptera and Thysanoptera from four different locations. Among these pest families, family Acrididae in Zalaung (6.8 ± 3.6 individuals) was the highest population followed by family Thripidae. Under order Coleoptera, the most abundant population was observed in family Tenebrionidae in YAU Campus (48 ± 33.9 individuals) and the family Scarabaeidae was observed as the second most abundant species (Figure 5).

In case of Order Hemiptera, 12 different families such as Alydidae, Cicadellidae, Cydnidae, Delphacidae, Dictyopharidae, Fulgoridae, Hydrometridae, Lygaeidae, Membracidae, Naucorinae, Pentatomidae and Tingidae were observed in the study areas (Figure 6). Among them, family Cicadellidae was the most abundant family (104 ± 65.3 individuals) and followed by the family Delphacidae (59.3 ± 25 individuals) in Zalaung Village.

Mean population number of different insect pest families of order Diptera from four different locations was shown in Figure 7. Family Ceratopogonidae was observed as the most abundant family (49.2 ± 43.7 individual) in Nyaungbingyisu and Dolichopodidaewas the second most abundant family (24.6 ± 10.4 individual) in Zalaung Village.

According to the present study, family Thripidae (*Stenchaetothrips biformis*) in Kyarku Village was observed as the highest population not only in all locations but also among families. Planthopper (*Nilaparvata lugens*) and leafhopper (*Nephotettix* spp.) was the highest mean population in Nyaungbingyisu and Zalaung Village. Lee and Park (2004) stated that the pest species were mainly Homoptera and dominated by Delphacidae (*Nilaparvata* *lugens* Stal and *Sogatella furcifera* Horvath) and Cicadellidae (*Nephotettix viresense*) which involved more than 81 percent of pest abundance.

Moreover, *Austracris guttulos* and *Bermiella acuta* of family Acrididae were found as the second most abundant family in Zalaung Village. Similar result was found in observation of Phyoe Tha Zin (2013). Therefore, family Acrididae (short-horned grasshoppers) may become as a serious pest in Myanmar at a time. Akhtar *et al.*, (2012) pointed out grasshoppers may be regarded as serious pests of rice as they can cause severe damages to rice crop at advance stages of growth.

Species Diversity of Natural Enemy Species of Rice Pests in Nyaungbingyisu, Kyarku, Zalaung and YAU Campus during August to December 2015

According to the calculating of Shannon-Wiener function, 37 different families from 7 orders of natural enemy species were observed in four different locations. As for the natural enemy species, the diversity index of Nyaungbingyisu, Kyarku, Zalaung and YAU Campus were 4.11, 3.90, 2.36 and 3.85 and equitability were 0.71, 0.77, 0.42 and 0.67, respectively (Figure 8).

In Nyaungbingyisu, 2 families of order Araneae, Dermaptera and Orthroptera, 5 different families of Coleoptera and Hymenoptera, 6 families of Hemiptera, 3 families of Odonata and 1 family of Mantodea were recorded during the study period. Among the families, the family Vellidae (*Microvelia* sp.) of order Hemiptera was observed as the highest population (65.9 $\pm$ 28.1 individuals) and the second highest population (38.4 $\pm$ 13.5 individuals) was found in family Corixidae of order Hemiptera (Figure 11).

During the study period, 3 families of order Araneae, 7 families of Coleoptera and Hemiptera, 3 families of Hymenoptera, 1 family of Orthroptera and Odonata were found in Kyarku Village. In this location, the highest population was occurred in family Formicidae of order Hymenoptera (17.9 $\pm$ 11.1 individuals) (Figure 12) and then, the second most abundant family was Carabidae of order Coleoptera (17.2 $\pm$ 8.2 individuals).

In Zalaung Village, 3 families of Araneae, 10 families of Coleoptera, 7 families of Hemiptera and Hymenoptera, 2 families of Orthroptera, 1 family of Mantodea and Odonata were observed. Among these families, the most abundant population was recorded in family Corixidae of order Hemiptera (678.2 $\pm$ 512.7 individuals) and the second highest population was found in family Vellidae (*Microvelia* sp.) of order Hemiptera (50.4 $\pm$ 20.6 individuals) during the study period (Figure 11).

In YAU Campus, 2 families of order Araneae, 9 families of Coleoptera, 1 family of Dermamptera, Odonata and Mantodea, 7 families of Hemiptera, 6 families of Hymenoptera and 2 families of Orthroptera were found in study area. Among them, family Hydrophilidae (*Laccobius* sp.) of order Coleoptera was the highest population (147.1 $\pm$ 68.6 individuals). As well as Kyarku Village, the second highest population was observed in family Carabidae of order Coleoptera (142 $\pm$ 52.9 individuals) in this location (Figure 10).

Figure 9 showed the families of order Araneae such as Lycosidae, Linyphiidae, Oxyopidae, Tetragnathidae and Dermaptera such as Anisolabididae and Forficulidae. In order Araneae, family Lycosidae was the most abundant family in YAU Campus among them. Although the family Anisolabididae was found in only Nyaungbingyisu, family Forficulidae was observed in Nyaungbingyisu and YAU Campus during the study period.

Order Coleoptera observed 10 different natural enemy families such as Carabidae, Cicindelidae, Coccinellidae, Dytiscidae, Gyrinidae, Hydrophilidae, Lampyridae, Noteridae, Pselaphidae and Staphylinidae were recorded in the study areas. Among these families, the highest population was found in family Hydrophilidae (147.1 $\pm$ 68.6 individuals) and followed by family Carabidae (142 $\pm$ 52.9 individuals) in YAU Campus (Figure 10). Under Hemiptera, 8 families were occurred in different four locations and family Corixidae in Zalaung Village (678.2 $\pm$ 512.7 individuals) was the most abundant family among other locations (Figure 11).

In Hymenoptera, 7 families such as Braconidae, Diaprridae, Formicidae, Halictidae, Ichenumonidae, Sphecidae and Vespidae were recorded in these study areas. Among them, family Formicidae was observed as the most abundant family (Figure 12). Another important natural enemy order Odonata was found 3 families such as Coenagrionidae, Gomphidae and Libellulidae and family Mantidae was occurred as the only one family of order Mantodea. Moreover, 2 different families of order Orthroptera such as Gryllidae and Tettigoniidae were observed in four different locations (Figure 13).

According to the Shannon-Wiener function analysis, the highest population was observed in family Corixidae in Zalaung Village among the study areas and the second highest population was found in family Hydrophilidae in YAU Campus in all locations.

Conclusion

The diversity was high in intensive rice growing area of Nay Pyi Taw Council. According to Shannon-Wiener function, 80 families from 12 Orders of insect species were observed from four different locations during the study period. The diversity index and equitability was highest in Nyaungbingyisu among others. This may be due to the cropping pattern such as rotation with pulses, surrounded by the vegetables farms and less use of chemical pesticides.

However, the diversity index and equitability of pest species was highest in YAU Campus. As for the natural enemy species, the diversity index and equitability of natural enemy species were highest in Nyaungbingyisu. Present study revealed that the species diversity of natural enemy species was high and insect pest species was low in Nyaungbingyisu and Kyarku Village. In contrast, in Zalaung and YAU Campus, species diversity of natural enemy species was low and pest species was high. The reasons for abundance of pest species may be due to the continuous rice cultivation (monoculture) and use of agro-chemicals without manipulation of weed cover.

Therefore, we need to conserve the better environment for natural enemies by reducing the usage of chemical pesticides, providing the shelter and food for natural enemies such as ecological engineering of the agricultural environment. By practicing these, the increasing number of natural enemy species may suppress the pest populations which may bring benefits to the farmers. Based on the above findings, we can conclude that the natural enemy population was significantly regulating the pest population, there seem to be balance in nature.

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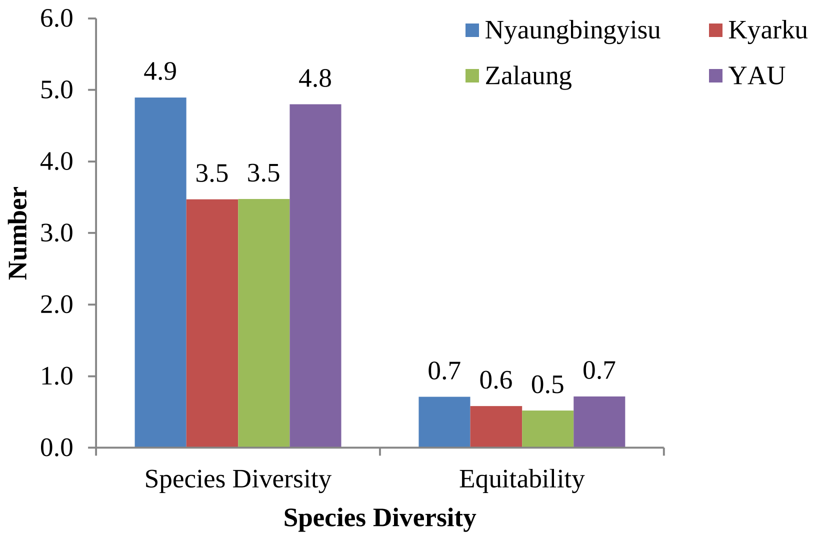

Figure 1. Species index and equitability of rice insect species in Nyaungbingyisu, Kyarku, Zalaung Village and YAU

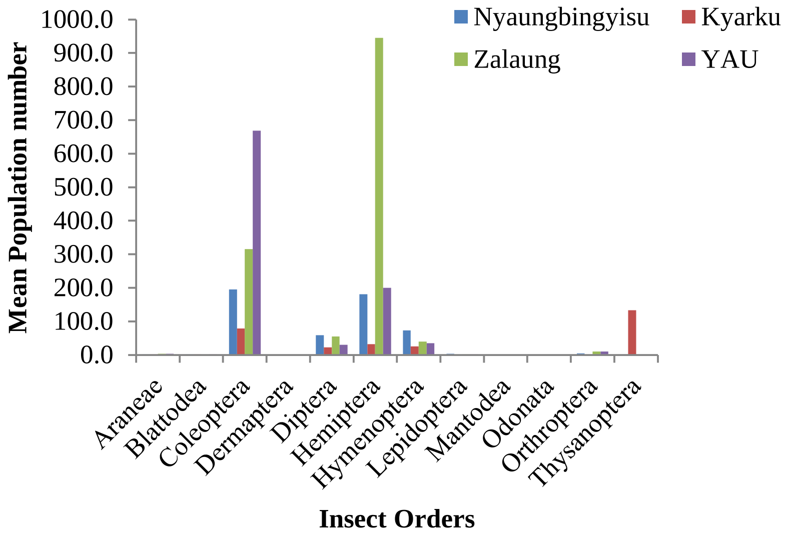

Figure 2. Mean population of rice insect species of different orders in Nyaungbingyisu, Kyarku, Zalaung Village and YAU Campus

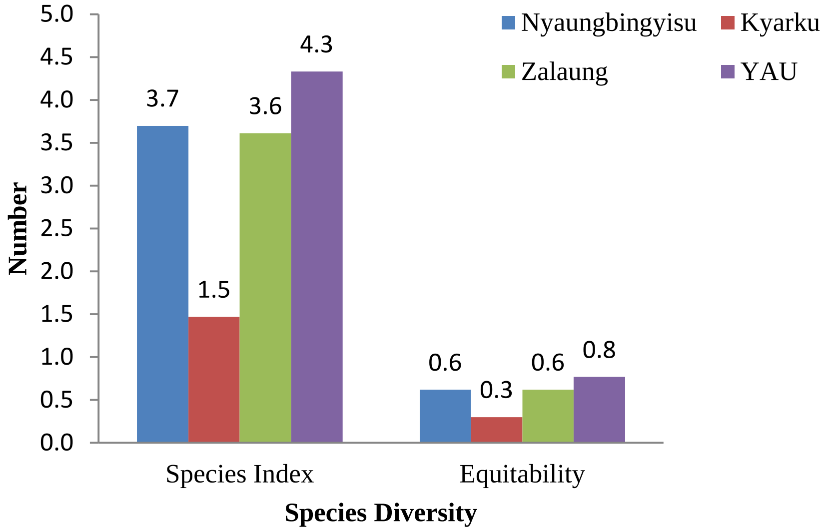

Figure 3. Species index and equitability of insect pests in Nyaungbingyisu, Kyarku, Zalaung Village and YAU

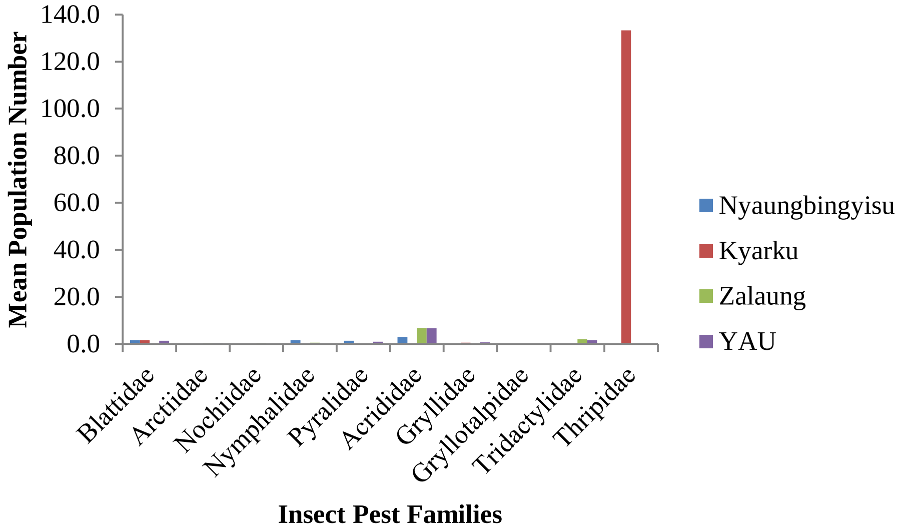

Figure 4. Mean population numbers of insect pest families of order Blattodea, Lepidoptera, Orthoptera and Thysanoptera from four different locations

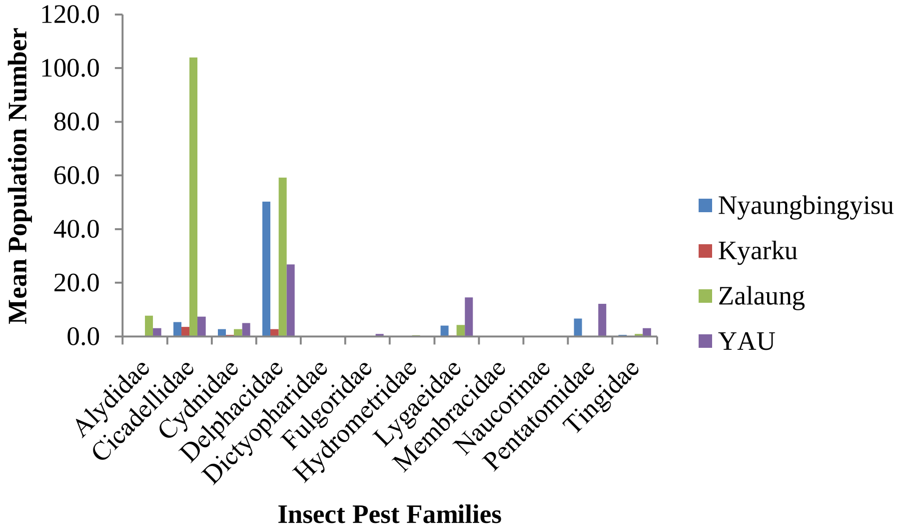

Figure 5. Mean population numbers of insect pest families of order Hemiptera from four different locations

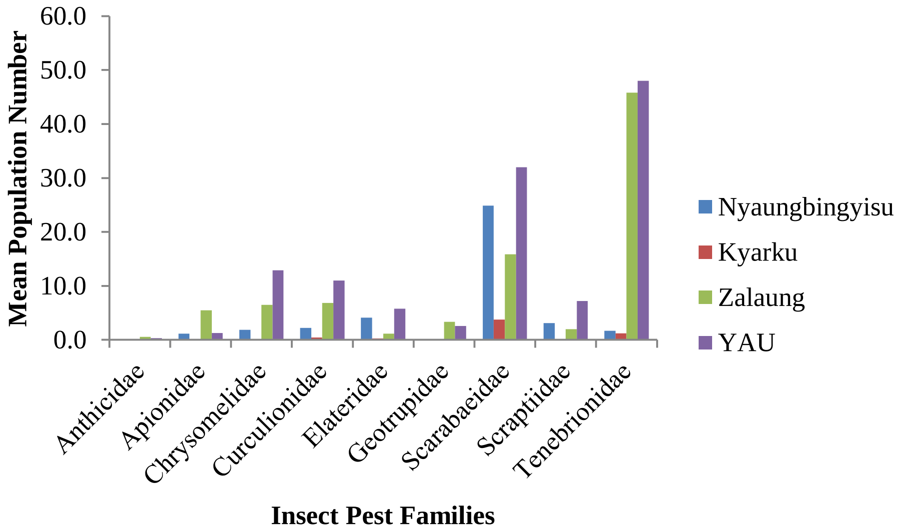

Figure 6. Mean population numbers of insect pest families of order Coleoptera from four different locations

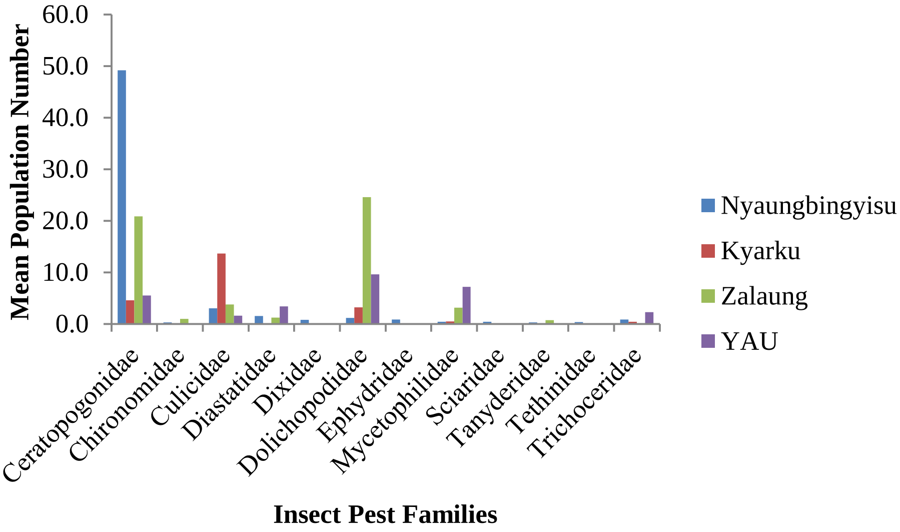

Figure 7. Mean population numbers of insect pest families of order Diptera from four different locations

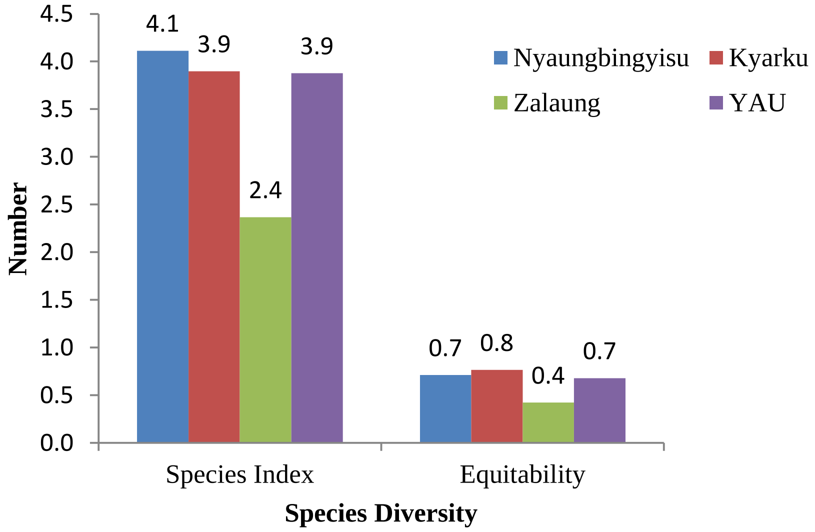

Figure 8. Species index and equitability of natural enemies in Nyaungbingyisu, Kyarku, Zalaung Village and YAU

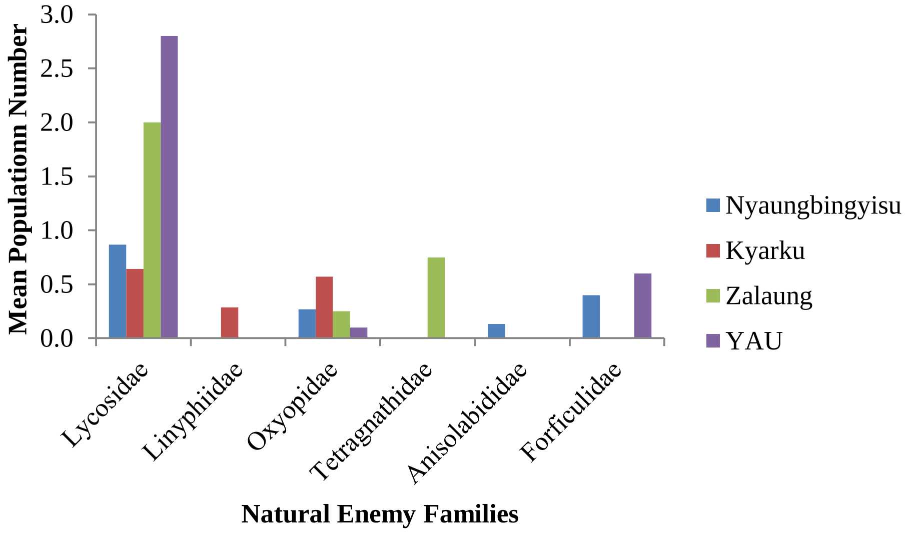

Figure 9. Mean Population numbers of natural enemy families of order Araneae and Dermaptera from four different locations

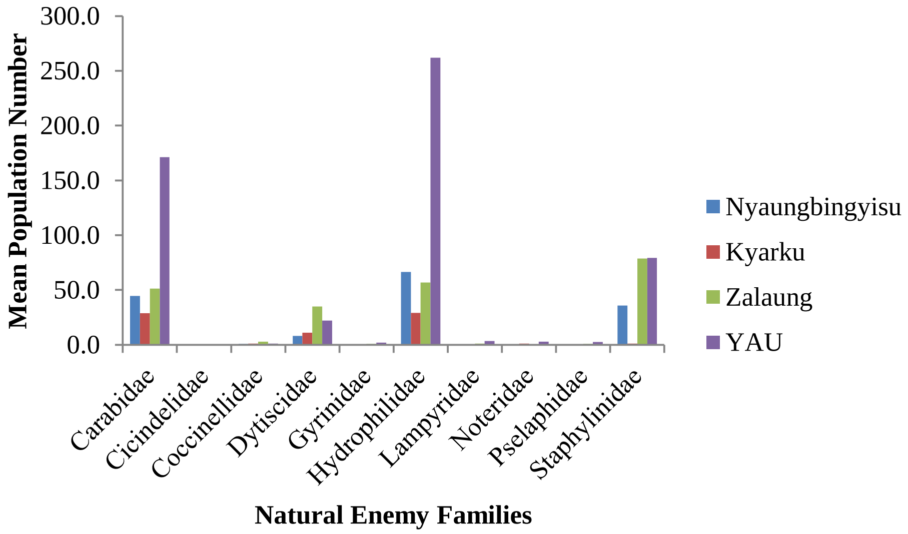

Figure 10. Mean Population numbers of natural enemy families of order Coleoptera from four different locations

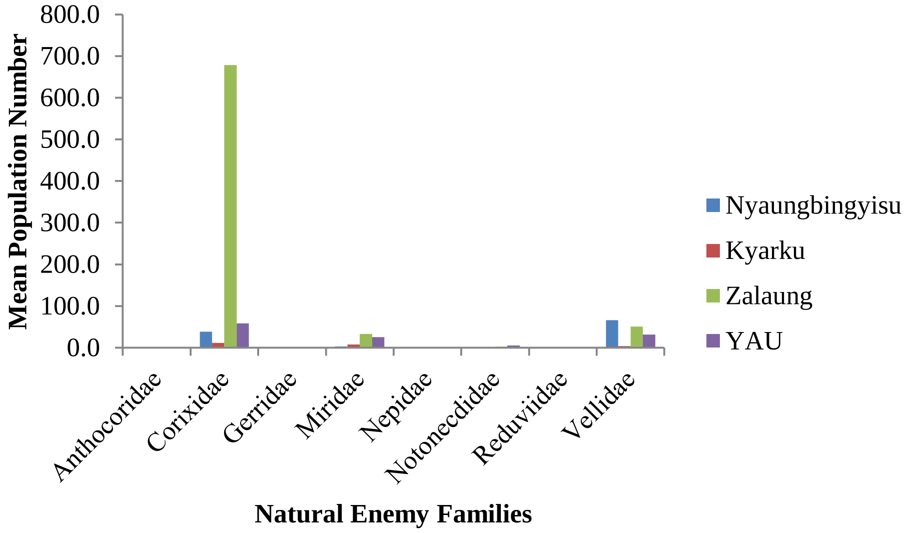

Figure 11. Mean Population numbers of natural enemy families of order Hemiptera from four different locations

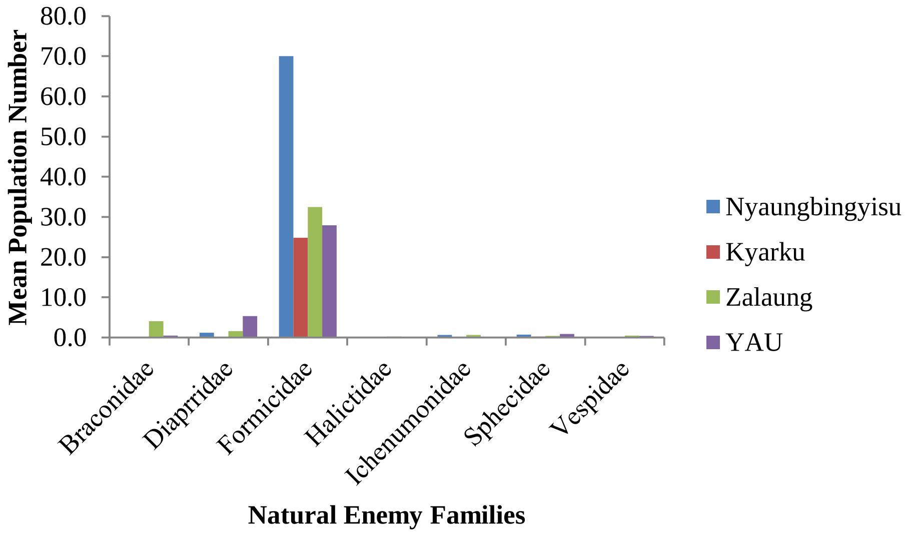

Figure 12. Mean Population numbers of natural enemy families of order Hymenoptera from four different locations

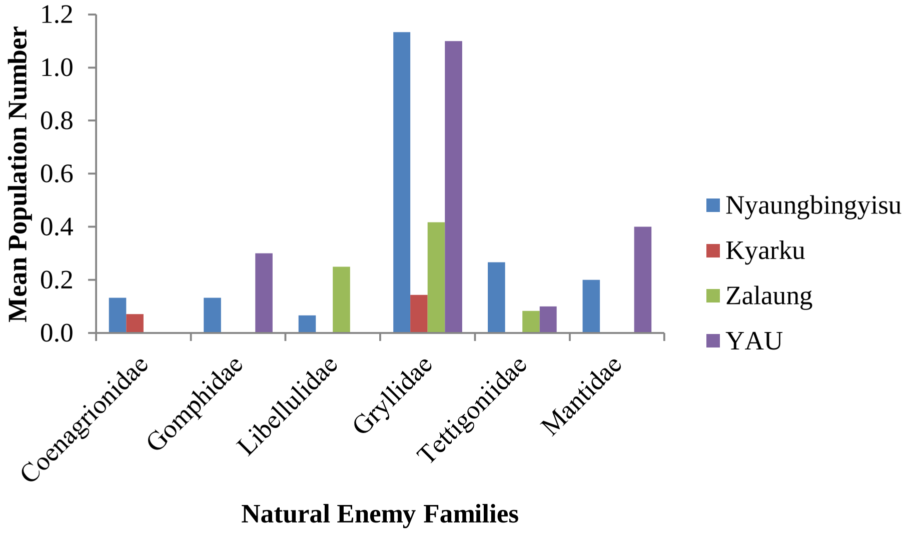

Figure 13. Mean Population numbers of natural enemy families of order Odonata, Orthoptera and Mantodea from four different locations