Species diversity of natural enemy association on rice at two different locations

Khin Ngu War Thant[1], Moe Hnin Phyu[2]* and Thi Tar Oo[2]

Abstract

The experiments were conducted to compare the species diversity and abundance of natural enemies on rice by using light trap, pitfall traps, yellow pan traps and yellow sticky traps at Nyaungbingyisu (Nay Pyi Taw Council Area) and Hmawbi from February to June 2014. Forty-four species from 7 orders of natural enemy were recorded from Nyaungbingyisu and 45 species from 7 orders of natural enemy were recorded from Hmawbi. Species abundance and species evenness were calculated by Shannon-Wiener formula. At Nyaungbingyisu, the species index of natural enemies in vegetative stage, reproductive stage and ripening stage were 2.94, 3.19 and 3.7, respectively. The equitability was 0.53, 0.58 and 0.67, respectively. At Hmawbi, the species index of natural enemies in vegetative stage, reproductive stage and ripening stage were 2.05, 2.46 and 4.04, respectively. The equitability of natural enemies in vegetative stage, reproductive stage and ripening stage were 0.36, 0.43 and 0.71, respectively. At Nyaungbingyisu, natural enemy family of Miridae was the highest populations in vegetative stage. The highest mean population number was observed in family Hydrophilidae in reproductive stage and Family Formicidae in ripening stage. At Hmawbi, natural enemy family of Formicidae had greater population number in all stages.

Key words: species diversity, natural enemy, growth stages

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Introduction

Rice (*Oryza sativa* L.) is one of the most important staple foods for more than half of the world's population (IRRI, 2006). It was grown in Asia, North and South America, European Union, Middle Eastern, and African countries. Myanmar is the seventh largest rice producing country in the world (Thiha, 2014). Total sown area is 7.28 million ha of 5.67 million ha monsoon rice and 1.61 million ha summer rice (MOAI, 2014).

More than 200 million tons of rice is lost every year due to abiotic stresses and biotic factors such as insect pests (Herdt, 1991). The world rice crop is attacked by more than 100 species of insects; 20 of them can cause economic damage. Insect pests that can cause significant yield losses are stem borers; leafhoppers and planthoppers (which cause direct damage by feeding as well as by transmitting viruses); gall midges, a group of defoliating species (mainly lepidopterans); and a grain-sucking bug complex that feeds on developing grains. Average yield loss due to various insect pests in Asia where more than 90% of the world's rice is produced is about 20%. Any decrease in pest damage means a corresponding increase is needed rice production (Pathak and Khan, 1994).

There are rich communities of beneficial insects, spiders, and diseases that attack insect pests of rice. The beneficial species often control insect pests, especially in places where use of broad-spectrum pesticides is avoided. Without these beneficial species, the insect pests would multiply so quickly that they would completely consume the rice crop (Shepard et al., 1987).

The natural arthropod enemies of rice pest insect include a wide range of predators and parasitoids that are important biological control 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).

In Japan, being ‘ecological’ or ‘environmental’ is on strong demand in agriculture nowadays. Sustainable management of rice paddies is also an increasing concern in the country. However, so-called environmentally sound farming is desired in terms of the production of safe food for humans, and its impact on biodiversity is often overlooked. Use of indicator organisms can provide the public concern to reconsider what is truly ‘ecological’ and the so-called eco-friendly farming from the viewpoint of biodiversity conservation. Because the biodiversity of beneficial natural enemies is a key resource to promote the productivity and sustainability in rice paddies, conservation of natural enemies should be an important approach for sustainable rice production (Ueno 2010, 2012). However, conserving the diversity of natural enemies and other organisms may be a formidable challenge. Use of insecticides dramatically reduces the incidence of rice pests and the yield loss, and herbicides allow reducing labor required for weed control (Pimentel, 1997; Dent, 2000). While the intensification of rice farming systems makes the yield higher and the price of rice lower, it might cause rice paddies poor in biodiversity. In contrast, biodiversity conservation through reduction of agrochemical use would decrease labor productivity of rice. Nevertheless, biodiversity conservation can help sustainable use of rice paddies and can reduce the incidence of pest outbreaks (Kruess and Tscharntke, 1994; Bianchi, 2006; Crowder et al., 2010). Importantly, recent studies have demonstrated that the presence of diverse species of natural enemies can enhance the control of pest populations through their complementary function (Kruess and Tscharntke, 1994, Bianchi, 2006; Crowder et al., 2010).

The objective of the present research is to compare the richness and abundance of natural enemy association on rice at different locations.

Materials and methods

Study Area

Experiments were conducted at two locations, Nyungbingyisu, Nay Pyi Taw Council Area, Mandalay Region and Hmawbi Campus, Yezin Agriculutral University, Hmawbi, Yangon Region. Pearl Thwe rice variety was used as tested variety.

Collection and Identification of Arthropods

Light trap (Minnesota trap) with fluorescent tube was used to collect the nocturnal insect pests and natural enemies. One light trap was set up for each location and it covers for 2 acres of rice field (Frost, 1958). The light was switched on at dark (6:00 pm - 6:00 am). The insects trapped in the jar were collected the next morning.

Pitfall trap was set up to collect the crawling insects. This involved using 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. Trapping days was used as the measure of sampling effort in case of pitfall traps, each "sample" containing insects caught in one pitfall trap during 7 days of continuous trapping.

Yellow pan trap was mounted on stand at approximately the same height of vegetation or just below the canopy level. Yellow pan trap attracted many small diurnal insects. Yellow pan traps collect insects that are attracted to the color. They are inexpensive and simple means of passively sampling insects in an area. This trapping method uses small pans filled with a mixture of water and liquid detergent. The pans were placed on the ground in conspicuous places in the morning. Use 500 ml bowl and cut holes near top of bowl and cover with mesh. In excessive rain this allows water to flow out of the bowl without losing any samples. Place the first bowl in the vegetation bordering the crop/ on the bund at field edge and the others in a transect and at distances of 0, then at1 m, 2 m, 4m, 8m, 16m, etc. into the centre of the paddy field. Cover each bowl with a coarse wire mesh to prevent scavenging of insects by birds. Leave out for 48 hrs at weekly interval throughout the rice-growing season. Use an aquarium net or fine sieve to collect the insects and place in 100>90% methylated spirit.

Yellow sticky traps are a commonly used method for population monitoring of many pests. The yellow sticky trap was made of art paper (10.5 × 28.5cm). Yellow sticky trap (three traps 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, collected after 24 hr). There were 120 samples for each sampling period. All types of data were recorded at weekly intervals starting from seedling to harvesting.

The collected specimens were carried to the Taxonomy Laboratory, Department of Entomology and Zoology, Yezin Agricultural University for further identification. All insect were identified to the families, subfamilies and genus level as far as possible by using keys outlined 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) 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.

$$\mathrm{H} = \sum_{i=1}^{s}(Pi)(log2Pi)$$

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 Natural Enemies on Rice at Nyaungbingyisu and Hmawbi during February to June 2014

At Nyaungbingyisu, the species index of natural enemies in vegetative stage, reproductive stage and ripening stage were 2.94, 3.19 and 3.7, respectively. The equitability was 0.53, 0.58 and 0.67, respectively. The species index and equitability of natural enemies were higher at ripening stage than the other stages (Figure 1).

At Hmawbi, the species index of natural enemies was in vegetative stage, reproductive stage and ripening stage were 2.05, 2.46 and 4.04, respectively. The equitability of natural enemies was in vegetative stage, reproductive stage and ripening stage were 0.36, 0.43 and 0.71, respectively. The species index and equitability were higher at ripening stage than the other stages (Figure 2).

Eight different families of order Coleoptera, 4 different families of order Hymenoptera, 2 different families of order Araneida, 2 different families of order Odonata, 2 different families of Hemiptera, 1 family of order Dermaptera and Mantodea were observed from Nyaungbingyisu and Hmawbi as shown in (Table 1).

Most parasites of rice pest belong to the order Hymenoptera and a few to Diptera. Egg parasites (mostly Hymenoptera) play a major role limiting the growth of rice pest. Major groups of predators in rice are spider, dragonflies and damselflies (Vreden and Ahmadzabidi, 1986).

Distribution of natural enemies throughout the different growth stages of rice at Nyaungbingyisu and Hmawbi during February to June 2014

Vegetative Stage

In general, the species composition was higher in Nyaungbigyisu than Hmawbi. The highest mean population was observed in order Hemiptera, followed by Coleoptera, Hymenoptera, Araneida, Dermaptera and Odonata.

Among the collected species, the highest population was observed in family Miridae (*Cyrtorhinus lividipennis*) at Nyaungbingyis (Figure 4). Predators were mainly from Heteroptera with *Cyrtorhinus lividipennis* (Miridae) and *Microvelia douglasi* (Veliidae) as the most abundant species (Heong et al., 1991). The second abundant family is Corixidae in Hmawbi (Figure 4).

Among the families of order Hymenoptera, the greater population was found in family Formicidae at Hmawbi (Figure 5).

Family Forficulidae of order Dermaptera was observed as higher in Nyaungbingyisu and Hmawbi (Figure 6). Family Libelludidae of order Odonata and Lycosidae of order Araneae were only observed in Nyaungbingyisu (Figure 6).

Reproductive stage

At the reproductive stage, the highest species composition was found in Nyaungbingyisu. The highest species composition and population was found in order Coleoptera, followed by Hemiptera, Hymenoptera, Dermaptera, Aranea, Odonata and Mantodea.

Among the families of collected species, the highest population number of family Hydrophilidae of order Coleoptera was found at Nyaungbingyisu (Figure 7). The second highest population was found in family Dytiscidae (Figure 7).

Among the family of order Hymenoptera, the highest mean population number was observed in family Formicidae at Hmawbi (Figure 9).

Family Forficulidae of order Dermaptera was higher in Nyaungbingyisu than Hmawbi (Figure 10). Family Libelludidae of order Odonata was higher in Nyaungbingyisu than Hmawbi. But the family Coenageionidae of order Odonata was higher in Hmawbi Campus than Nyaungbingyisu (Figure 10). Family Mantidae of order Mantodea was not found in Hmawbi. The mean population of family Lycosidae of order Araneida was higher in Hmawbi than those of Nyaungbingyisu (Figure 10). *Lycosa pseudoannulata* of family Lycosidae of order Araneida is an effective predator of leafhopper and planthopper and anything up to 15-20 nymphs and adults may be consumed per day under caged conditions. They also attack all other sorts of insects (Vreden and Ahmadzabidi, 1986).

Ripening Stage

In general, the highest species composition was observed in Hmawbi. Among the collected order, the highest species composition and population of order Hymenoptera followed by Hemiptera, Coleoptera, Araneida, Dermpatera and Odonata.

Among the collected families, the highest mean population number was found in family Formicidae of order Hymenoptera at Nyaungbingyisu (Figure 13). The second highest abundant family is Corixidae of order Hemiptera at Nyaungbingyisu (Figure 12). Corixids are among the most abundant organisms in coastal and saline inland ecosystems in many parts of the world (Scudder, 1976).

Mean population number of family Libelludidae of order Odonata was higher in Nyaungpingyisu than Hmawbi (Figure 14). But the population of family Coenageionidae of order Odonata was higher in Hmawbi than those of Nyaungbingyisu (Figure 14).

Conclusion

The present study explored the diversity and abundance of natural enemy species in Nyaungbingyisu (Nay Pyi Taw Council Area) and Hmawbi. According to the calculation of Shannon-Wiener function, 45 species from 7 orders of natural enemy were observed from Nyaungbingyisu and 45 species from 7 order of natural enemy were observed from Hmawbi.

At Nyaungbingyisu, natural enemy species of *Cyrtorhinus lividipennis* of family Miridae of order Hemiptera was the highest populations in vegetative stage. Family Corixidae of order Hemiptera was the second most abundant species in vegetative stage. The highest population number was observed in family Hydrophilidae of order Coleoptera in reproductive stage. Laccophilinae of family Dytiscidae of order Coleoptera was the second highest in reproductive stage. The highest mean population number was observed in family Formicidae of order Hymenoptera in ripening stage. Family Corixidae of order Hemiptera was the second most abundant species in ripening stage.

At Hmawbi, Formicidae of order Hymenoptera was greater population number of natural enemy speceis in vegetative stage, reproductive stage and ripening stage.

The highest population number was observed in Family Hydrophilidae of order Coleoptera in Nyaungbingyisu and the highest population number was found in Family Formicidae of order Hymenoptera in Hmawbi.

As for the natural enemy of species, species index and equitability of natural enemies were higher at ripening stage than vegetative stage and reproductive stage in Nyaungbingyisu and Hmawbi. Species index of natural enemy were higher at Nyungbingyisu than Hmawbi in vegetative stage and reproductive stage. However, the species index at ripening stage in Hmawbi was higher than Nyungbingyisu. Equitability of natural enemy species in vegetative stage and reproductive stage at Nyaungbingyisu was higher than Hmawbi. However, equitability of natural enemies in Hmawbi was higher than Nyaungbingyisu at the ripening stage. It may be due to the alternative cropping pattern such as rice with the legumes in Nyaungbingyisu. There were vegetables field around the rice field at Nyaungbingyisu. Meanwhile, the cropping pattern in Hmawbi is monoculture, only rice is growing. Therefore, it may be assumed that alternative cropping pattern with the other crop not only reduce the insect pest population but also increase the natural enemy population.

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Table 1. Mean number of recorded natural enemies from Nyaungbingyisu and Hmawbi during February to June 2014

Order	Family	Subfamily	Genus	Species	Nyaungbingyisu	Hmawbi
Coleoptera	Staphylinidae		*Tachyporus*	sp.	✓	✓
	Staphylinidae		*Lathrobium*	*impressum*	✓	✓
	Staphylinidae		*Gabrius*	*nigritulus*	✓	-
	Staphylinidae		*Paederrus*	*riparius*	✓	✓
	Staphylinidae	Paderinae			-	✓
	Staphylinidae	Oxytelinae			✓	✓
	Staphylinidae		*Sepedophilue*	*testaceus*	✓	✓
	Staphylinidae		*Astenus*	sp.	✓	✓
	Staphylinidae				-	✓
	Staphylinidae		*Autalia*	*impressa*	-	✓
	Scaritidae	Scaritinae			-	✓
	Carabidae	Panagaeinae			✓	-
	Carabidae		*Blinina*	*fossor*	✓	✓
	Carabidae	Harpalinae			-	✓
	Carabidae		*Pheropsophus*	sp.	✓	✓
	Carabidae		*Platymetopus*	sp.	-	✓
	Carabidae		*Casnoidea*	*indica*	✓	✓

Table 1. (Continued)

Order	Family	Subfamily	Genus	Species	Nyaungbingyisu	Hmawbi
Coleoptera	Carabidae	Bembidiinae			-	✓
	Carabidae		*Bembidion*	sp.	✓	✓
	Carabidae		*Casnoidea*	*ishii ishii*	✓	-
	Carabidae				-	✓
	Coccinellidae	Coccinellinae	*Hermonia*	*octomacuntea*	✓	✓
	Hydrophilidae		*Hydrophilus*	*piceus*	✓	✓
	Hydrophilidae		*Anacaena*	*globulus*	✓	-
	Hydrophilidae				-	✓
	Hydrophilidae		*Pyropisternus*	sp.	✓	-
	Hydrophilidae		*Laccobius*	sp.	✓	✓
	Broscidae	Broscinae			-	✓
	Aleocharidae	Aleocharinae			✓	✓
	Dytiscidae	Laccophilinae			✓	-
	Dytiscidae		*Canthydrus*	sp.	-	✓
	Dytiscidae	Dytiscinae			✓	✓
	Leiodidae				-	✓

Table 1. (Continued)

Order	Family	Subfamily	Genus	Species	Nyaungbingyisu	Hmawbi
Coleoptera	Pselaphaidae				✓	-
Hemiptera	Corixidae				✓	✓
	Notonectidae				-	✓
	Reduviidae		*Polytoxus*	*fuscovittatus*	✓	-
	Reduviidae	Havarpactorinae			✓	-
	Reduviidae		*Oncocephalus*	*confuses*	✓	✓
	Veliidae	Microvellinae			-	-
	Veliidae		*Microvelia*	*darglasi*	✓	-
	Miridae		*Cytrohinus*	*lividipenis*	✓	✓
Hymenoptera	Formicidae	Ponerinae			✓	✓
	Formicidae		*Ponera*	sp.	✓	✓
	Formicidae				✓	✓
	Formicidae	Myrmicinae			✓	✓
	Formicidae		*Pheidole*	sp.	✓	✓
	Formicidae		*Myrmecocystus*	*mexicanus*	✓	✓
	Formicidae		*Prolasius*	sp.	-	✓
	Diapriidae	Diapriinae			✓	✓

Table 1. (Continued)

Order	Family	Subfamily	Genus	Species	Nyaungbingyisu	Hmawbi
Hymenoptera	Ichneumonidae				✓	-
	Ichneumonidae	Ophioninae			✓	-
Dermaptera	Forficulidae		*Forficula*	*auricularia*	✓	✓
	Forficulidae		*Doru*	sp.	✓	-
Araneida	Araneidae		*Araneus*	sp.	-	✓
	Lycosidae		*Lycosa*	*pseudoannulata*	✓	✓
	Lycosidae		*Hippasa*	*greendliae*	✓	✓
Odonata	Coenageionidae				✓	✓
	Libelludidae				✓	✓
Mantodea	Mantidae				✓	-

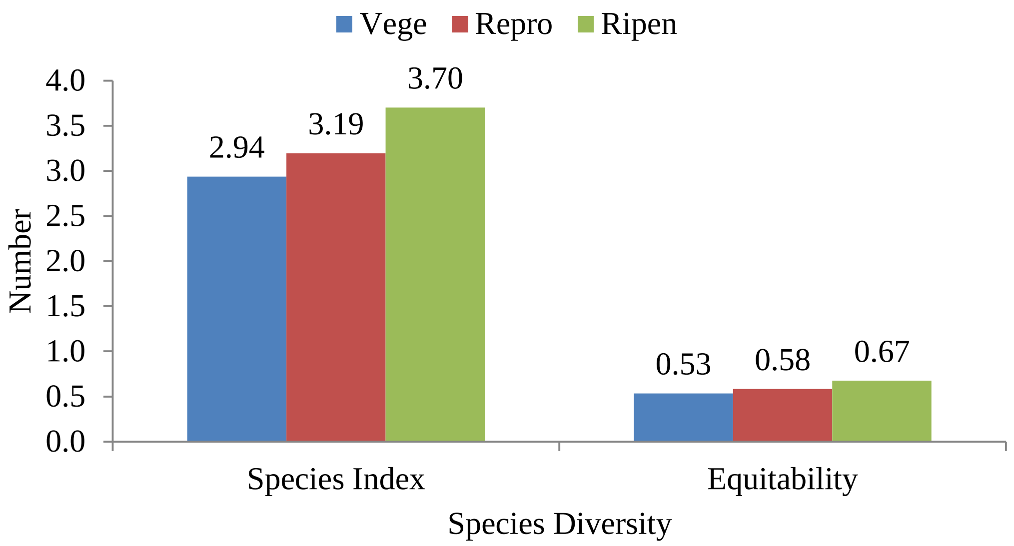

Figure 1. Species index and equitability of natural enemies on the different growth stages in Nyaungbingyisu

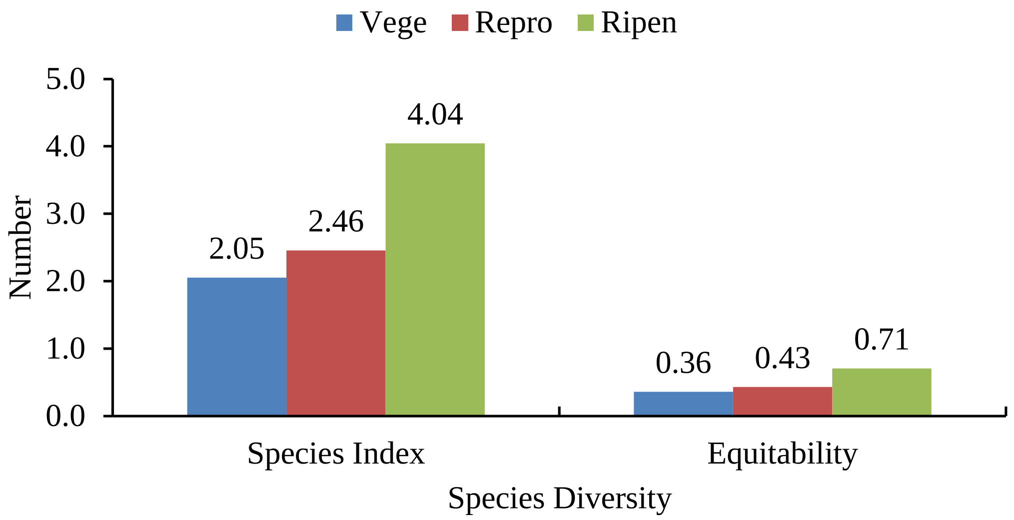

Figure 2. Species index and equitability of natural enemies on the different growth stages in Hmawbi

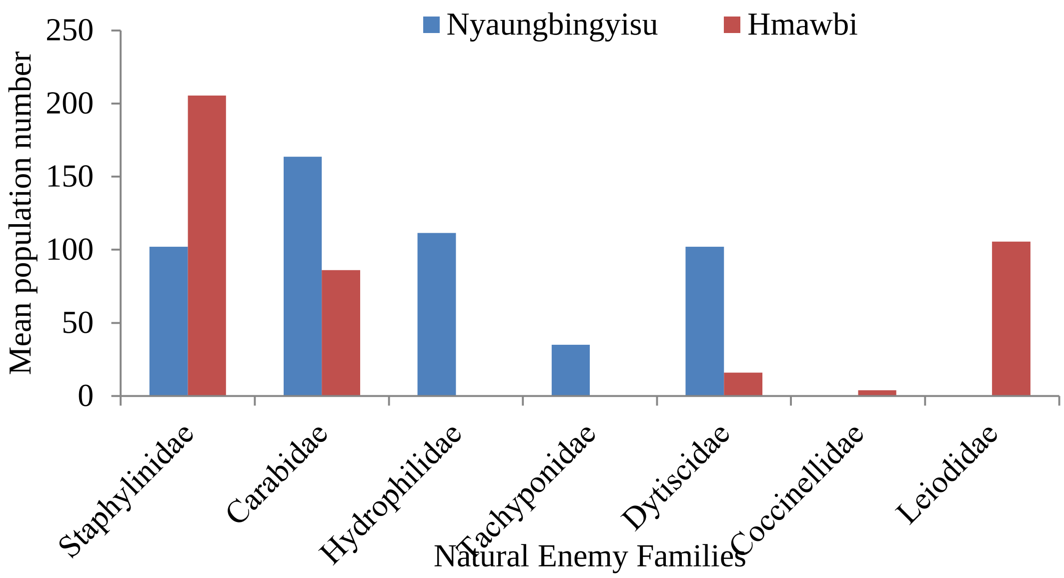

Figure 3. Mean population number of natural enemy families of order Coleoptera from Nyaungbingyisu and Hmawbi at the vegetative stage

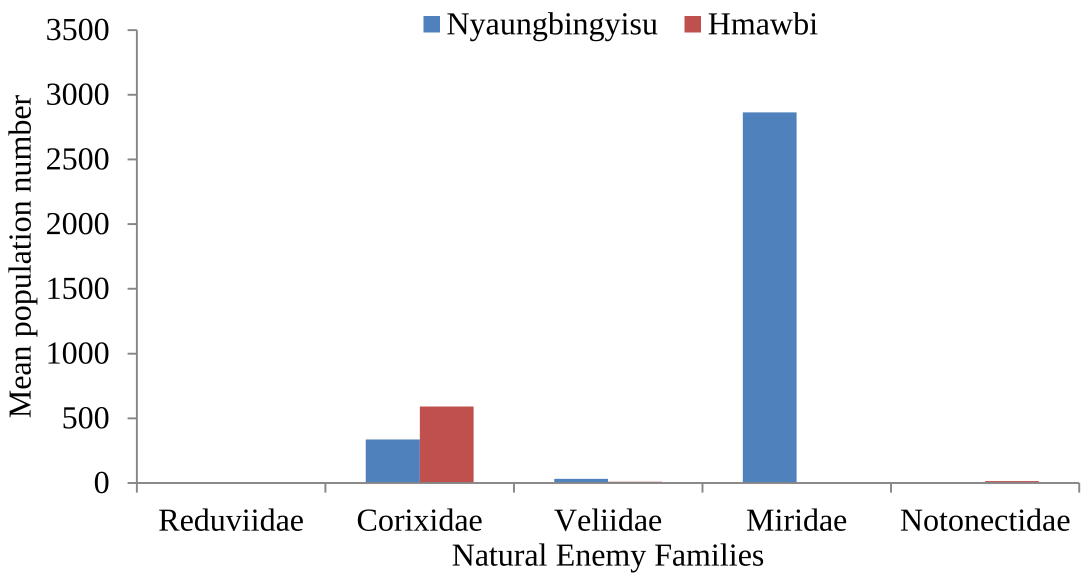

Figure 4. Mean population number of natural enemy families of order Hemiptera from Nyaungbingyisu and Hmawbi at the vegetative stage

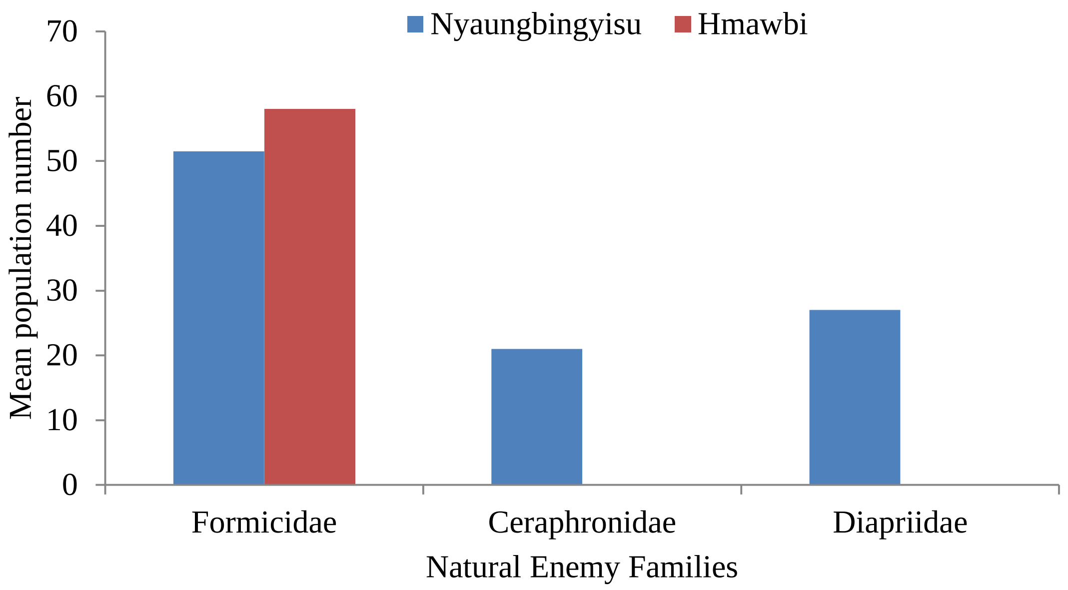

Figure 5. Mean population number of natural enemy families of order Hymenoptera from Nyaungbingyisu and Hmawbi at the vegetative stage

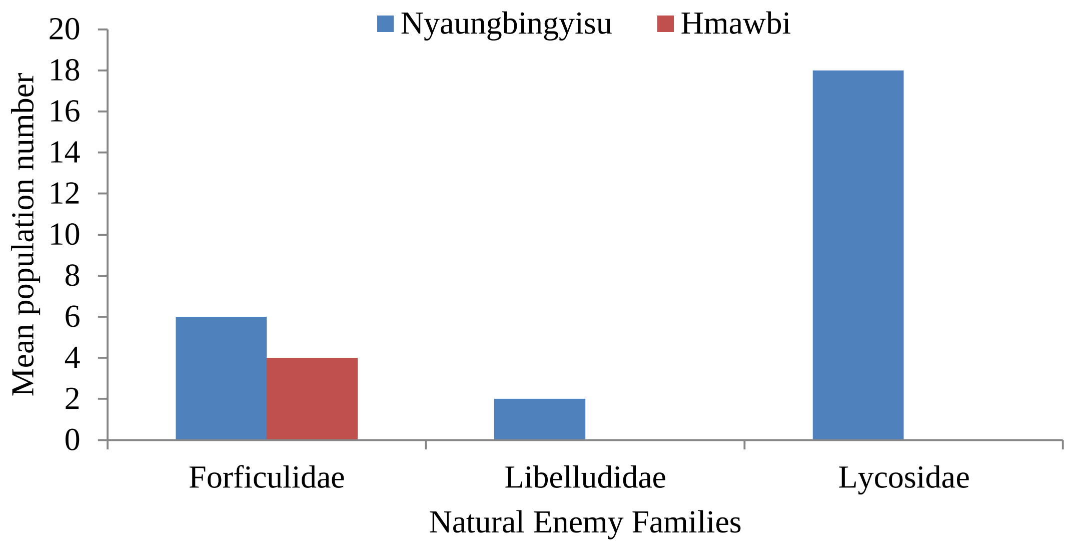

Figure 6. Mean population number of natural enemy families of order Dermaptera, Odonata and Araneida from Nyaungbingyisu and Hmawbi at the vegetative stage

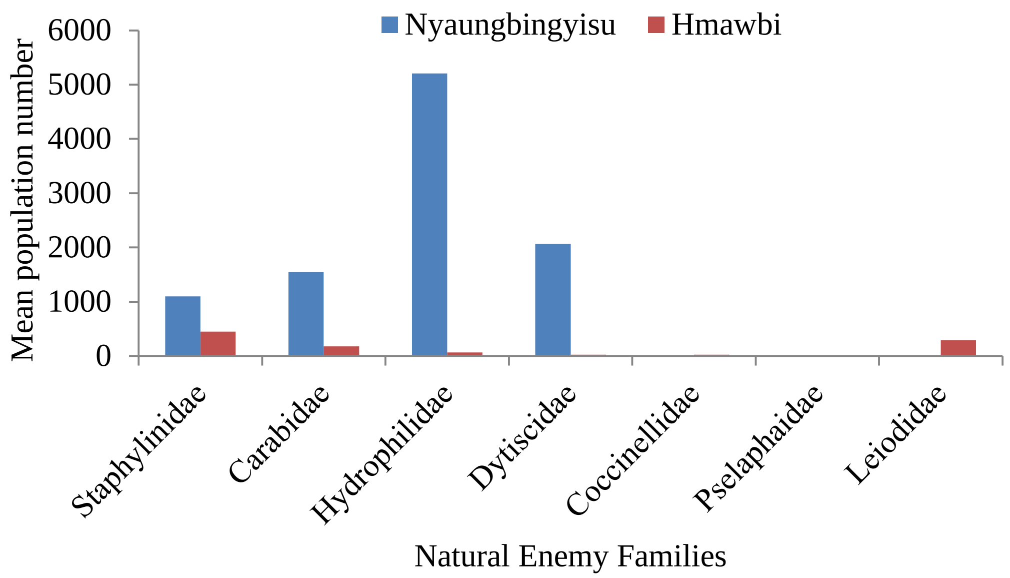

Figure 7. Mean population number of natural enemy families of order Coleoptera from Nyaungbingyisu and Hmawbi at the reproductive stage

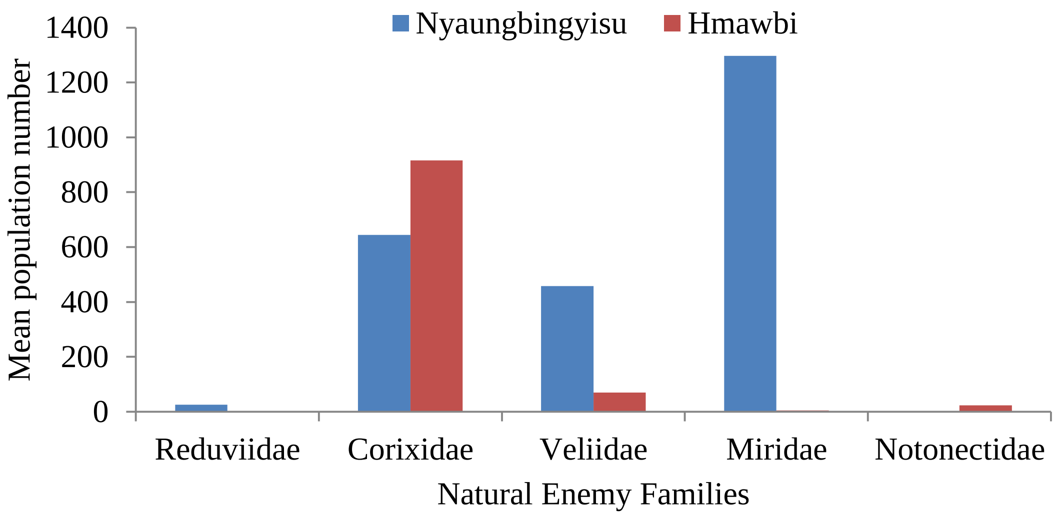

Figure 8. Mean population number of natural enemy families of order Hemiptera from Nyaungbingyisu and Hmawbi at the reproductive stage

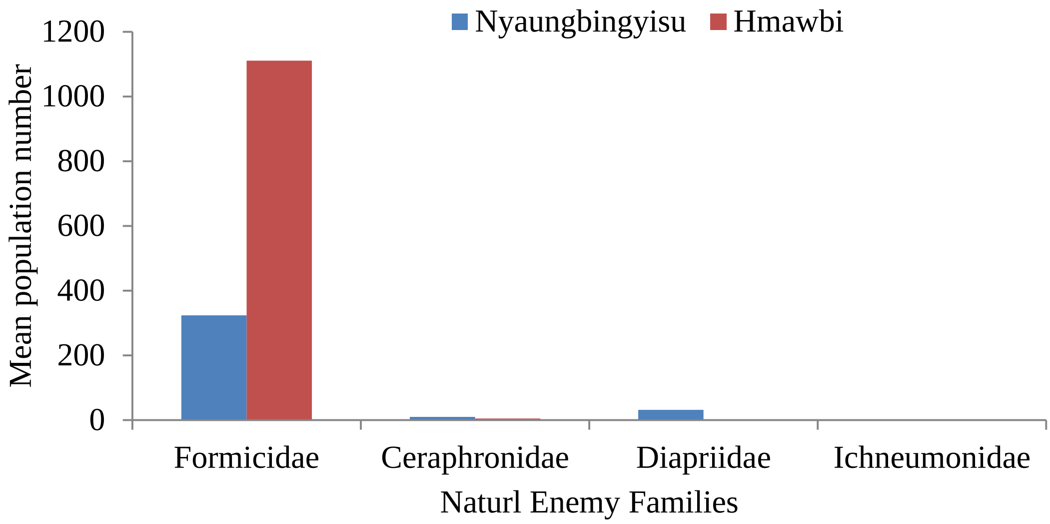

Figure 9. Mean population number of natural enemy families of order Hymenoptera from Nyaungbingyisu and Hmawbi at the reproductive stage

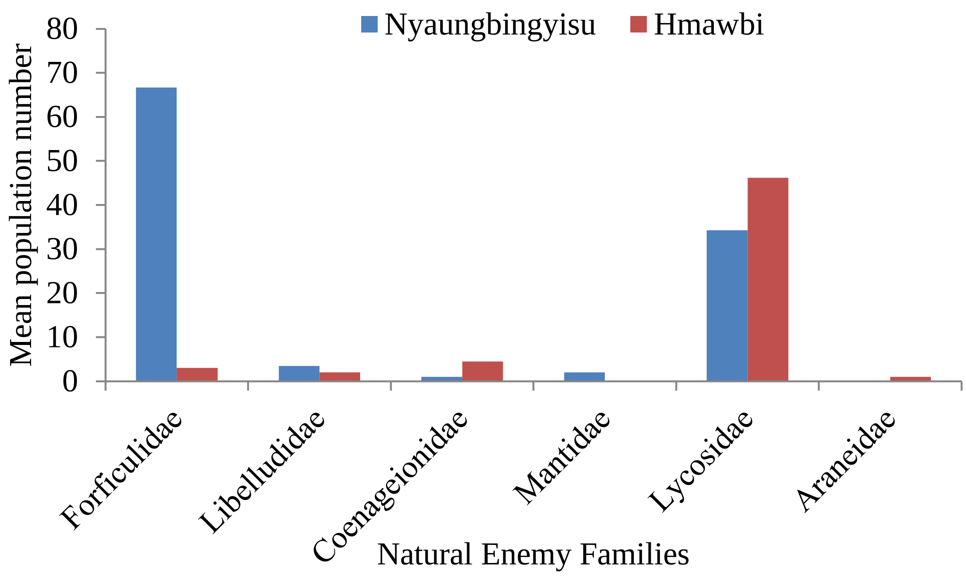

Figure 10. Mean population number of natural enemy families of order Dermaptera, Odonata and Araneida from Nyaungbingyisu and Hmawbi at the reproductive stage

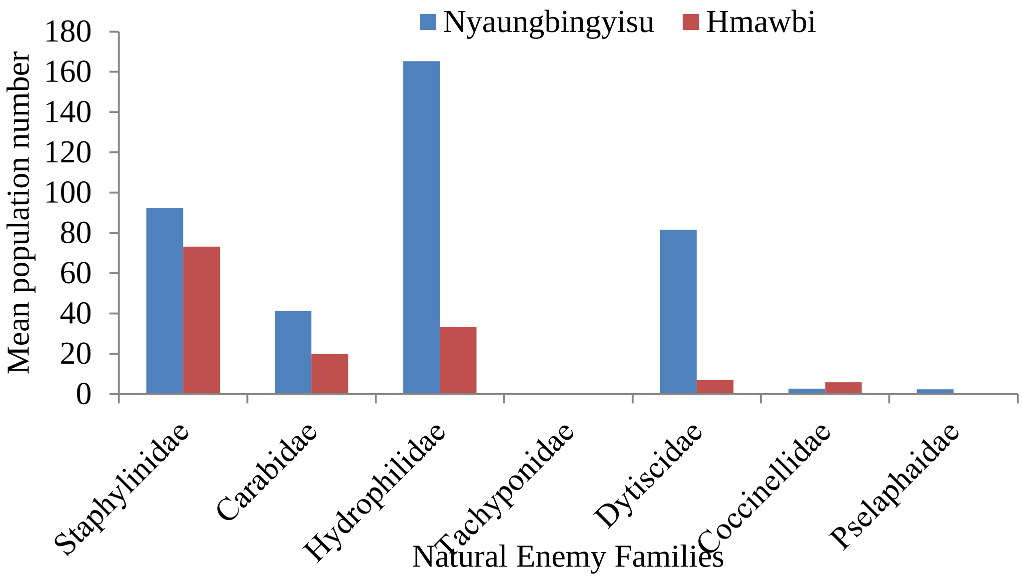

Figure 11. Mean population number of natural enemy families of order Coleoptera from Nyaungbingyisu and Hmawbi at the ripening stage

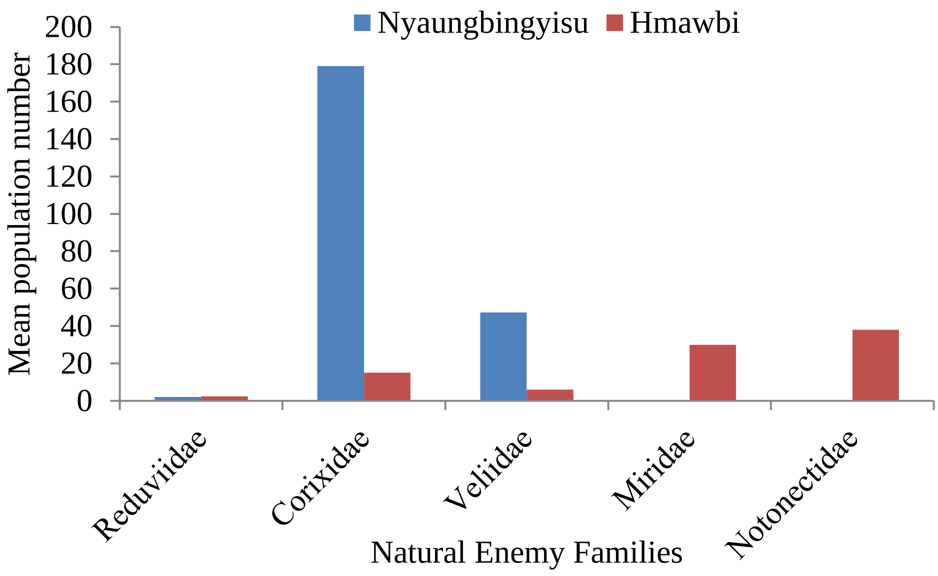

Figure 12. Mean population number of natural enemy families of order Hemiptera from Nyaungbingyisu and Hmawbi at the ripening stage

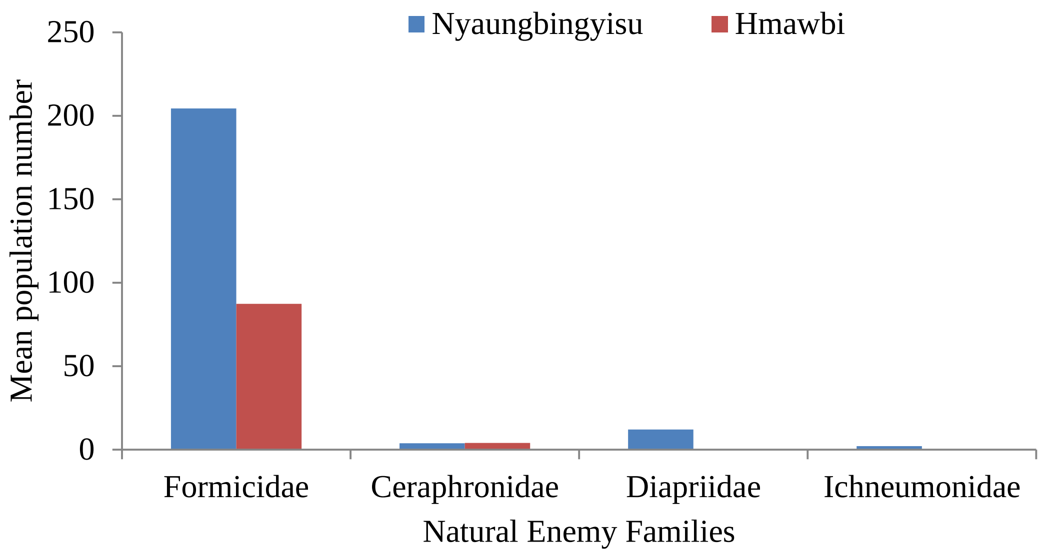

Figure 13. Mean population number of natural enemy families of order Hymenoptera from Nyaungbingyisu and Hmawbi at the ripening stage

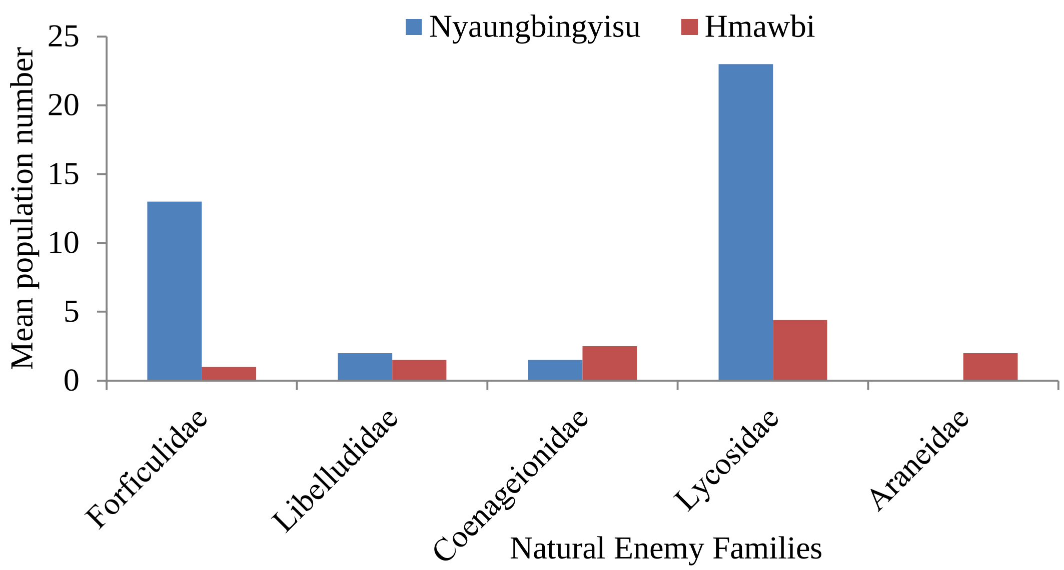

Figure 14. Mean population number of natural enemy families of order Dermaptera, Odonata and Araneida from Nyaungbingyisu and Hmawbi at the ripening stage