The species richness and abundance of arthropod diversity in natural and agricultural habitats of a tropical highland (Pyinoolwin, Myanmar)

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Abstract—This study examined the arthropods communities by malaise trap sampling and quantified the number and richness of arthropods in natural pine forest, semi forest (Coffee plantation) and cultivated vegetable crops in tropical highland, Myanmar in the summer and rainy season in 2009. Arthropods communities in semi forest (coffee plantation) were significantly more diverse than those other habitats. Diversity, abundance, and richness of arthropods were significantly high in semi forest than other habitats, in contrast, the abundance, and richness of natural enemies were significantly higher in the natural forest than other habitats, and meanwhile the abundance and richness of pest species were significantly higher in semi forest than other habitats. The results indicated that the habitat of the pest species considered is limited to cultivated land does not include the forest. Most of the natural enemies recorded in this study would be able to exist permanently in the natural forest area. They all depend on a closed forest habitat and therefore will become extinct as the forest disappears with proceeding slash and burn agriculture. However, some but not all of the pest and natural enemies were regularly recorded from the cultivated land.

Keywords—cultivated agricultural land, malaise trap, natural pine forest, semi forest.

I. Introduction

Biodiversity is the sum total of all biotic variation from the level of genes to ecosystem. The most commonly considered facet of diversity is to species richness – the number of species in a site or habitat. Hence, species are an obvious choice of unit when trying to measure diversity [1]. The degree of knowledge about biodiversity varies with both location and taxon. Another way to observe richness of species is to look for the most concentrated area [2].

The simplest measure of species diversity is to count the number of species. The number of species is the first and oldest concept of species diversity and is called species richness. Another concept of species diversity is that of heterogeneity. The knowing of species richness in a habitat is the most important thing for sustainable agriculture.

Increasingly intensive agriculture production methods, involving a widespread use of agro-chemicals and the progressive loss of many natural and semi-natural habitats have led to an impoverished wildlife in agro-ecosystems. The awareness of the necessity to conserve, enhance or restore biodiversity in depleted agricultural landscapes has increased in the last decades. However, biodiversity assessments often require much effort in terms of time and economical resources. In particular, when analyzing Arthropods, one of the groups most commonly used to assess biodiversity in agro-ecosystems, the employment of taxonomists is required for species identification [3].

The objective of this study were to (1) determine the abundance and species richness of arthropods at different habitats; (2) to investigate the relationship between climate, topography and the species richness from the different habitats; and (3) to observe the species originating from the forest are able to colonize other habitats.

II. Materials and Methods

A. Study area

The study was conducted in two different places (sites), i.e. highland area of Myanmar in 2009 (March – July). The study sites in the highland were located in Pyinoolwin (is lied between 96º to 97º East Longitude and 22º North Latitude). Geographically, it is located on the western part of Shan Plateau and set on a vast plain enclosed by deciduous forest around. The altitude of the high land area lies between 1200 – 1233 m above sea level. The climate of highland area was typical of a tropical high land, with a maximum temperature range from 15 to 28°C and an annual precipitation of about 1346 mm (Fig. 1). Three study sites were subdivided in the first group that were natural Pine forest, Coffee plantation (semi forest) and cultivated vegetable crops.

The natural pine forest was composed of *Pinus khasya., Cinnamomum* spp., Eastern gooseberry (*Emblica officinalis*), the Eugenia tree, *Alternanthera pungens* and white costus (*Costus speciosus*). The coffee plantation (semi forest) was composed of coffee (var. Catimor, Caturra and Robusta), *Erythrina arborescens*, and *Cassia javanica.* The

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cultivated vegetable land was composed of small patches (5-50 m^2) of seasonally changing vegetables. The main crops grown were *Lactuca sativa*, iceberg lettuce, butter lettuce with some damson (*Prunus communis*) and persimmon as perennial intercropping plants.

Fig. 1. Natrual Forest and agricultural habitats map of highland (Pyinoolwin) showing the study area.

B. *Field methods and species selection*

The study was carried out at two localities of the same slope in the natural pine forest, Coffee plantation (semi forest) and cultivated vegetable crops at about 1500 m distance from each other. Arthropods sampling was carried out using Malaise traps (Malaise, 1937; Townes, 1962, 1972). At both localities, Malaise trapping was carried out 15 days interval. The collecting jars were filled with 80% alcohol and kept open for 15 days, then cleared from the collected individuals (Fig. 1). Sampling was carried out over a total period of 5 months (March – July 2009), yielding a total 72 samples from all localities. The individuals of all taxa from all samples collected throughout the study period were listed in Appendix 1 and 2 and they were divided into three groups such as pest, predator-parasite and non-pest. The first group (in the following termed as “pest species”) includes 82 families of the forest, coffee and vegetable crops. The second group (in the following termed as “predator-parasite”) is represented by 55 families and the third group (in the following termed as “non-pest species”) includes 14 families from all localities. Identification of the selected species was carried out at Taxonomy Laboratory, Department of Entomology and Zoology, Yezin Agricultural University, Yezin, Myanmar. Using keys outlined by the text books of Insect of Australia (Waterhouse 1970), Immature insect Vol I and II (Frederick, 1987), Insects (Borror and White, 1970).

Species abundances in the two localities were pooled over the total sample period with respect to habitats. Thus, mean values of the numbers of the selected pest, predator-parasite and non-pest species, calculated from the total of the samples per trap of both localities over the entire sampling period of 5 months, were used for data analysis. Climatic data for the study areas on the observations for a period of 5 months (February – July, 2009) at two weather stations which are the nearest to the study areas. All climatic data are recalculated basing on the data source from the Department of Meteorology and Hydrology, Yangon, Myanmar (Fig. 2).

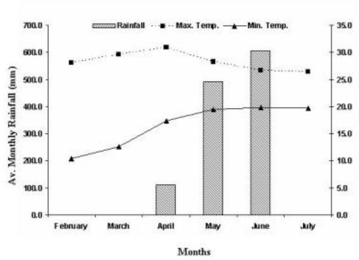

Fig. 2. Climatogram for highland (Pyinoolwin, Myanmar) weather station which are the nearest to the study areas.

C. *Data analysis*

Abundances and species richness of arthropods at two localities from different habitats was measured by the Shannon-Wiener function [4].

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

where H = index of species diversity or information content of sample (bits/individual)
S = number of species
p_i = proportion of total sample belonging to i^{th} species

Information content is a measure of the amount of uncertainty, so that the larger the value of H, the greater the uncertainty. Two components of diversity are combined in the Shannon-Wiener function: (1) number of species and (2) equitability or evenness of allotment of individuals among the species [5]. Equitability can be measured in

$$E = \frac{H}{H_{max}}$$

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

Cluster analyses, Principal Component Analysis (PCA) was done to investigate the relationship between different habitats which are the variables divided from a multivariate data. Data were encoded and processed employing Excel 4.0 (Microsoft Windows XP 2002) and statistical analyses were performed using the software programme SAS 9.1 [6].

III. Results and Discussion

A. Species composition and diversity

The five-month sampling period allowed the collection of a high number of arthropods species during dry and rainy periods (a total of 151 families from 27 orders). According to the Shanon-Weiner function, 151 families from 17 orders

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of Arthropods were observed from different sites during the study period. Index of species diversity and equitability in Forest were 1.8260 and 0.4467, in Coffee Plantation (semi forest) 2.4347 and 0.5956 and in Vegetable 2.2657 and 0.5543 in highland study sites, respectively. It was shown that a greater number of species increases species diversity, and a more even or equitable distribution among species also increase species diversity (Table I). The data clearly showed that the greater number of species and more species evenness in semi-forest (coffee plantation) site than the other sites of the highland.

The 17 Orders were collected and identified from this study among which Collembola, Diptera, Hymenoptera, Coleoptera and Lepidoptera were the most abundant in population and greater numbers of species were recorded in different study sites. Index of species diversity and equitability of 151 families in Forest were 2.1684 and 0.2996, in Coffee (semi forest) 3.6544 and 0.5049 and in Vegetable 2.9281 and 0.4045 respectively in highland study sites (Table II).

Total mean population density of arthropods from June 2009 (442.0) was the highest in natural Forest (Fig. 3). The highest mean population from Coffee plantation (semi forest) (218.5) was obtained in June 2009 (Fig. 3). However, the highest mean number from cultivated vegetable crops (299.5) was observed in July 2009 (Fig. 3).

As for the natural enemies, the 55 families were collected and identified from this study. Index of species diversity and equitability of 55 natural enemies families in Forest were 7.5343 and 1.3032, in Coffee (semi forest) 2.9122 and 0.5066 and in Vegetable 2.2042 and 0.3813 respectively in highland study sites (Table III).

As for the pest species, the 82 families were collected and identified from this study. Index of species diversity and equitability of 82 pest families in Forest were 2.7569 and 0.4336, in Coffee (semi forest) 3.5821 and 0.5634 and in Vegetable 2.1484 and 0.3379 respectively in highland study sites (Table IV).

As for the other arthropods species, the 14 families were collected and identified from this study. Index of species diversity and equitability of 14 other arthropods families in Forest were 0.1036 and 0.0272, in Coffee (semi forest) 0.2723 and 0.0715 and in Vegetable 0.3845 and 0.1009 respectively in highland study sites (Table V). Other studies conducted on the distribution of arthropods in tropical landscapes indicated that different taxa show relationships between natural and cultivated habitats, and that diversity or abundance decrease with increasing degree of disturbance [7]. This was true for ground-dwelling insects [8], dung- and carrion beetles [9] and moths [9], [10].

The most commonly used diversity measures based on proportional abundances of species are the Shannon-Wiener and Simpson indices [11]. Forests are structurally and biologically diverse often containing an herbaceous plant community, a shrub layer, midstory trees, and a dominant overstory tree canopy [11]. In this study species richness was measured on the different habitats (natural Forest, Coffee plantation and cultivated vegetable crops). Krebs [4] found that the tropical biotas are examples of mature biotic evolution, whereas temperate and polar biotas are immature communities. In short, all communities diversify in time, and thus older communities have more species than younger ones.

TABLE I
COMMUNITY INDICES FOR ARTHROPODS SPECIES (ORDER) IN DIFFERENT HABITATS, HIGHLAND, MYANMAR

	Forest	Semi-Forest	Vegetable
Diversity	2.1684	2.4347	2.2657
Evenness	0.4467	0.5956	0.5543

TABLE II
COMMUNITY INDICES FOR ARTHROPODS SPECIES (FAMILIES) IN DIFFERENT HABITATS, HIGHLAND, MYANMAR

	Forest	Semi-Forest	Vegetable
Diversity	2.1684	3.6544	2.9281
Evenness	0.2996	0.5049	0.4045

TABLE III
COMMUNITY INDICES FOR ARTHROPODS SPECIES (NATURAL ENEMIES) IN DIFFERENT HABITATS, HIGHLAND, MYANMAR

	Forest	Semi-Forest	Vegetable
Diversity	7.5354	2.9122	2.2042
Evenness	1.3032	0.5066	0.3813

TABLE IV
COMMUNITY INDICES FOR ARTHROPODS SPECIES (PESTS) IN DIFFERENT HABITATS, HIGHLAND, MYANMAR

	Forest	Semi-Forest	Vegetable
Diversity	2.7569	3.5821	2.1484
Evenness	0.4336	0.5634	0.3379

TABLE V
COMMUNITY INDICES FOR ARTHROPODS SPECIES (OTHER ARTHROPODS) IN DIFFERENT HABITATS, HIGHLAND, MYANMAR

	Forest	Semi-Forest	Vegetable
Diversity	0.1036	0.2723	0.3845
Evenness	0.0272	0.0715	0.1009

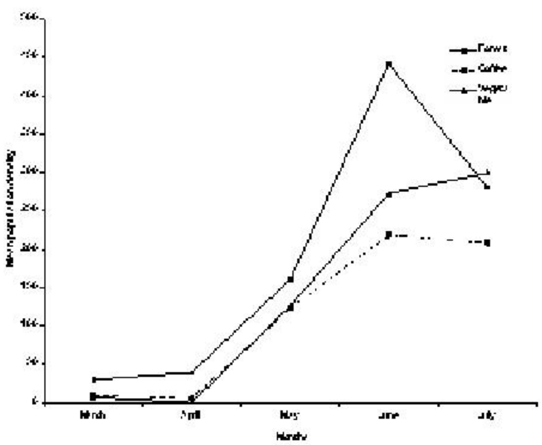

Fig. 3 Total mean caught population of various arthropods from three different sites was showed in monthly surveyed.

A. Effects of different habitats on the abundance and richness of arthropods diversity

TABLE VI
CORRELATION MATRIX OF THE EFFECT OF DIFFERENT HABITATS ON THE SPECIES DIVERSITY OF ARTHROPODS

	Forest	Semi-forest	Vegetable
Forest	1.0000	0.9553	0.9251
Semi-forest	0.9553	1.0000	0.9828
Vegetable	0.9251	0.9828	1.0000

TABLE VII
EIGENVALUES OF THE CORRELATION MATRIX

	Eigenvalue	Difference	Proportion	Cumulative
Forest	2.908	2.830	0.969	0.9697
Semi-Forest	0.078	0.066	0.026	0.9959
Vegetable	0.012		0.004	1.0000

TABLE VIII
EIGENVECTORS MATRIX OF FOUR DIFFERENT HABITATS FOR THE THREE PRINCIPAL COMPONENTS IN 151 FAMILIES OF ARTHROPODS

	Prin1	Prin2	Prin3
Forest	0.571	0.7886	0.2264
Semi-forest	0.583	-.1962	-.7882
Vegetable	0.577	-.5826	0.5721

The eigenvalues of the correlation matrix were observed in the present study such as 2.91, 0.08, and 0.01 (Table VII and VIII). These add to 3.00, the sum of the diagonal terms in the correlation matrix (Table VII). The correlation matrix of the effect of different habitats on the diversity of arthropods was observed in Table VIII.

The first principal component (PC_1) explained about 96.9 % and the second (PC_2) about 2.6% of the total variation in the standard data. For these reasons, the main sources of the variation among the different habitats were PC_1 and PC_2. The coefficients of the effect of different habitats in the PC_1 were (0.5) ant it was not significantly different in the variables x1, x_2 and x_3. The remaining variable was less than 0.5 (Table VIII). The value of eigenvectors was large in x1, x_2 and x_3. Hence the first PC indicated that the species diversity of arthropods was greatly influenced by the different habitats.

In addition to providing host plant resources, woody plant diversity reportedly contributes to habitat complexity for butterflies and other insect species by providing microclimate variation [12].

The PC_2 mentioned about 2.6% of the total variation. However, the effect of PC_2 was still of some importance. The natural forest habitat on the species diversity (0.79 in PC_2 x_1) and the coffee plantation (-0.19 in PC_2 x_2) had negative effect on the species diversity of arthropods. The rest of the PCs can be ignored because the average percentage of each PC is $\sum PC_i/n = 16.68/4 = 4.17\%$. The measurements were small, less than 15 %, thus the remaining variables can be ignored. Ricketts et al. [10] reported that no significant difference in moth species richness between different agricultural habitats was evident, but species richness decreased with increasing distance to the forest fragments. It was also found that the majority of moth species frequently moved between forest and agricultural habitats.

IV. CONCLUSION

Arthropod diversity was higher in natural forest than in the semi-forest (coffee plantation) and the cultivated vegetable crops. These finding are in general agreement with other findings. It would be necessary to conduct different topography and different forest structure to achieve the information of species exist and extinct between the natural forest and the cultivated lands. In this study, there was clearly showed that the highest composition of natural enemies' composition was found in the natural forest. Maintaining this balance between natural enemies and the pest population should also be one of the best ways of maintaining a sustainable agriculture sector. Therefore, the protection of the natural forest is to maintain sustainable agriculture and to improve the protection of environmental pollution.

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