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Ecology and distribution of carabid beetles in selected forests of Eastern Visayas, Philippines

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Key words: community structure, species richness, species diversity, natural forest, agricultural land

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Abstract

The study has been carried out to provide basic data for analyzing the ecology and distribution of carabid beetles in six forests of Eastern Visayas namely: Lake Danao, Mt. Nacolod, Kuapnit Balinsasayao, Asug Forest, City Forest, and Closed Canopy on January to June of 2019. Collected carabid beetles was comprised of 7844 individuals belonging to 41 species under 25 genera, 13 tribes, and two (2) subfamilies. Carabid species diversity, as estimated by diversity indices, was significantly different among the six forests. Of the six forests, Mt. Nacolod had comparatively high diversity (4.00). equitability (0.78), dominance (2.709), and species richness (32). In terms of habitat types, there were 41 species belonging to 25 genera identified among 3,771 carabids collected from natural forests of Eastern Visayas. In agricultural habitat type, 28 species were identified from 4, 073 carabid beetles. Natural forest had comparatively high diversity (5.95), high equitability (0.80), dominance (3.1), and species richness (41) over agricultural land. Along with other factors, these habitat parameters are influenced by the nature of the vegetation. Conservation should be conducted to the carabid beetles especially the rare and endemic ones in some forests. Strengthened implementation of protection in both protected landscapes against mining, illegal logging, slash and burn farming and human settlements should also be done.

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Introduction

Tropical forests, which include a crucial part of terrestrial biodiversity (Myers *et al.,* 2000) are decreasing at a fast rate (Tole 1998, Dudley *et al.,* 1998, Laurance *et al.,* 2000, Chazdon 2003). Specifically, the tropical forests of South East Asia are among the most truly disturbed because of excessive logging and continuous slash-and-burn agriculture (Laurance *et al.,* 1999, Fu 2003, Giri *et al.,* 2003). The forested regions of South East Asia showed a decline of more than 16 million ha in 1990s, with a yearly loss rate of 1.2% (FAO 2001). Among the mostly affected are biodiversity hotspots of the Philippine archipelago, which contain a high number of endemic species (Brooks *et al.,* 2002). Philippines has one of the most astounding deforestation rates in the most recent decade, with a loss of 30,350 ha every year (Kincaid 2002). Geoanalytics (2003) presented satellite images showing a remaining forest cover of 17.8% with 9.3% as secondary forest and 8.6% as regular forest cover.

Habitat changes have occurred in different parts of the world for over 1000 years, but in more dramatic ways over the last 300-400 years (Essen *et al.,* 1997). Habitat heterogeneity affects the spatial distribution of invertebrates on several spatial scales (Niemela ¨ *et al.,* 1992; Niemela ¨ 1996, 1993). From a biogeographic and nature conservation perspective, understanding the changes in biodiversity within and between habitats is clearly very important. Increased habitat "island" heterogeneity increases the number of habitat edges where different habitat types meet (Murcia 1995), affecting microclimate (Matlack 1993; Chen *et al.,* 1995), which can modify the species composition of two adjacent environments.

Change in land use like forest conversion to agricultural land, has been pinpointed as the leading source of variation in species composition at both local and regional scales (Huston 1993; Myers & Knoll 2001; Adams 2010), and has been influential to the decrease of responsive species like carabid beetles in various parts of the world (Brooks *et al.,* 2002; Kotze & O'Hara 2003; Vanbergen *et al.,* 2010). Carabid beetles are noticeably distributed, and taxonomically acclaimed, with a solid systematics, and their ecological behavior has been widely studied (Lövei & Sunderland 1996; Homburg *et al.,* 2014). Carabid beetles are important for the following reasons; (1) experimental evidence proposes that carabid beetles maybe used as keystone indicators (Kotze *et al.,* 2011); (2) carabids are responsive to anthropogenic induced conditions, such as pesticide use in agro ecosystems or contamination of soils by heavy metals (Menalled *et al.,* 2007; Butovsky 2011); (3) carabid beetles host various species that are representative of a particular habitat types or successional stages, making them promising bio indicators (Lövei & Sunderland 1996); (4) carabids can also perform as early-warning signalers, as suggested by recent studies linking climate and carabid distributions (Gómez *et al.,* 2014; Pozsgai & Littlewood 2014); and (5) Carabids contemplates natural and human-induced disturbances and management (Lövei & Sunderland 1996).

Carabid distribution and environmental structure refer to the structural features of the soil and plants in the carabids' immediate surroundings, as well as other factors that may affect their dispersal (Theil, 1977). Apart from providing economic benefit in agricultural systems, carabids fulfill several environmental tasks within biological systems (Wilson 1987; Isaacs *et al.,* 2009). Because of their limited dispersion mobility on the ground and the fact that many species rely on specific host plants for food and reproduction, changes in plant composition and soil quality as a result of plant invasions may have detrimental consequences for arthropods (Wilson 1987; Kremen *et al.,* 1993; Niemela and Mattson 1996; Tallamy 2004; Burghardt *et al.,* 2008).

Other carabid taxa's distribution, abundance, and reproductive success are likewise influenced by soil conditions such as moisture, ambient temperature, light intensity, and pH, as well as these fundamental changes in community structure because of invasive plants may change environment quantity and quality (Niemela and Mattson 1996, Antvogel and Bonn 2001; de Souza and de Souza Modena 2004; Lassau *et al.,* 2005).

Changes across the edge gradient have been reported for carabid beetles (Coleoptera: Carabidae) across forest-grassland edges (Kotze and Samways 1999; Magura *et al.,* 2001) and forest clear-cut edges (Helio¨la¨ *et al.,* 2001). The ecotone between agricultural land and forest may potentially represent a stricter barrier for carabid beetles than the clear-cut-forest boundary. Carabids associated with closed-canopy habitats can be almost equally abundant in the clear-cuts and in the adjacent mature forests, whereas open-habitat species are restricted to the clear-cuts (Helio¨la¨ *et al.,* 2001). Carabid beetles live in nearly every available habitat, although some species are associated with particular ecosystems, like meadows, woodlands, or crop fields. Due to the habitat specificity of some species, these beetles can be used as biological indicators to assess land use changes among different ecosystems. This paper will look into the distribution of carabid beetles at the open forest and agricultural habitat types and take note of its vegetation and physico-chemical parameters.

In the tropics, there have been little studies on the biodiversity of cleared and fragmented land, compared to temperate places, where there have been numerous studies on the diversity, roles, and interactions in agricultural systems. Carabids are worldwide, with tropical regions having the most species diversity (Erwin 1982). Our understanding, on the other hand, is based on study conducted in temperate northern hemisphere regions, resulting in unavoidable bias. Despite their important function in the environment, ground-dwelling beetles are rarely studied in the northeastern hemisphere, notably in Asia (Magagula 2003, Padayachi *et al.,* 2014). The majority of research focuses on beetles in the northern hemisphere, where their taxonomy and ecology are well-understood (Thiele 1977, Atlegrim *et al.,* 1997, Fahy and Gormally 1998, Jukes *et al.,* 2001, Woodcock *et al.,* 2003).

Although there have been a few studies on ground-dwelling beetles in the Philippines, they have mostly focused on tiger beetles and cannot be used to account for the total quantity and diversity of carabids in the country. Because the Philippines has such a diverse insect population, studying insect diversity is extremely important. According to Baltazar (2001), there are 87 families, 1567 genera, and 7375 species of Coleoptera in the Philippines, with 5840 of them being endemic. However, the Philippines' beetle communities, their conservation status, and the anticipated impact of habitat degradation and anthropogenic activities on these groups have received very little consideration. This, being a pioneer study aims to identify the occurrence and habitat preferences of carabid beetles and analyze species richness, diversity and distribution of carabid beetles in different forests and habitat types in Lake Danao, Mount Ncolod, Kuapnit Balinsasayao, Asug Forest, City Forest, and Closed Canopy Forest in Eastern Visayas to provide baseline data for the conservation of carabid beetles.

Therefore the research objectives is 1. Analyze species richness, diversity and distribution of carabid beetles in selected forests and habitat types. 2. Identify environmental parameters which include soil parameters and vegetation survey. 3. Correlate environmental parameters with species assemblage per habitat.

Materials and methods

Site selection

The study was conducted in selected forests of Eastern Visayas: (1) Lake Danao National Park of Ormoc City, Leyte; (2) Kuapnit Balinsasayao National Forest of Abuyog and Baybay City, Leyte; (3) City Forest and Marble Park in Calbayog City, Samar; (4) Asug Forest Reserve, Biliran; (5) Mount Nacolod Forest in Silago, Southern Leyte; and (6) Borongan-Llorente Closed Canopy Forest in Borongan, Eastern Samar (Fig. 1). These forests were chosen based on (1) slope position (incline extending from ≥8-18% can be utilized for regular and lasting yield generation), (2) cultivated area is located near the forest, (3) portions of the forest have been formed by slash-and-burn practices, and (4) contains areas under current cultivation. These forests are either declared as protected areas or proposed protected areas by the Department of Environment and Natural Resource (DENR) of Eastern Visayas.

Survey methods

Carabid beetles were collected using pitfall trapping and manual collection and/or searching the ground. The pitfall traps were 500-ml plastic containers (11.4cm long x 11.4cm wide x 8cm high) which were half-filled with bait substance and were buried in the ground so that the top of the trap was at the soil surface. One hundred traps were placed in every habitat type at each forest with a total of 200 pitfalls traps placed in every study site.

The traps were arranged in square grids with 20m between adjacent traps to avoid trap interactions (e.g., the "digging in" effect [Hoekman *et al.,* 2017]).

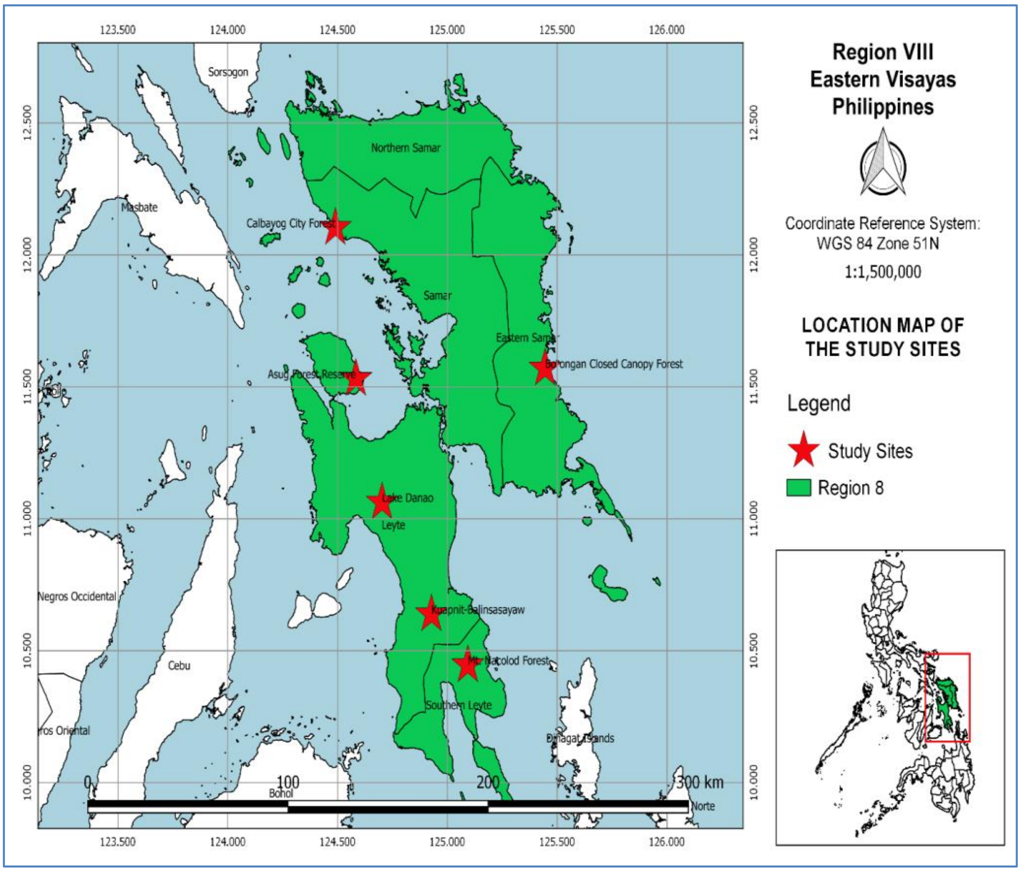

Fig. 1. Map of Region 8 and Location of Study Sites.

After a 2-wk comparison of baits, we decided to use vinegar, vinegar with catsup, fermented fish with vinegar, and ground meat as attractants in the traps. Pitfall traps captured carabid beetles using these bait materials, while previously used baits did not effectively capture any carabid beetles. A 13 x 13cm piece of metal was secured over each trap as a shield from rain, litter, and disturbance by animals. Traps were emptied and refilled twice weekly at which time carabids were collected and returned to the laboratory for sorting and identification.

Meanwhile, hand picking/searching on the ground (GS) was conducted by actively searching for the beetles on the ground, in leaf litter, under logs and other substrates, under tree bark, and in rotting deadwood. Sixty man-hours were spent in active searching for each visit at each site, occurring primarily between 2000 and 2300 h, as most carabid beetles are nocturnal. Collections were made 4 times a month over 6 months (i.e., January-June 2019) for each site. A 0.5-cm mesh screen was used to sift dry leaf litter for carabid beetles. Collecting took place both during the day and at night. All specimens were transferred into a killing agent preservative (9.0:0.5:0.5 parts of 70% ethyl alcohol, table vinegar, ethyl acetate (3:1) as per Hoekman *et al.* (2017).

Vegetation survey

In each study site, 40 x 5m (200m²) (Gillison, 1981, 1988, 2000, 2001a, b) quadrats were established. To estimate plant richness in the open forest, all individuals of trees and shrubs were counted and identified observing the Braun-Blanquet Method. This method is based on 100% identification and listing of all species in the plots. At each plot, data collection was undertaken separately for each of the 3 canopy layers or vegetative stratifications. The vegetative strata used were: 1) ground layer, for plants of up to 2-m high; 2) understory, for plants whose leaf canopy reaches 2-m to 7-m high; and 3) the tree layer, for all plants over 7-m in height. At each layer data collection started with identification of all species present.

For the agricultural land or cultivated area, the plot size of each crop grown as well as single plants (e.g. pineapples, fruit trees, cassava), planted in between the crop patches was considered. The agricultural flora within the field was examined from January to June 2019. Depending on the homogeneity of the fields, a larger or smaller number of quadrates was placed in order to collect data which are representative of the whole area sampled.

Data Analysis

Besides Pielou's evenness index, Simpson's dominance index, and Shannon index of diversity, other measurments of diversity of carabid beetles for each forest were also consulted, namely: Simpson's diversity, Menhinick index and Margalef's index (Simpson 1949), and Sorensen's index of similarity (Sorensen 1948). And before the data were statistically analyzed, the data were first checked for normality, i.e. to guide on the appropriate tests to be employed. Since data obtained is not normally distributed, i.e. data on richness by method per habitat type, thus nonparametric Mann-Whitney U test which is equivalent to the independent two-sample t-test was used. This is an appropriate analysis to compare differences that come from same population when the dependent variable is ordinal (Leech, Barrett & Morgan, 2005). Furthermore, Kruskal-Wallis test was used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. PAST (Version 3.10) RStudio and softwares were used for calculation and plotting (Hammer *et al.,* 2001).

Taxonomic Classification

Identification of carabids was done up to species level if conceivable and was based on accessible published studies (Thiele 1977; Lindroth 1949; Scholtz 2005; Luff 1987; Kirschenhofer 2008; Trautner *et al.,* 1987). After which, identification was affirmed and corrected by Dr. Bernard Lassale, a pioneer of French Entomological Society in France, and Dr. Rainer Schnell, a professor in the University of Duisburg Essen, Germany, who have been identifying and publishing studies about carabid beetles. The voucher samples were stored in the laboratory.

Permit(s)

Prior to the collection of the specimens, Gratuitous Permit (GP) from the DENR was sought. Communication and letter of request were sent to respective municipal mayors and barangay chairpersons where collection was conducted.

Soil analysis and Physico-chemical parameters

For soil analysis, soil samples were taken randomly at each site in about 15cm depth. The samples were mixed together. After air drying, samples were sieved and weighed. Sieving was done using a 2 mm sieve (for pH and phosphorus (P) determination) and a 0.5 mm sieve for organic matter (OM) and nitrogen (N). The chemical analyses were carried out at the Department of Soil Science, VSU (Visayas State University), Leyte, Philippines.

Results and findings

Distribution of Carabid Species Among Sites

In total, 7,844 carabid beetle individuals were collected, belonging to 25 genera and 41 species in the six selected forests of Leyte and Samar. There were 26 species recorded from the forest of Lake Danao, 32 species in Mt. Nacolod, 20 species in Kaupnit Balnsasayao Forest, 11 species in Asug Forest, 19 species in City Forest and 26 species found in Closed Canopy Forest. Mt. Nacolod garnered the most number of individual with 2315 which accounts for 31% of the total carabid beetles collected, followed by Lake Danao and Closed Canopy with 1647 and 1198 individuals accounting for 22% and 16% respectively.

Table 1. Total number of carabid beetles in six selected forests of Leyte and Samar.

Species	Forest Habitats						Total
	LD	MN	KF	AF	CF	CC	
1. *Brachinus leytensis* (*new*)	96	64	27	0	0	0	187
2.*Trigonotoma goeltenbothi*	0	0	1	0	0	0	1
3. *Prothyma heteromallicollis*	0	0	0	39	0	26	65
4. *Pheropsophus uliweberi* (*new*)	55	93	0	0	0	19	167
5. *Pheropsophus* sp. (*new*)	0	1	0	0	1	0	2
6. *Pheropsophus hassenteufeli*	258	431	130	120	112	200	1251
7. *Pheropsophus nigerrimus*	0	1	0	0	0	0	1
8. *Pheropsophus azouleyi*	183	198	136	108	0	0	625
9. *Pheropsophus fumigatus*	1	1	0	0	0	0	2
10. *Pheropsophus lumawigi*	128	167	73	41	51	36	496
11. *Neocollyris filicornis*	0	0	0	0	50	44	94
12. *Therates fasciatus quadrimaculatus*	57	79	0	0	0	17	153
13. *Lesticus samarensis*	0	0	0	0	83	75	158
14. *Pseudozaena orientalis opaca*	0	32	0	0	69	79	180
15. *Orthogonius luzonicus*	0	0	0	0	43	34	77
16. *Chlaenius* sp.1	44	71	0	0	24	17	156
17. *Chlaenius* sp.2	56	0	0	0	0	11	67
18. *Chlaenius* sp.3	0	61	0	0	0	11	72
19. *Gnathaphanus impressipennis*	53	0	0	0	0	33	86
20. *Tricondyla aptera punctipennis*	213	402	120	181	121	112	1149
21. *Tricondyla ovicollis*	87	151	77	103	111	122	651
22. *Tricondyla conicicollis*	74	185	110	130	125	95	719
23. *Haplochlaenius femoratus philippinus*	55	63	36	41	0	0	195
24. *Oodes* sp.	0	0	15	0	0	20	35
25. *Trichotichnis* sp.	0	0	14	0	0	21	35
26. *Lebia Poecilothais sp*	0	42	0	0	0	0	42
27. *Pentagonica ruficollis*	32	32	0	0	0	15	79
28. *Catascopus elegans*	16	21	0	0	0	0	37
29. *Catascopus aequatus*	0	19	0	0	0	0	19
30. *Therates fasciatus pseudolatreillei*	54	32	0	0	0	0	86
31. *Pentagonica* sp.	53	0	5	0	0	6	64
32. *Drypta lineola philippinensis*	0	0	28	0	51	92	171
33. *Dicranoncus philippinensis*	0	21	36	14	39	65	175
34. *Dolichoctis gilvipes*	0	31	37	0	0	0	68
35. *Paratachys leytensis*	0	0	27	0	0	0	27
36. *Tachys* sp. 1	36	0	31	0	39	26	132
37. *Tachys* sp. 2	0	0	4	0	0	0	4
38. *Thopeutica sp.*	32	33	6	0	51	0	122
39. *Prothyma sp.*	29	32	0	1	0	20	82
40. *Cicindela* sp. 1	30	41	0	0	19	0	90
41. *Cicindela* sp. 2	0	4	0	0	0	0	4
42. Unidentified sp. 1	1	0	0	0	0	1	2
43. Unidentified sp. 2	1	0	0	0	0	0	1
44.Unidentified sp. 3	0	1	0	0	1	1	3
45. Unidentified sp. 4	0	2	0	0	0	0	2
46. Unidentified sp. 5	2	1	1	0	0	0	4
47. Unidentified sp.6	1	0	0	1	0	0	2
48. Unidentified sp. 7	0	2	0	0	0	0	2
49. Unidentified *sp. 8*	0	0	0	0	1	0	1
50. Unidentified sp. 9	0	1	0	0	0	0	1
Total	*1647*	2315	914	779	991	1198	7844

Legend: LD-Lake Danao, MN- Mount Nacolod, KF-Kuapnit Forest, AF-Asug Forest, CF-City Forest, CC-Closed Canopy

Out of 7844 individuals, 1251 were Pheropsophus hassenteufeli, 1149 were Tricondyla aptera punctipennis, 719 were Tricondyla conicicollis, 651 were Tricondyla ovicollis, 625 were Pheropsophus azouleyi, and 496 were Pheropsophus lumawigi, respectively, accounting for 19.54, 14. 64, 9.2, 8.30, 7.97, and 6.32% of the total number of carabid beetles collected. These were the top most species with the highest number of individuals all throughout the forests and were considered dominant species. All the remaining species comprising less than 5% were considered common and rare species.

Table 2. Measures of richness, diversity, dominance, and evenness of carabids in six forest ecosystems in Leyte and Samar.

Indices	Forest Habitats					
	LD	MN	KF	AF	CF	CC
Number of individuals	1647	2315	914	779	991	1198
Number of species	26	32	20	11	19	26
Simpson's Dominance	0.08	0.096	0.097	0.15	0.08	0.077
Simpson's Diversity	0.92	0.904	0.903	0.85	0.92	0.923
Shannon-Weiner	2.798	2.709	2.538	2.017	2.589	2.828
Evenness	0.63	0.469	0.633	0.683	0.74	0.65
Menhinick	0.64	0.66	0.66	0.39	0.57	0.75
Margalef	3.375	4.00	2.787	1.502	2.464	3.527

Legend: LD-Lake Danao, MN- Mount Nacolod, KF-Kuapnit Forest, AF-Asug Forest, CF-City Forest, CC-Closed Canopy

As reflected in Table 2, of the six forest, Mt. Nacolod had comparatively high diversity (4.00). equitability (0.78), dominance (2.709), and species richness (32); Lake Danao and Closed Canopy forests had almost the same values in high diversity (3.37), equitability (0.86), dominance (2.798), and species richness (26). Indices for Kuapnit and City forests did not differ significantly, both have low diversity (2.787 and 2.464), high equitability (0.85 and 0.89), dominance (2.53 and 2.58), and species richness (20 and 19), but were relatively lower than Mount Nacolod. Asug forest got the lowest indices value for both dominance, diversity and species richness.

Table 3. Total number of carabid beetles in natural forest and agricultural land habitats.

Species	Habitat Type		Total
	Open Forest	Agricultural	
1. Brachinus leytensis (new)	102	85	187
2.Trigonotoma goeltenbothi	1	0	1
3. Prothyma heteromallicollis	65	0	65
4. Pheropsophus uliweberi (new)	73	94	167
5. Pheropsophus sp. *(new)*	2	0	2
6. Pheropsophus hassenteufeli	486	765	1251
7. Pheropsophus nigerrimus	1	0	1
8. Pheropsophus azouleyi	277	348	625
9. Pheropsophus fumigatus	1	1	2
10. Pheropsophus lumawigi	200	296	496
11. Neocollyris filicornis	43	51	94
12. Therates fasciatus quadrimaculatus	71	82	153
13. Lesticus samarensis	68	90	158
14. Pseudozaena orientalis opaca	91	89	180
15. Orthogonius luzonicus	77	0	77
16. Chlaenius sp. 1	61	95	156
17. Chlaenius sp. 2	28	39	67
18. Chlaenius sp. 3	40	32	72
19. Gnathaphanus impressipennis	37	49	86
20. Tricondyla aptera punctipennis	447	702	1149
21. Tricondyla ovicollis	320	331	651
22. Tricondyla conicicollis	247	472	719

Species	Habitat Type		Total
	Open Forest	Agricultural	
23. *Haplochlaenius femoratus philippinus*	195	0	195
24. *Oodes* sp.	35	0	35
25. *Trichotichnis sp.*	35	0	35
26. *Lebia Poecilothais* sp.	42	0	42
27. *Pentagonica ruficollis*	36	43	79
28. *Catascopus elegans*	18	19	37
29. *Catascopus aequatus*	19	0	19
30. *Therates fasciatus pseudolatreillei*	36	50	86
31. *Pentagonica sp.*	64	0	64
32. *Drypta lineola philippinensis*	82	89	171
33. *Dicranoncus philippinensis*	175	0	175
34. *Dolichoctis gilvipes*	68	0	68
35. *Paratachys leytensis*	10	17	27
36. *Tachys* sp. 1	61	71	132
37. *Tachys* sp. 2	4	0	4
38. *Thopeutica* sp.	53	69	122
39. *Prothyma* sp.	38	44	82
40. *Cicindela* sp. 1	42	48	90
41. *Cicindela* sp.2	4	0	4
42. Unidentified sp. 1	2	0	2
43. Unidentified sp. 2	1	0	1
44. Unidentified sp. 3	2	1	3
45. Unidentified sp. 4	2	0	2
46. Unidentified sp. 5	3	1	4
47. Unidentified sp.6	2	0	2
48. Unidentified sp. 7	2	0	2
49. Unidentified sp. 8	1	0	1
50. Unidentified sp. 9	1	0	1
Total number of individuals	3771	4073	7844

A total of 41 species belonging to 25 genera in two subfamilies were identified among 3,771 carabids collected from an open forest of six selected forests of Leyte and Samar. In agricultural habitat type, there were 28 species identified from 4, 073 carabid beetles. Species like *Trigonotoma goeltenbothi, Prothyma heteromallicollis, Pheropsophus sp., Pheropsophus nigerrimus, Orthogonius luzonicus, Haplochlaenius femoratus philippinus, Oodes sp., Trichotichnis sp., Lebia Poecilothais sp., Catascopus aequatus, Pentagonica sp., Dicranoncus philippinensis, Dolichoctis gilvipes, Tachys sp., and Cicindela sp*. were exclusively found in an open forest. The rest of the species were both found in open forest and agricultural land

Both the open forest and agricultural sites were dominated by *Pheropsophus hassenteufeli* and *Tricondyla aptera punctipennis* (20% and 16.51%, respectively). Twelve species accounted for less than 5% of the caught (less than approximately 50 individuals) (Table 3.). In agricultural lands, *Pheropsophus hassenteufeli, Pheropsophus azouleyi, Tricondyla aptera punctipennis, Tricondyla conicicollis, and Pheropsophus lumawigi* were relatively abundant species than in open forests.

Natural forest had comparatively high diversity (5.95), high equitability (0.80), dominance (3.1), and species richness (41) over agricultural land. The use of Mann-Whitney U test between richness of forest and agricultural land showed significant, i.e. p-value = 0.01722, indicating that the mean abundance of forest richness is significantly different from the mean abundance of agricultural richness. Along with other factors, these habitat parameters are influenced by the nature of the vegetation. In this study, no correlation was shown between the number of species and different physico-chemical parameters. The result of the correlation test indicates that the number of carabid species is not due to any of the physico-chemical parameters, such as pH,% OM. Total N, available P, and exchange K.

Different forest eosystems as study sites in this study showed different values in soil physico chemical paramters. In terms of pH, Kuapnit forest garnered the highest value, around 7.1, followed by Lake Danao with 5.6. Closed Canopy and Mt. Nacolod almost have the same pH with 5. City forest has a pH of 4.8 and Asug forest has the lowest pH recorded at 4.5. For the result of organic matter (%OM), both Lake Danao and Mt. Nacolod have 5.0, showing a higher percentage over the other forests. Available phosphorus in soil showed that Kaupnit forest has the highest at 139.507mg/kg, followed by City forest, Closed Canopy, Asug forest, and Mt. Naccolod respectively. For the total N, Lake Danao garnered the highest value of 0.449%, followed by Kaupnit forest with 0,424%, Closed canopy with 0.128%, Asug forest with 0.122; lagging behind are Mt. Nacolod and City forest with 0.116% and 0.105%, respectively. For the parameter of exchange K, it showed that Kaupnit forest has the highest value with 411.350mg/kg, Lake Danao with 373.580mg/kg, followed by Asug forest, City forest, Closed Canopy, and Mt. Nacolod with 147.795, 135.050, 121.973, and 70.911mg/kg, respectively.

Discussion

One of the most important variables impacting species diversity in an area is different habitat types. The differences in species composition and diversity of carabid beetles in different habitat types among selected forests of Leyte and Samar were presented in this study. The diversity of ground beetle species was higher in open forests than in cultivated fields. This result is consistent with the findings of other studies (Fahy and Gormally 1998, Magura *et al.,* 2003, Finch 2005). where open forest yielded a higher number of carabid beetle species than agricultural fields, and that this result was consistent across the six open forest ecosystems studied; Yu *et al.* (2009) and Warren-Thomas *et al.* (2014), who found that open oak forest in northern China, North America, and Europe showed higher diversity than cultivated farmlands Farmland, an agricultural habitat type, with a community structure that differed from forest habitats in terms of vegetation and microenvironmental circumstances due to human influence such as plowing and sowing (Rusch *et al.,* 2013), impacts of different crops (Liu *et al.,* 2010), and application of fertilizers (Schröter and Irmler 2013).

The agricultural environment type had a higher abundance but lesser diversity, as well as high uniformity and dominance indices, in this study. A total of 28 species were recognized from a total of 4,073 individuals, which is significantly less than the 41 species discovered from 3,771 individual carabids in an open forest. This is due to an increase in the number of species, which results in less equitability and dominance. *Pheropsophus hassenteufeli* and *Tricondyla aptera punctipennis*, for example, accounted for 38% of all agricultural carabids, demonstrating the sensitivity of the diversity index to changes in species abundance, as well as the fact that abundance has a direct impact on community structure and biodiversity. The number of ground beetles and the species composition vary by habitat type and are influenced by edaphic factors (Bukejs and Balalaikins, 2008). Because many species are adapted to agriculture and occur in high quantities, carabid beetle species contribute greatly to insect diversity in farms (Booij, 1994). According to Thiele (1977) and Kromp (1999) cultivated land is comprised of widely distributed, eurytopic ground beetle species, many of which have high tolerance to disturbances.

In the present study, the main reason for the low species diversity towards agricultural field was assumed to be the loss of micro habitats towards the agricultural land. In the forest the vegetation is composed of trees, bushes, ferns, epiphytes and undergrowth vegetation which in total provides a manifold structure of plant organs from the bottom up to the canopy, thus a high number of micro habitats. In the agricultural land, a smaller number of habitats is composed by similar crop plants and weeds. Similarly, but only regarding Lepidoptera, Schulze *et al.* (2004) reported a decrease in diversity from the forest towards the agricultural field, when sampling the abundance of Lepidoptera species richness from an open forest towards maize fields on Sulawesi. With regards to carabid beetles, Baranová *et al.* (2013) found a significant lower diversity of species in cultivated land, compared to primary forest. They also related the loss of carabid species in the modified habitats of the agricultural land to a loss of microhabitats.

Furthermore, the current study's drop in carabid richness in agricultural fields is believed to be linked to changes in ecosystem features produced by agricultural practices. This decrease in species richness from open forest to cultivated areas is consistent with several published studies (Bonham *et al.,* 2002; Finch 2005; Vanbergen *et al.,* 2005; Packeman & Stokan 2014). Also, microclimatic factors such as soil water content and ground surface temperature affect carabid beetle richness and composition (G. Lövei and K. D. Sunderland, 1996). Carabid beetles have been proposed as valuable bioindicators of environmental change because of their tight relationships with vegetation structure experiencing natural and human changes, as well as the microclimatic fluctuations associated with such changes (Niemelä *et al.,* 2002). Although there was no correlation between the number of species and soil parameters in the current study, the species composition of carabid beetles has been shown to change across habitats characterized by different vegetation structures, such as the presence of a tree canopy or forest type, which is similar to the result of Isaia, M. as well as others (2015).The richer vegetation found in natural forest compared to limited number of crops in the agricultural land could be the factor resulting to a higher species diversity in the forests than in agricultural land. Habitat type is in that case more influential.

Differences in ground beetle assemblages between forest types or management regimes have been widely examined but only rarely at national, regional, or larger spatial scales (Kotze and O'Hara 2003). This study involving forests of Leyte and Samar, to the best of my knowledge, represents the first study of carabid beetle communities in Region 8. The recorded 41 species with 9 species still to be identified, under 25 genera will be used as a substantial baseline information about carabid beetle's diversity and community structure.

Conclusion and recommendations

The findings of this study indicate that open forests do indeed represent important vestiges for biological diversity. The carabid communities of open forests are distinct from those of agricultural land. Forests are the home to more species and individuals of carabid beetles than agricultural land. Results of this study underline the implications of converting natural forests to agricultural land on carabid biodiversity. Carabid assemblages in natural forests were species rich, and converting natural forests decrease biodiversity. Decrease in carabid richness may be used as an indicator for biodiversity loss when natural and open forests are being converted to agricultural lands. Species in agricultural land had a different species composition and a considerably lower species richness which decreased with vegetation, ground cover and plant richness. Not all carabid beetle species are able to maintain viable populations in these altered ecosystems. The adverse effects of converting natural and forests with agricultural land underscores the importance of forest management and conservation of biodiversity. Conservation should be conducted to the carabid beetles especially the rare and endemic ones in some forests. Strengthened implementation of protection in both protected landscapes against mining, illegal logging, slash and burn farming and human settlements should also be done.

References

Adams J. 2010. Species Richness-Patterns in the Diversity of Life. Praxis Publishing Ltd, Chichester, UK.

Antvogel H, Bonn A. 2001. Environmental Parameters and Microspatial Distribution of Insects: A Case Study of Carabids in an Alluvial Forest. Ecography **24,** 470-482.

Atlegrim O, Sjoberg K, Ball JP. 1997. Forestry effects on a boreal ground beetle community in spring: Selective logging and clear-cutting compared. Biodiversity and Conservation **12,** 487-506.

Baltazar CR. 2001. Directions of Systematic Entomology in the Philippines. Tra11s. Nall. Acad. Sci. & Tech., Philippines (2001) **23,** 95-104

Baranová B, Fazekašová D, Jászay T, Manko P. 2013. Ground beetle (Coleoptera: Carabidae) community of arable land with different crops. - Folis faunistica Slovaca **18(1),** 21-29.

Bond W, Slingsby P. 1984. Collapse of an ant-plant mutualism: the argentine ant (*Iridomyrmex humilis*) and myrmecochorous proteaceae. Ecology **65,** 1031-1037

Bonham KJ, Mesibov R, Bashford R. 2002. Diversity and abundance of some ground-dwelling invertabrates in plantation vs. native forest in Tasmania. Aust. For. Ecol. Manage **158,** 237-247.

Brooks TM, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Rylands AB, Konstant WR, Flick P, Pilgrim J, Oldfield S, Magin G, Hilton-Taylor C. 2002. Habitat loss and extinction in the hotspots of biodiversity. Conservation Biology **16,** 909-923.

Burghardt KT, Tallamy DW, Shriver WG. 2008. Impact of native plants on bird and butterfly biodiversity in suburban landscapes. Conservation Biology **23,** 219-224.

Chen J, Franklin JF, Spies TA. 1995. Growing-season microclimatic gradients from clearcut edges into old-growth Douglas-fir forests. Ecol. Appl. **5,** 74-86

de Souza ALT, de Souza Modena E. 2004. Distribution of spiders on different types of inflorescences in the Brazilian pantanal. The Journal of Arachnology **32,** 345-348.

Detwiler RP, Hall AS. 1988. Tropical Forest and the Global Carbon Cycle. Science **329,** 42-47.

Erwin TL. 1982. Tropical forests: their richness in coleoptera and other arthropod species. The Coleopterist Bulletin **36,** 74-75.

Esseen PA, Ehnstro¨ m B, Ericson L, Sjo¨ berg K. 1997. Boreal forests. Ecol. Bull. **46,** 16-47

Fahy O, Gormally M. 1998. A comparison of plant and carabid beetle communities in an Irish oak woodland with a nearby conifer plantation and clearfelled site. Forest. Ecol. Manag **110,** 263-273.

Finch OD. 2005. Evaluation of mature conifer plantations as secondary habitat for epigeic forest arthropods (Coleoptera: Carabidae; Araneae). Forest. Ecol. Manag **204,** 23-36.

Gillison AN. 1981. Towards a functional vegetation classification. In: A.N. Gillison and D.J. Anderson (eds.) Vegetation Classification in Australia, pp.30-41. Commonwealth Scientific and Industrial Research Organization & Australian National University Press, Canberra.

Gillison AN. 1988. A Plant Functional Proforma for Dynamic Vegetation Studies and Natural Resource Surveys. Tech. Mem. 88/3, Commonwealth Scientific and Industrial Research Organization Div. Water Resources, Canberra.

Gillison AN. 2000. Rapid vegetation survey. In: A.N. Gillison (Coord.) Above-ground Biodiversity assessment Working Group Summary Report 1996-99 Impact of different land uses on biodiversity. pp. 25-38. Alternatives to Slash and Burn project. ICRAF, Nairobi.

Gillison AN. 2001a. Vegetation Survey and Habitat Assessment of the Tesso Nilo Forest Complex; Pekanbaru, Riau Province, Sumatra, Indonesia. Report prepared for WWF-US. (October-November, 2001).

Gillison AN. 2001b. Promoting biodiversity conservation and sustainable use in the frontier forests of Northwestern Mato Grosso: Bioregional assessment, land use and zoning for biodiversity conservation. Report prepared for UNDP/GEF and PróNatura (August, 2001).

Groombridge B. 1992. Global biodiversity: status of the earth's living resources Chapman & Hall, London.

Hammer O, Harper DA, Ryan PD. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontol. Electron **4,** 1-9

Hansson L. 1992. Landscape ecology of boreal forests. Trends Ecol. Evol **7,** 299-302

Helio¨ la¨ J, Koivula M, Niemela¨ J. 2001. Distribution of carabid beetles (Coleoptera: Carabidae) across boreal forestclearcut ecotone. Conserv. Biol **15,** 370-377.

Hoekman D, LeVan KE, Ball GE, Browne RA, Davidson RL, Erwin TL, Knisley CB, LaBonte JR, Lundgren J, Maddison DR, Moore W, Niemel€a J, Ober KA, Pearson DL, Spence JR, Will K, Work T. 2017. Design for ground beetle abundance and diversity sampling within the National Ecological Observatory Network. Ecosphere **8(4),** e01744.10.1002/ecs2.1744

Huston MA. 1993. Biological Diversity: The Coexisence of Species on Changing Landscapes. Cambridge University Press, Cambridge, UK

Isaacs R, Tuell J, Fiedler A, Gardiner M, Landis D. 2009. Maximizing arthropod mediated ecosystem services in agricultural landscapes: the role of native plants. Frontiers in Ecology and the Environment **7,** 196-203.

Isaia MM, Paschetta Gobbi M, Zapparoli M, Chiarle A, Vigna Taglianti A. 2015. "Stand maturity affects positively ground-dwelling arthropods in a protected beech forest," Annals of Forest Science**72(4),** pp. 415-424.

Jukes MR, Peace AJ, Ferris R. 2001. Carabid beetle communities associated with coniferous plantations in Britain: The influence of site, ground vegetation and stand structure. Forest Ecology and Management **148,** 271-286

Kirschenhofer E. 2008. Neue und wenig bekannte Arten sowie drei neue Synonyme (Tribus Chlaeniini) der palaarktischen, orientalischen und himalayanischen Region. (Coleoptera: Carabidae). Acta Coleopterologica **24(3),** 3-34.

Kotze DJ, Samways MJ. 1999. Invertebrate conservation at the interface between the grassland matrix and natural Afromontane forest fragments. Biodivers. Conserv **8,** 1339-1363.

Kotze DJ, O'Hara RB. 2003. Species decline—but why? Explanation of carabid beetle (Coleoptera: Carabidae) declines in Europe. Oecologia **135,** 138-148

Kremen C, Colwell RK, Erwin TL, Murphy DD, Noss RF, Sanjayan MA. 1993. Terrestrial arthropod assemblages: their use in conservation planning. Conservation Biology **7,** 796-808.

Lassau SA, Hochuli DF, Cassis G, Reid CAM. 2005. Effects of habitat complexity on forest beetle diversity: do functional groups respond consistently? Diversity and Distributions **11,** 73-82.

Laurance WF. 1999. Reflections on the tropical deforestation crisis. Biological Conservation **91,** 109-117.

Leech NL, Barrett KC, Morgan GA. 2005. SPSS for Intermediate Statistics, Use and Interpretation. 2nd Edition, Lawrence Erlbaum Associates Inc., Mahwah.

Lindroth CH. 1949. Die Fennoskandischen Carabiden, Part 3, Algemeiner Teil. Stockholm; Bröderna Lagerström Boktrychare.

Liu YH, Axmacher JC, Wang CL, Li LT, Yu ZR. 2010. Ground beetles (Coleoptera: Carabidae) in the intensively cultivated agricultural landscape of Northern China a implications for biodiversity conservation. Insect. Conserv. Diver **3,** 34-43.

Lövei GL, Sunderland KD. 1996. Ecology and behavior of ground beetles (Coleoptera: Carabidae). Annual Review of Entomology **41(1),** 231-256.

Luff ML. 1987. Biology of polyphagous ground beetles in agriculture. Agric Zool Rev **2,** 237-278.

Magagula CN. 2003. Changes in carabid beetle diversity within a fragmented agricultural landscape. African Journal of Ecology **41,** 23-30

Magura T, Tóthmérész B, Ele Z. 2003. Diversity and composition of carabids during a forestry cycle. Biol. Conserv **12,** 73-85.

Magura T, To´ thme´ re´ sz B, Molna´ r T. 2001. Forest edge and diversity: carabids along forest-grassland transects. Biodivers. Conserv **10,** 287-300.

Matlack GR. 1993. Microenvironment variation within and among forest edge sites in the eastern United States. Biol. Conserv **66,** 185-194.

Murcia C. 1995. Edge effects in fragmented forests: implications for conservation. Trends Ecol. Evol **10,** 58-62.

Myers N, Knoll AH. 2001. The biotic crisis and the future of evolution. Proceedings of the National Academy of Sciences of the United States of America **98,** 5389-5392.

NiemeIa J, Halroe E. 1992. Habitat associations of carabid beetles in fields and forests on the Aland Islands, SW Finland. Ecography, 15, 3-11. ZooKeys **147,** 497-526.

Niemela JP, Mattson WJ. 1996. Invasion of North American forests by European phytophagous insects. BioScience **46,** 741-753.

Niemela J, Spence R, Langor D, Haila Y, Tukia H. 2002. Logging and boreal ground-beetle assemblages on two continents: implications for conservation. pp.29-50. In K. J. Gaston, T. R. New, and M. J. Samways (eds). Perspectives on Insect Conservation. Intercept Ltd, Andover.

Niemela J. 1993. Mystery of the missing species: species-abundance distribution of boreal ground-beetles. Ann Zool Fenn **30,** 169-172

Padayachi Y, Proches S, Ramsay LF. 2014. Beetle assemblages of indigenous and Alien decomposing fruit in subtropical Durban, South Africa. Arthropod-Plant Interactions **8,** 21-28

Pakeman RJ, Stockan JA. 2014. Drivers of carabid functional diversity: abiotic environment, plant functional traits, or plant functional diversity? Ecology **95(5),** 1213-1224.

Raven PH. 1980. Research Priorities in Tropical Biology. National Academy of Science Press, Washington DC.

Rusch A, Bommarco R, Chiverton P, Öberg S, Wallin H, Wiktelius S, Ekbom B. 2013. Response of ground beetle (Coleoptera, Carabidae) communities to changes in agricultural policies in Sweden over two decades. Agr. Ecosyst. Environ. **176,** 63-69.

Scholtz CH, Grebennikov VV. 2005. Scarabaeiformia Crowson, 1960. Pp. 345-366. In R. G. Beutel and R. A. B. Leschen (eds). Coleoptera, Beetles, Volume1. Morphology and Systematics (Archostemata, Adephaga, Myxophaga, Polyphagapartim). Walter de Gruyter, Berlin.

Schröter L, Irmler U. 2013. Organic cultivation reduces barrier effect of arable fields on species diversity. Agr. Ecosyst. Environ **164,** 176-180.

Schulze CH. 2004. Auswirkungen anthropogener Störungen auf die Diversität von Herbivoren - Analyse von Nachtfalterzönosen entlang von Habitatgradienten in Ost-Malaysia. Ph.D., University of Bayreuth

Seastedt TR, Crossley DA, Jr. 1984. The influence of arthropods on ecosystems. BioScience **34,** 157-161.

Simpson EH. 1949. Measurement of diversity. Nature **163,** 688-688. doi:10.1038/163688a0.

Tallamy DW. 2004. Do alien plants reduce insect biomass? Conservation Biology **18,** 1689-1692

Thiele HU. 1977. Carabid beetles in their environments. Berlin, Heidelbelg, New York: Springer-Verlag p. 369

Townsend CR, Begon M, Harper JL. 2008. Essentials of Ecology 3rd ed. Blackwell Publishing. Malden, USA.

Trautner J, Geigenmüller K. 1987. Sandlaufkäfer Laufkäfer. J. Margraf Publisher, Aichtal 488.

Vanbergen AJ, Woodcook BA, Watt AD, Niemel€a J. 2005. Effect of land-use heterogeneity on carabid communities at the landscape scale. Ecography **28,** 3-16.

Warren-Thomas E, Zou Y, Dong LJ, Yao XN, Yang MJ, Zhang XL, Qin Y, Liu YH, Sang WG, Axmacher JC. 2014. Ground beetle assemblages in Beijing's new mountain forests. Forest. Ecol. Manag **334,** 369-376.

Wilson JS. 1992. The diversity of life. W.W. Norton & Company, New York.

Wilson EO. 1987. The little things that run the world (the importance and conservation of invertebrates). Conservation Biology **1,** 344-346.

Woodcock BA, Leather SR, Watt AD. 2003. Changing management in Scottish birch woodlands: a potential threat to local invertebrate biodiversity. Bull Entomol Res. **2,** 159-67