Research Article

Competence of Litter Ants for Rapid Biodiversity Assessments

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Rapid Biodiversity Assessment approaches associated with focusing taxa have overcome many of the problems related to large scale surveys. This study examined the suitability of litter ants as a focusing taxon by checking whether diversity and species assemblages of litter ants reflect the overall picture of arthropod diversity and assemblages in leaf litter in two vegetation types: secondary forest and pine plantation in Upper Hanthana forest reserve, Sri Lanka. In each vegetation type, arthropods were sampled using three sampling methods (Winkler extraction, hand collection, and pitfall traps) along three 100 m line transects. From the two sites, 1887 litter ants (34 species) and 3488 litter arthropods (52 species) were collected. Species assemblages composition of both ants and other arthropods differed significantly between the two sites (ANOSIM, $p = 0.001$) with both groups generating distinct clusters for the two sites (SIMPROF, $p = 0.001$). But there was no significant correlation ($p > 0.05$) between abundance and richness of litter ants and those of other arthropods in both vegetation types. The overall finding suggests that the litter ants do not reflect the holistic picture of arthropod diversity and assemblages in leaf litter, but the quality of the habitat for the survival of all litter arthropods.

1. Introduction

The term "biodiversity monitoring" can literally mean "observing the variety of life and assume that its aim is to following variations in the biological unity of ecosystems" [1]. The multicellular taxa are the most common operational units for measuring biodiversity [2]. Majority of these operational units are invertebrates, such as insects and other arthropods. Invertebrates are considered as powerful monitoring tools in environmental management because of their high abundance, diversity, functional importance, sensitivity to perturbation, and their ease of sampling [3]. Due to their high dominance and importance, biodiversity monitoring programs can become not sensible without the incorporation of invertebrates [4]. Sampling entire invertebrate assemblages is the most dependable way of monitoring their biodiversity, but inexorably this sampling process includes large numbers and a vast variety of specimens. Though there are advanced computer aided processing systems which facilitate the management of such samples [5], the effectiveness of an "entire assemblage" approach is controversial [6]. Other than that, the inclusion of invertebrates in environmental monitoring programs is too difficult and not cost effective for a number of reasons. In addition, it becomes problematic for countries which are in a situation of "taxonomic impediment" [7]: the lack of taxonomic knowledge, trained taxonomists, curators, and reference collections identified by experts.

Rapid Biodiversity Assessment (RBA) approaches have overcome many of the problems related to large scale invertebrate surveys. Reducing the effort or cost of sampling and to condense complicate ecological details by nonprofessionals are the main objectives of RBA. But few scientists have claimed that RBA approaches are not that sensitive to give precise information about species abundances in a particular habitat [8, 9]. However, errors associating RBA sampling were generally small, narrowly distributed, or rare [10]. There are four general categories of RBA approaches: (1) sampling surrogacy (restricted sampling in place of intensive sampling), (2) species surrogacy (use of taxonomic levels higher than species, i.e., families, orders), (3) taxonomic surrogacy (use of recognizable taxonomic units identified by nonspecialists), and (4) taxon focusing (use of surrogate taxa in place of all taxa) [11].

Taxon focusing includes a range of approaches that aim to identify a species, or a group of species that act as a surrogate for a wider range of taxa (such as keystone species, umbrella species, and indicators). Among them "biodiversity indicators" are statistical measures of biodiversity which help scientists, managers, and politicians understand the condition of biodiversity and the factors that affect it [12].

In the northern hemisphere, the most widely used invertebrate indicator is beetles, especially Carabidae [13, 14]. Other invertebrate groups, such as spiders [15], grasshoppers [16], and moths [17], have also been proposed as potentially useful indicators in many countries, but they still suffer from poor knowledge of them.

Many biodiversity studies are conducted at different localities using ants as bioindicators [18, 19]. Ants have numerous attributes that highlight them as indicator taxa for conservation practices [20]. Among those are (1) their high diversity, and numerical and biomass dominance in terrestrial habitats throughout the world, (2) being an easily collected and sampled group with statistically representative samples within a short time period, (3) being highly sensitive to environmental changes, and (4) having short generation times and responding quickly to ecological changes [21].

Ants are the most common bioindicators in Australia for many years [1] and have been considered for use in other areas of the world as well [18, 19]. Although they are now commonly used throughout Australia, parts of Africa, North and South America, Europe, and Asia, few data [22] are available to test their effectiveness as biodiversity indicators, particularly in relation to the potential value of other taxa.

Ants are the most common group of invertebrates in many terrestrial habitats in Sri Lanka. The study done by Dias [23] reported 215 species of ants belonging to 63 genera in 12 subfamilies. Although a considerable amount of literature is available on ants of Sri Lanka, none of the studies have tested the effectiveness of ants as biodiversity indicator and their importance for RBAs. This study examined the suitability of litter ants as a focusing taxon by checking whether diversity and species assemblages of litter ants reflect the overall picture of arthropod diversity and assemblages in leaf litter in two vegetation types in Upper Hanthana forest reserve, Sri Lanka.

2. Materials and Methods

2.1. Study Sites. Hanthana hill range lies within the Kandy district (7°-15′N, 80°-45′E) in the mid country wet zone of the island. It is approximately 4 km to the southwest of Kandy city and extends from Hindagala to Peradeniya more or less parallel to the Mahaweli River. Generally, a tropical hot humid climate prevails in the area. The mean annual temperature is 24.1°C and mean annual rainfall is 2121 mm (source: Natural Resources Management Center, Peradeniya).

Vegetation of Hanthana can be categorized into six different types: *Albizia* woodland (12.5%, introduced as a shade tree for tea), *Alstonia* woodland (5%), mixed species woodland (18%), pine woodland (23%), Patana grasslands (39.5%), and patches of undisturbed natural forest (2%) [24]. During the British colonial period, lower and upper lands of Hanthana forest were cleared first for coffee and later for tea and rubber plantations. In 1946, when the University of Peradeniya acquired the lands, most parts were devoid of natural vegetation. Establishment of pine plantations started in 1980. Restoration of plant diversity in pine plantations in Lower Hanthana was initiated in 2002 [25]. Though people have no access to this site, legal and illegal wood extraction and forest fires are major threats to the Hanthana forest reserve. Among several vegetation types in Hanthana forest reserve, this study was conducted in pine plantation (7.246413°N, 80.612706°E and elevations 700–800 m) and secondary forest in the mixed species woodland (7.247195°N, 80.613768°E, and elevations 700–800 m) (Figure 1).

2.2. Collection of Litter Ants and Other Arthropods. The study was conducted for a period of six months (as one visit per month) from January to June 2014. Each site was visited three times for sampling from 9.00 am to 2.00 pm. Litter ants and other arthropods were collected using three established methods: pitfall traps, Winkler extraction, and hand collection. In each visit, a 100 m line transect was laid within the forest (Figure 2).

Hand collection and litter sifting were done in six $1\,\text{m}^2$ quadrates placed 20 m apart along both sides of each transect. Along one side of each transect, leaf litter in six $1\,\text{m}^2$ quadrats were collected and sifted using a litter sifter [26]. A layer of leaves and detritus which can readily be scraped away from the more compact soil was defined as litter. The sifted material was collected into separate bags and brought to the laboratory. In the laboratory, the sifted material was transferred to 4 mm mesh inlet sacks, and sacks were placed inside mini-Winkler sacks. Mini-Winkler sacks were hung for 24 hours [26, 27] for invertebrates to fall to containers filled with 70% alcohol. Hand collection was performed in the six $1\,\text{m}^2$ quadrats on the other side of the transect. Small quantities of litter and top humus layer were collected at a time onto a white tray and were examined for ants/other arthropods until all the individuals within the quadrat were collected. Arthropods collected in such a way using forceps and brushes were stored in labeled vials filled with 70% alcohol. Additionally, arthropods were collected randomly outside the transect using six pitfall traps placed two meters away on either side of each transect. Pitfall traps were made of plastic cups (~3 inches in height) containing 10% ethanol to fill 1/3rd of the bottom of the cups which were inserted in to the ground for 24 hours. Arthropods collected were preserved in 70% alcohol in labeled vials. Field visits were planned according to the climatic information in the study areas to avoid rainy days. During rainy months, sampling was done at least two days after heavy rains. This was to make sure that small arthropods would not stick to the water film on leaves and could easily be collected using Winkler extraction method.

Arthropods were identified to order level using keys and descriptions given by Bland and Jaques [28]. Ants were identified into genus level and then into morphospecies level using the keys given by Bolton [29] and reference specimens lodged in the Invertebrate Systematics and Diversity Facility
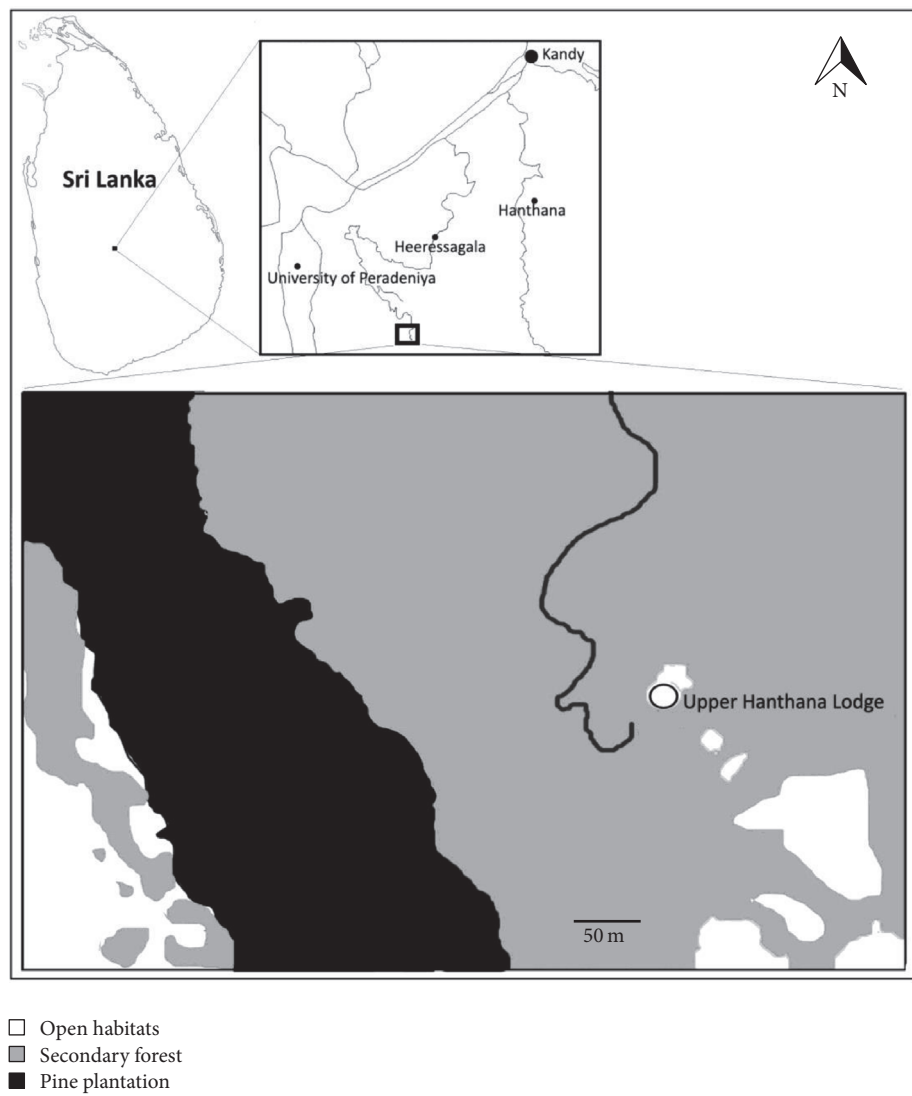
FIGURE 1: Map showing the location of study area consisting of a pine plantation and adjoining secondary forest in Upper Hanthana forest reserve, Sri Lanka.
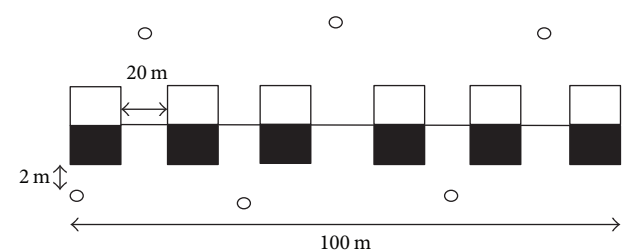

FIGURE 2: Sampling design for ants and other arthropods collection (not in a proportion). Six $1 \, m^2$ quadrats were placed at every 20 m interval on both sides of the 100 m transect. Along one side of the transect, litter was collected from six $1 \, m^2$ quadrats for Winkler extraction (white squares), hand collection from the six $1 \, m^2$ quadrats of the other side of transect (solid black squares) and six pitfall traps (white circles) were laid down 2 m away from the transect.

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2.3. Data Analysis. For each site, abundance data from 18 Winkler extractions, 18 hand collections, and 18 pitfall traps were combined separately for ants and other arthropods. Species richness and abundance (combined data from three collection methods) of both ants and other arthropods between two sites were compared using one-way Analyses of Variance (ANOVA) in the MINITAB 17 statistical software. Prior to other analyses, ant abundance data were presence/absence transformed because being social insects ants tend to clump spatially which might affect analyses of abundance data. Since no social insect species were included in other arthropod data, their abundances were square-root transformed to reduce the contribution from highly

abundant species to the resemblance matrix. Transformed data were used to generate Bray-Curtis dissimilarity matrix. Analyses of Similarity (ANOSIM) within the PRIMER 6 statistical software were then performed to compare the differences in ant and other arthropod communities between the two sites. This analysis was used to test the null hypothesis that there is no significant difference in species assemblages between the two sites. Two ordinations using nonmetric multidimensional scaling (NMDS) were then generated using Bray-Curtis matrix to visualize community composition of ants and other arthropods in the two sites. Dendrograms, each for ants and other arthropods, were constructed using group-average linkage method using Bray-Curtis similarities. Then a Similarity Profile test (SIMPROF) with 999 simulations within the PRIMER 6 statistical software was run to identify clusters with significant internal structure in each dendrogram. Species accumulation curves for ants and other arthropods were generated by plotting observed species richness (combined results of three collection methods) and species richness estimated by commonly used estimator, against sampling effort (18 sampling points per site) to assess the adequacy of sampling in the two sites. Incidence based first-order jackknife richness estimator was used to quantify the species richness.

The relationships between the abundance and species richness of ants and those of other litter arthropods were analyzed with correlation analysis test within the MINITAB 17 statistical software. By using Pearson correlation coefficient (r), the strength and direction of the linear relationship between litter ants (Hymenopterans) and other litter arthropod groups were determined. By comparing the p value (<0.05), the significance of correlation between variables was determined.

3. Results

3.1. Litter Ant Composition and Distribution in the Two Forest Types.
From 36 Winkler extractions, 36 hand collections, and 36 pitfall collections taken from the two study sites, 1887 worker ants belonging to seven subfamilies were collected. They represented 34 morphospecies (referred to as species hereafter) in 25 genera (Table 1). Myrmicinae was the most dominant subfamily followed by Ponerinae and Dolichoderinae (Figure 3). This pattern was observed in both secondary forest and pine plantation. Of the total species, secondary forest harbored 34 species of litter ants, of which 22 were restricted to the secondary forest, whereas pine plantation had only 12 species. Twelve species recorded in pine plantation were shared between the two sites.

Of the collected species, *Solenopsis* sp. 1 was the most ubiquitous and abundant species in the secondary forest, which consisted of 21% of the total individuals from both forests. In pine plantation, *Pheidole* sp. 1 was the most common species and also represented 21% of the total collection. In secondary forest, *Solenopsis* sp. 1, *Solenopsis* sp. 2, *Tapinoma* sp. 1, *Recurvidris* sp., and *Oligomyrmex* sp. were the five most abundant species. But in pine plantation, *Pheidole* sp. 1, *Pheidole* sp. 2, *Kartidris* sp., *Pachycondyla* sp. 1, and *Pheidole* sp. 3 were the five most abundant species.

TABLE 1: Genera and species of ants within each subfamily collected from the secondary forest and pine plantation in the Upper Hanthana forest reserve.

Subfamily	Species
Cerapachyinae (1)	*Cerapachys* sp.
Dolichoderinae (5)	*Indomyrma* sp.
	Tapinoma sp. 1
	Tapinoma sp. 2
	Technomyrmex sp. 1*
	Technomyrmex sp. 2*
Formicinae (3)	*Paratrechina* sp. 1
	Paratrechina sp. 2
	Anoplolepis sp.*
Leptanillinae (1)	*Leptanilla* sp.
Myrmicinae (16)	*Acanthomyrmex* sp.
	Cardiocondyla sp.
	Cataulacus sp.
	Kartidris sp.*
	Oligomyrmex sp.
	Pheidole sp. 1*
	Pheidole sp. 2*
	Pheidole sp. 3*
	Pheidole sp. 4*
	Recurvidris sp.
	Solenopsis sp. 1
	Solenopsis sp. 2*
	Meranoplus sp.
	Wasmannia sp.
	Strumigenys sp.
	Tetramorium sp.
Ponerinae (7)	*Anochetus* sp.
	Hypoponera sp.
	Leptogenys sp. 1
	Leptogenys sp. 2
	Odontomachus sp.
	Pachycondyla sp. 1*
	Pachycondyla sp. 2*
Pseudomyrmecinae (1)	*Tetraponera* sp.*

* indicates ant species present in both secondary forest and pine plantation. Other species are restricted only to the secondary forest.

3.2. Other Litter Arthropods' Diversity and Composition in the Two Forest Types.
The present study yielded a total of 3488 litter arthropods belonging to 18 orders from 36 Winkler extractions, 36 hand collections, and 36 pitfall collections made from two study sites (Table 2). They were represented by 52 species. Of the total species, secondary forest harbored 52 other arthropod species of which 40 were restricted to secondary forest, whereas pine plantation had only 12 other arthropod species which were shared between the two sites. Six orders were common to both sites. Eighteen orders were recorded from secondary forest, while only shared six orders were recorded from pine plantation.
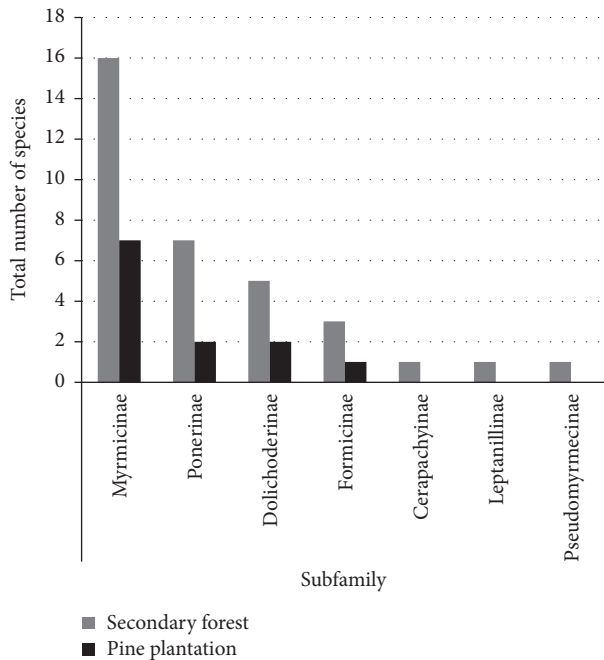
FIGURE 3: Total number of ant species recorded for each subfamily collected using three methods from the secondary forest and pine plantation in the Upper Hanthana forest reserve.

TABLE 2: Arthropod orders and number of morphospecies within each order collected by the three methods from the secondary forest and pine plantation, in Upper Hanthana forest reserve.

Secondary forest		Pine plantation	
Order	Number of morpho spp.	Order	Number of morpho spp.
Hymenoptera	34	Hymenoptera	12
Coleoptera	14	Coleoptera	6
Diptera	6	Araneae	3
Acari	6	Diptera	1
Homoptera	4	Hemiptera	1
Grylloblattodea	3	Acari	1
Hemiptera	3		
Orthoptera	3		
Araneae	3		
Lepidoptera	2		
Collembola	1		
Diplura	1		
Dictyoptera	1		
Ephemeroptera	1		
Heteroptera	1		
Phasmida	1		
Protura	1		
Thysanoptera	1		

Among all recorded orders, 16 belonged to Class Insecta, while two orders belonged to Class Arachnida.

As mentioned earlier, order Hymenoptera was the most common arthropod order in both sites. Of the collected arthropod species from secondary forest and pine plantation, *Solenopsis* sp. 1 and *Pheidole* sp. 1 were the most common species, respectively. In secondary forest, *Solenopsis* sp. 1, *Solenopsis* sp. 2, *Tapinoma* sp. 1, Coleoptera sp. 1, and *Recurvidris* sp. were the five most abundant arthropod species. In pine plantation, *Pheidole* sp. 1, *Pheidole* sp. 2, *Kartidris* sp., *Pachycondyla* sp. 1, and Coleoptera sp. 1 were the five most abundant arthropod species.

3.3. Ant Species and Other Arthropod Diversity and Assemblages in the Two Forests. Secondary forest supported 22 more ant species compared with the pine plantation. Ant species richness (one-way ANOVA; $F1, 34 = 79.92$, $p < 0.001$) and abundance (one-way ANOVA; $F1, 34 = 60.92$, $p < 0.001$) were significantly higher in the secondary forest compared to pine plantation. When considering all litter arthropods, secondary forest supported 40 more species compared to pine plantation, and significantly higher arthropod richness (one-way ANOVA; $F1, 34 = 94.27$, $p < 0.001$) and abundance (one-way ANOVA; $F1, 34 = 34.70$, $p < 0.001$) were observed in the secondary forest.

There was a significant difference between the secondary forest and pine plantation in terms of ant assemblages (ANOSIM; Global $R = 0.630$, $p = 0.001$) and other arthropod assemblages (ANOSIM; Global $R = 0.603$, $p = 0.001$) which is also clearly seen in NMDS ordinations (Figures 4(a) and 4(b)) and dendrogram (Figures 5(a) and 5(b)). The clusters observed in dendrograms for ant species and other arthropod species had significant internal structures that correspond to forest type (SIMPROF; ant assemblages, $\pi = 2.68$, $p = 0.001$; arthropod assemblages, $\pi = 8.81$, $p = 0.001$).

Species accumulation curves were plotted from the data gathered on ants and arthropods in the 18 sampling points (six sampling points per transect) in the two forest types (Figure 6). Number of species collected from Winkler extractions, hand collection, and pitfall trap methods was considered as the total number of species in each sampling point. The species accumulation curves did not reach a plateau indicating that there are more species inhabiting these two sites.

Jackknife 1 species estimators for ants estimated 34 for the secondary forest, whereas only 15 for the pine plantation. Jackknife 1 species estimators for other arthropods estimated 68 for the secondary forest, but only 14 for the pine plantation.

3.4. Correlation with Litter Ants (Hymenoptera) and Other Arthropod Orders. According to the results of Pearson's correlation (r) analysis (Tables 3 and 4), there was a positive relationship between ants and ten other arthropod groups (Coleoptera, Collembola, Diplura, Ephemeroptera, Homoptera, Heteroptera, Orthoptera, Protura, Thysanoptera, and Acari) in secondary forest. Remaining seven orders (Diptera, Dictyoptera, Grylloblattodea, Hemiptera, Lepidoptera, Phasmida, and Aranea) had a negative relationship with ants. But none of them had a significant correlation ($p > 0.05$). In pine plantation, three orders (Coleoptera, Diptera, and Araneae) were positively correlated with ants. Remaining

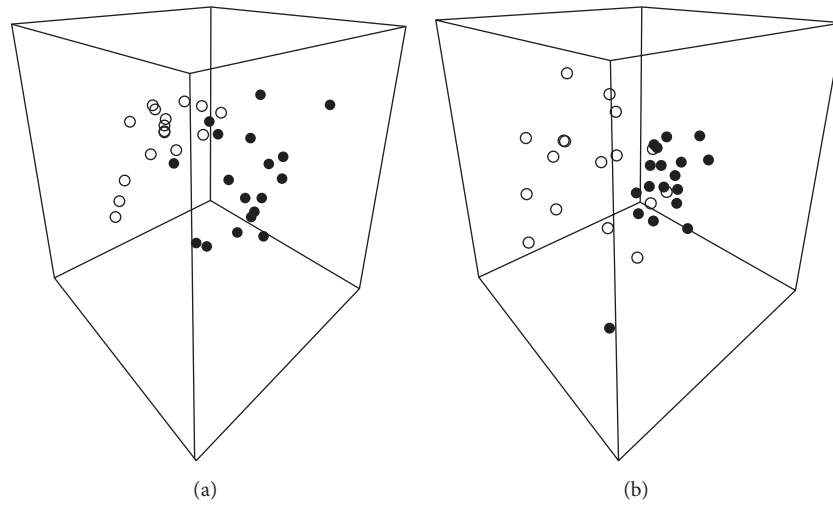(a)   (b)

FIGURE 4: Nonmetric multidimensional scaling (NMDS) ordination of ant community (a) and other arthropod communities (b), using Bray-Curtis similarity measure based on presence/absence transformed data of ants and square-root transformed data of other arthropods in secondary forest (solid black circles) and pine plantation (white circles). Both litter ant assemblages and other litter arthropods assemblages show strong compositional differences in relation to forest type.

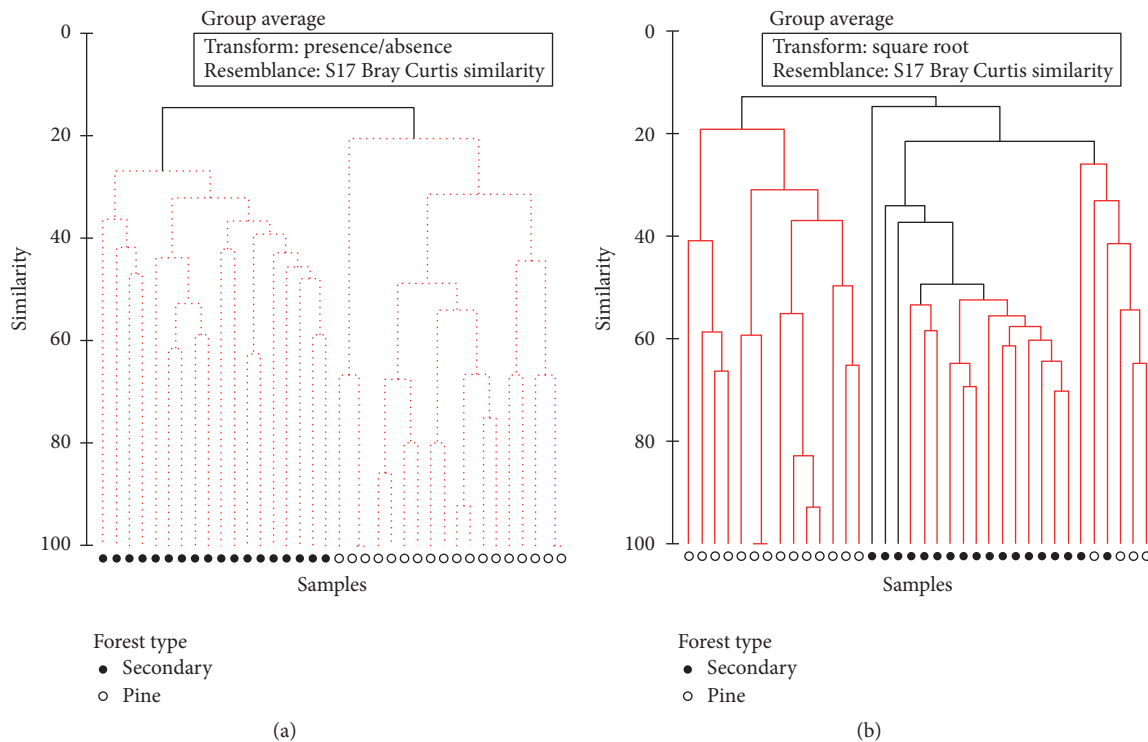(a)   (b)

FIGURE 5: (a) Dendrogram generated by clustering with group-average linkage from Bray-Curtis matrix calculated from presence/absence transformed abundance data of ant species at each sampling point within secondary forest (solid black in color) and pine plantation (white in color). Grouping at 14.5% similarity splits sampling points in two forest types (SIMPROF; $\pi = 2.68$, $p = 0.001$). (b) Dendrogram generated by clustering with group-average linkage from Bray-Curtis matrix calculated from square-root transformed abundance data of other arthropods at each sampling point within secondary forest (solid black in color) and pine plantation (white in color). Solid lines indicate significant different groups of samples, and grouping at 12.64% similarity splits sampling points more or less into forest types (SIMPROF, $\pi = 8.81$, $p = 0.001$).
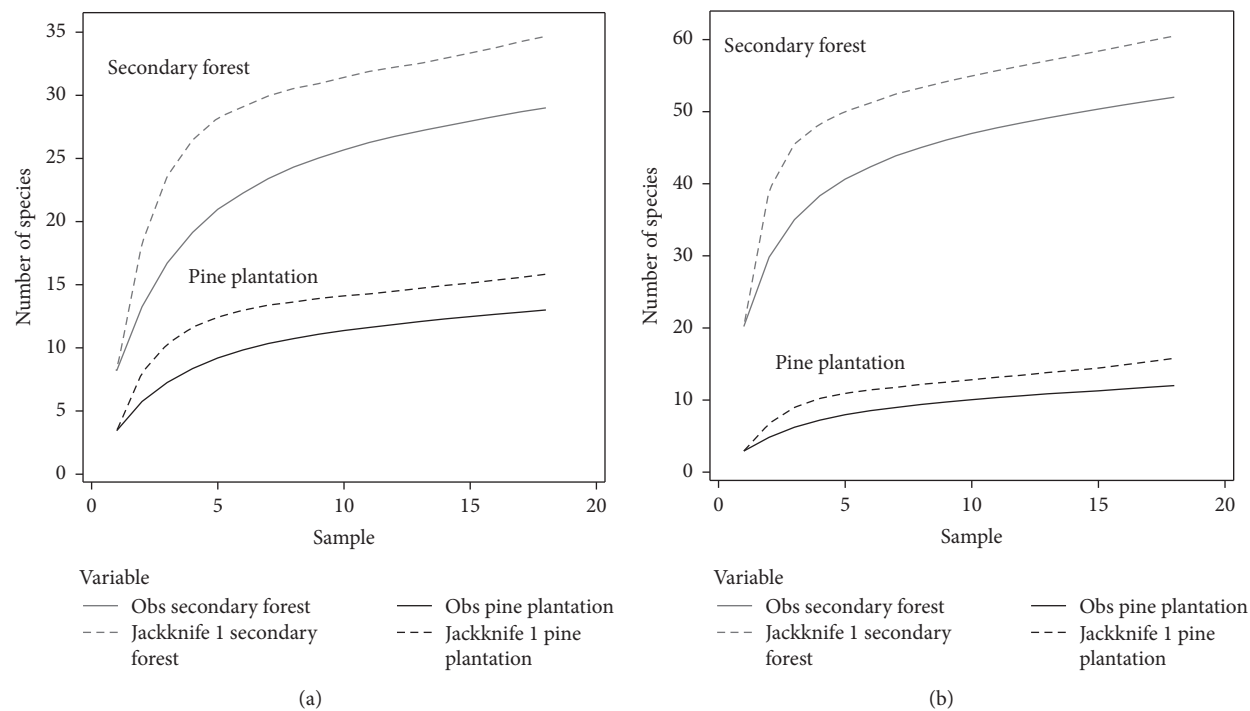
(a)

(b)

FIGURE 6: Observed species richness (solid line) and species richness estimated by Jackknife 1 estimator (dash dotted line) for ant species (a) and other arthropod species (b) collected from the pine plantation (dark lines) and secondary forest (light lines) in Upper Hanthana forest reserve.

TABLE 3: Pearson's correlation (r) and associated probability (p) between the abundance of ants and the abundance of other arthropods associated with leaf litter.

Forest type	Pine plantation		Secondary forest	
	r	p	r	p
Coleoptera	0.137	0.588	0.289	0.245
Collembola	—	—	0.201	0.423
Diplura	—	—	0.335	0.175
Diptera	0.223	0.374	−0.220	0.380
Dictyoptera	—	—	−0.032	0.899
Ephemeroptera	—	—	0.336	0.227
Grylloblattodea	—	—	0.227	0.366
Hemiptera	−0.180	0.476	−0.670	0.002
Homoptera	—	—	0.090	0.722
Heteroptera	—	—	0.138	0.586
Lepidoptera	—	—	−0.167	0.508
Orthoptera	—	—	0.064	0.801
Phasmida	—	—	−0.287	0.248
Protura	—	—	0.284	0.254
Thysanoptera	—	—	0.410	0.091
Acari	−0.013	0.954	0.082	0.746
Araneae	0.411	0.090	−0.523	0.026

TABLE 4: Pearson's correlation (r) and associated probability (p) between the species richness of ants and the species richness of other arthropods associated with leaf litter.

Forest type	Pine plantation		Secondary forest	
	p	r	p	r
Coleoptera	0.067	0.441	0.819	−0.058
Collembola	—	—	0.244	0.289
Diplura	—	—	0.803	−0.063
Diptera	0.900	−0.032	0.661	0.111
Dictyoptera	—	—	0.541	−0.154
Ephemeroptera	—	—	0.603	0.132
Grylloblattodea	—	—	0.893	−0.034
Hemiptera	0.518	0.163	0.014	−0.566
Homoptera	—	—	0.332	−0.243
Heteroptera	—	—	0.917	0.026
Lepidoptera	—	—	0.603	0.132
Orthoptera	—	—	0.027	−0.519
Phasmida	—	—	0.063	0.447
Protura	—	—	0.244	0.289
Thysanoptera	—	—	0.565	0.146
Acari	0.687	−0.102	0.366	0.227
Araneae	0.497	0.171	0.579	0.140

two orders (Hemiptera and Acari) were negatively correlated with ants, but not significantly ($p > 0.05$).

4. Discussion

This study examined the correlation between the diversity of litter ants and other arthropods with the aim of finding the

competence of litter ants for Rapid Biodiversity Assessments. Among all recorded arthropod orders, Hymenoptera, which was represented only by ants (Family Formicidae) during the present study, was the most diverse group in both sites. Seven out of the 12 ant subfamilies known from Sri Lanka [30] were recorded. The present study found 34 species (~16%) of ants in 25 genera out of 215 species in 63 genera [31] recorded for Sri Lanka. However, the present study may have missed the strictly nocturnal and crepuscular ant species such as *Camponotus* that belongs to subfamily Formicinae as sampling was done during day time. According to Wilson [32] the Sri Lankan relict ant, *Aneuretus simoni* had been recorded from two sites (Peradeniya and Kandy) in wet zone of Sri Lanka. Recent similar study done by Karunarathna and Karunaratne [33] also yielded *Aneuretus simoni* from a wet zone forest, Moraella which is located in the Knuckles forest reserve. However, this species was not recorded in the present study done in wet zone forest may be due to high level of human disturbances compared to Moraella forest. The monotypic genus *Dorylus*, a very rare subterranean army ant, which was recorded during the study conducted by Karunaratne et al. [34] along with an altitudinal gradient in Hanthana forest reserve, was also not recorded in this study, may be due to low sampling efficiency.

According to the results of ANOVA test, there was a significant difference between the two vegetation types in terms of arthropod abundance and richness (overall diversity), and the same pattern was observed when only ant abundance and richness were considered. ANOSIM test showed that these two vegetation types have significant differences in terms of both ant assemblages (Global $R = 0.630$, $p = 0.001$) and arthropod assemblages (Global $R = 0.603$, $p = 0.001$). This was confirmed by a clear separation of study plots of the two vegetation types with very low similarity and low p value for ants assemblages and other litter arthropods assemblages in ordination plot and dendrogram. This result reveals that ant data alone can be used to measure the habitat quality which further helps to reduce the cost of time, money, and taxonomic knowledge required for a complete survey of all taxonomic groups.

One of the key findings of the present study was the lower arthropod diversity in pine plantation compared to natural and secondary forests [35]. This is because secondary forests contain high density of different kinds of trees which enhance both the quality and quantity of leaf litter where litter arthropods live, while pine plantation does not have high heterogeneity in plant composition; there was a thick litter layer. Quantity, as well as the quality of leaf litter, is determined by tree species in the habitat. High density of different tree species and high leaf fall rates in secondary forests contributed more resources which lead to higher species diversity than in pine plantation [36]. Though not quantified in this study, vegetation structure is another [37] important factor affecting litter arthropod population. A similar study done by Sobek et al. [38] found that tree density and structural heterogeneity affected species richness and therefore, it can have a significant effect on litter ants and other arthropod species assemblages in secondary forest and pine plantation which are structurally dissimilar. According to Tews et al. [37], the majority of studies found a positive correlation between habitat heterogeneity and species diversity. As with similar studies in Sri Lanka [39] and globally [40], this study demonstrates that exotic woody pine plantations support lower faunal species richness and different community assemblages, compared to neighboring native forest.

If ants are considered as a biodiversity indicator for RBA, the correlation between the species richness and diversity of ants and other arthropod taxa must be recognized. According to the results of this study, we did not find any significant correlation ($p < 0.05$) between ants and other arthropod orders except Hemiptera, Orthoptera, and Araneae.

Similarly, study carried out by Morrison III et al. [41] showed that ant species richness, in general, does not correlate positively with many taxa and those correlations are not consistent between different habitat types. In contrast, study done by Alonso [42] found positive significant correlations between ants and several other taxa. The study done by Majer et al. [43] found a high correlation between the species diversity of ants, tree bugs, beetles, and spiders. The similar study done by Andersen et al. [44] in the Kakadu region of Northern Australian territory also found several positive associations between ant species composition and that of seven other taxa. Many studies have shown positive correlations of species richness of ants and plants. Such correlation is possible as ants are a diverse community which requires a variety of plants that provide nesting sites and food or regulate micro climate they need. The study done by Ribas et al. [45] found ant species richness correlates positively with tree density and structural heterogeneity. However, Gunawardene et al. [46] found no significant relationship between ant and tree species diversity in a lowland dipterocarp-dominated forest in Sri Lanka. Positive correlations may be seen between ant species diversity and other taxa as ants are found commonly in almost every habitat making them an important component of the ecosystem. There may be many other factors such as history of disturbances and climatic condition that determine this correlation.

But there is no presumptive logic to explain that indicator taxa (surrogate taxa) should correlate with the diversity of other taxa. The effectiveness of the surrogate taxa varies with habitat type (e.g., grasslands, boreal zones, deserts, and tropical forests) and more effective in studies examining larger areas [47]. By using taxa that are easily measurable, habitat specialists approach to a precise conclusion.

Species distribution and diversity have an involvement from their evolutionary history and even within the same habitat, different genera and families may be influenced by various factors [48]. Expecting positive correlations may be possible in areas of high stability, undisturbed areas where high species rate, low extinction rates, and close mutuality associations occur. But most habitats in today's world are disturbed and historical evolutionary factors may cause different levels of species richness in different taxa. In these situations, one indicator taxa or surrogate taxa may not be ideal for RBAs. In addition, most scientists now criticize the use of individual taxa or restricted groups of taxa as indicators of overall biodiversity.

For example, study done by Billeter et al. [49] found that no single species group developed as a good quality indicator of every other species groups as it does not give an entire picture. It further clarifies that indicator taxa are doubtful to consider as a viable method for foreseeing biodiversity at a large spatial scale, particularly where there is a large biogeographic variation in species richness. Considering all these factors it is clear that conservation and management plans should not be designed exclusively for the measures on species richness or diversity data gather using one surrogate taxa in an area, but also on the identity and biology of the species present and type of habitat plan to conserve.

Species accumulation curves provide useful information about completeness of the survey. In this study species accumulation curves for ants and arthropods collected from the three sampling methods (Winkler extraction, hand collection, and pitfall method) did not reach a plateau indicating that the study sites are undersampled and more sampling is needed to collect all the existing species in these two habitats. With the limited time period and limited resources available, each habitat was sampled only three times by the three methods. Sampling protocol was tedious that needed a lot of labor and time. Sorting and identifying arthropods into morph-species under dissecting microscope is a time-consuming process which requires dedication and patience. Results may vary if we did more trials using more sampling methods.

5. Conclusion

This study reveals that litter ants are not ideal as a leaf litter biodiversity indicator as they do not reflect the holistic picture of litter arthropod diversity. But they have great competence to show the quality, standard, and status of a particular habitat for survival of all litter arthropods. Therefore, use of improved sampling methods to conjugate ants with other surrogate taxa with different ecological requirements would provide more valuable details on an area's overall species richness or diversity.

Conflicts of Interest

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

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