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Arthropod Community Structure during the Early Stages of Leaf Litter Decomposition

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Abstract - Arthropods constituting 51 families of 13 orders were collected from leaf litter during the early stages of decomposition. These groups were classified into their respective trophic categories based on mouthpart inference. These categories are as follows: chewing detritivores (15 families) > chewing predators (6 families) > chewing herbivores and sucking herbivores (5 families) > sucking predators (3 families) > chewing parasites and chewing omnivores (2 families). A simplified food web of the arthropods in leaf litter is also presented.

Keywords - arthropod community, foodweb, leaf litter, trophic categories

INTRODUCTION

Litter decomposition is a key process in the tropical forest ecosystem. It is estimated that around 99% of the above -ground net primary production enters the decomposer subsystem in the form of plant litter. Hence, litter decay is an indispensable component of the nutrient cycling process in forest ecosystems (Melillo et al., 1989). It is affected by three main factors, namely; the climate, the litter quality and the nature and abundance of the decomposing organisms.

The above and below ground plant litter constitutes the main resource of energy and matter for a diverse community of soil fauna connected by highly complex interactions (Hattenschwiler, Tiunov and Scheu, 2005). This means that a few centimeters of top soil and the accumulated leaf litter above it are a compacted region of biological activity. However, the inconspicuous nature of leaf litter arthropods make them the least known taxa as most biological studies are more concentrated on looking at diversity of larger arthropods in terrestrial ecosystems.

In fact, the diversity of leaf litter arthropods in the Philippines has been left undocumented. Knowledge of the array of litter leaf arthropods as well as the complex biotic relationships that exist among them is just as vital as any scientific endeavor. Change in diversity and composition of these arthropods can affect the quality and quantity of nutrients that become available to the other organisms of the terrestrial ecosystem. No group of organisms can surrogate another group's role in the ecosystem; studies to document how these organisms mediate ecological processes like decomposition of organic matter are needed. This cannot be done without initial documentation of the kinds of arthropods existing in leaf litter.

OBJECTIVES OF THE STUDY

This study aimed to document arthropod community structure during the early stages of leaf litter decomposition. Specifically, this study aims to: (1) provide family-level taxonomic information about these leaf litter arthropods; (2) classify arthropods into respective trophic categories, and (3) present a simplified food web of the arthropods in leaf litter.

MATERIALS AND METHODS

A two meter by two meter area of secondary growth forest understory at the Mt. Makiling Forest Reserve was cleared for this study. Clearing here was done by sweeping the previously accumulated plant litter materials in the area, leaving behind an area ready for the deposition of newly-fallen leaf litter. Then, the area was divided into 16 squares (Fig. 1). Each square was measured 0.5 meters by 0.5 meters and was delineated by plastic twine.

A total of 1.6 kilograms of mixed fresh leaf litter that had forcefully detached after a typhoon was collected at the experiment site. One hundred (100) grams were subsequently laid out in each of the 16 squares set up. A nylon net cover was also placed above the experimental area in order to avoid deposition of additional leaf litter during the duration of the study.

Fig. 1. Dimensions of the experimental set-up

Two (2) 100 gram samples were randomly collected in the experimental area every other week for two months. These were photographed to qualitatively document the early stages of leaf decomposition. Then the samples were weighed before placing them separately in the Berlese-Tullgren funnel for 48 hours. The dried litter samples were weighed thereafter.

Identification and analysis. The extracted arthropods from the Berlese-Tullgren funnel were identified up to family level using Mackerras (1970) and Stehr (1998). The latter was mainly used to

identifying immature insects.

Once identified, the arthropods were classified into trophic categories. These categories were inferred from observation of their mouthparts as well as ecological information about the families available from Mackerras (1970) as well as Romoser and Stoffolano (1994). The abundance of individuals in each trophic category was recorded. Lastly, any observed pattern of colonization of arthropods during the early stages of leaf litter decomposition was noted.

RESULTS AND DISCUSSION

Taxonomic Information on Leaf Litter Arthropods

Despite of the limited sampling period and area, the arthropods collected from this study were far from few. Total 1650 individuals representing 13 orders and 51 families (with 10 unidentified) of arthropods were collected from leaf litter (Table 1). These 13 arthropod orders are namely: Acarina (1 unknown family), Araneida (3 families), Blattodea (1 family); Coleoptera (12 families + 2 unknown families), Collembola (4 families), Dermaptera (1 family), Diptera (9 families + 1 unknown family), Hemiptera (6 families + 2 unknown families), Hymenoptera (3 families), Isopoda (1 unknown family), Lepidoptera (1 family); Psocoptera (1 unknown family) and Trichoptera (1 family + 2 unknown families).

Much of the impediment in the accurate identification of these arthropods is attributed to the lack of published forest leaf litter arthropod records in the country, specifically for the Mount Makiling Forest Reserve. In fact, the study stemmed from the need to have a passport guide for students conducting plant litter decomposition exercise in their basic ecology class. Usually, the students enrolled in this class depend on line drawings of typical arthropods lifted from various general entomology books. What makes it all the more difficult is that they would have to compare these poster-size line drawings with what they have collected in the field laboratory; microscopic invertebrates. Minute leaf litter arthropods make them unpopular candidates for study even regardless of how valuable they are in nutrient cycling (Sakchoowong et al., 2008). So, for students to actually understand the mechanics of energy flow in the decomposition food

web one cannot emphasize enough the need to recognize the existing arthropod community first. It is here that basic taxonomic information becomes relevant. This study, while preliminary in nature, hopes to provide baseline information that could serve as a jumping-off point for future investigations (e.g. species turnover in litter decomposition).

Table 1. Summary classification of the arthropods collected from leaf litter.

Order	Family	
Acarina	1.	unknown family 1
Araneida	1.	Gnaphosidae
	2.	Heteropodidae
	3.	Salticidae
Blattodea	1.	Blaberidae
Coleoptera	1.	Bostrichidae
	2.	Colydiidae
	3.	Chrysomelidae
	4.	Curculionidae
	5.	Elateridae
	6.	Histeridae
	7.	Hydrophilidae
	8.	Lathridiidae
	9.	Leoididae
	10.	Mordellidae
	11.	Platypodidae
	12.	Staphylinidae
	13.	unknown family 2 (immature)
	14.	unknown family 3 (adult)
Collembola	1.	Entomobryidae
	2.	Isotomidae
	3.	Poduridae
	4.	Sminthuridae
Dermaptera	1.	Forficulidae

Diptera	1.	Drosophilidae
	2.	Cecidomyiidae
	3.	Clusiidae
	4.	Phoridae
	5.	Psychodidae
	6.	Scatophagidae
	7.	Scatopsidae
	8.	Simuliidae
	9.	Xylophagidae
	10.	unknown family 4 (immature)
Hemiptera	1.	Cicadellidae
	2.	Cixiidae
	3.	Delphacidae
	4.	Meenoplidae
	5.	Miridae
	6.	Reduviidae
	7.	unknown family 5 (immature)
	8.	unknown family 6 (adult)
Hymenoptera 1. Chalcididae 2. Formicidae	1.	Braconidae
Isopoda	1.	unknown family 7 (adult)
Lepidoptera	1.	Pyralidae immature
Psocoptera	1.	unknown family 8 (adult)
Trichoptera	1.	Hydropsychidae
2.unknown family 10 (adult)	3.	unknown family 9 (immature)

Litter Arthropod Guilds during Early Stages of Leaf Litter Decomposition

Like other organisms, arthropods assume specific roles in the environment. They can either be categorized as herbivore, carnivore, omnivore or detritivore. Trophic categories of the collected arthropods

were determined by observing their mouthparts or using pertinent data about the nature of the different families.

Types of mouthparts include, chewing, lapping, sponging, piercing-sucking, and sipping. From these mouthparts, trophic category can be determined. Arthropods with chewing mouthparts can be herbivorous, carnivorous or omnivores. Lapping mouthpart is usually found in herbivorous arthropods. Sponging mouthpart is found mostly in detritivorous arthropod. Piercing-sucking mouthpart can be found in herbivorous and parasitic arthropods. Sipping mouthpart is found in herbivorous arthropods (Barbereba-Arias and Aide, 2003).

All families of arthropods that were categorized into guilds: chewing herbivore, sucking herbivore, chewing predator, sucking predator, chewing parasitic, chewing omnivore, chewing detritivore and sucking detritivore (Table 2). Fig. 2 summarizes the relationships between these arthropods in the form of a food web.

Acarina. These small arthropods are known to be parasitic or predatory on adults and larval forms of insect (Stehr, 1998). However, they are also classified as saprophagous micro arthropods. They are predominant in soil and litter together with Collembolans (Pramanik, Sarkar and Joy, 2001). The lone mite (Fig. 3A) collected in this study was determined to be a predator (Lit, pers. comm). The presence of this mite was probably due to the presence of available prey that thrive in leaf litter.

Collembola. Members of this order are known as micro arthropod decomposers. They are common in soil, leaf litter and other decaying dead organic matter (Romoser and Stoffolano, 1994). Collembolans collected from leaf litter belong to four families, namely: Poduridae (Fig. 3G), Isotomidae, Entomobryidae (Fig. 3F) and Sminthuridae.

Araneida. Families of order Araneida (Fig. 3B-D) were identified to belong to the hunting spider families Gnaphosidae, Heteropodidae and Salticidae (Barrion and Litsinger, 1995). All these spiders have chewing mouthparts specialized in predating on insects (Romoser and Stoffolano, 1994). Their presence in leaf litter was probably due to the presence of arthropod prey in leaf litter.

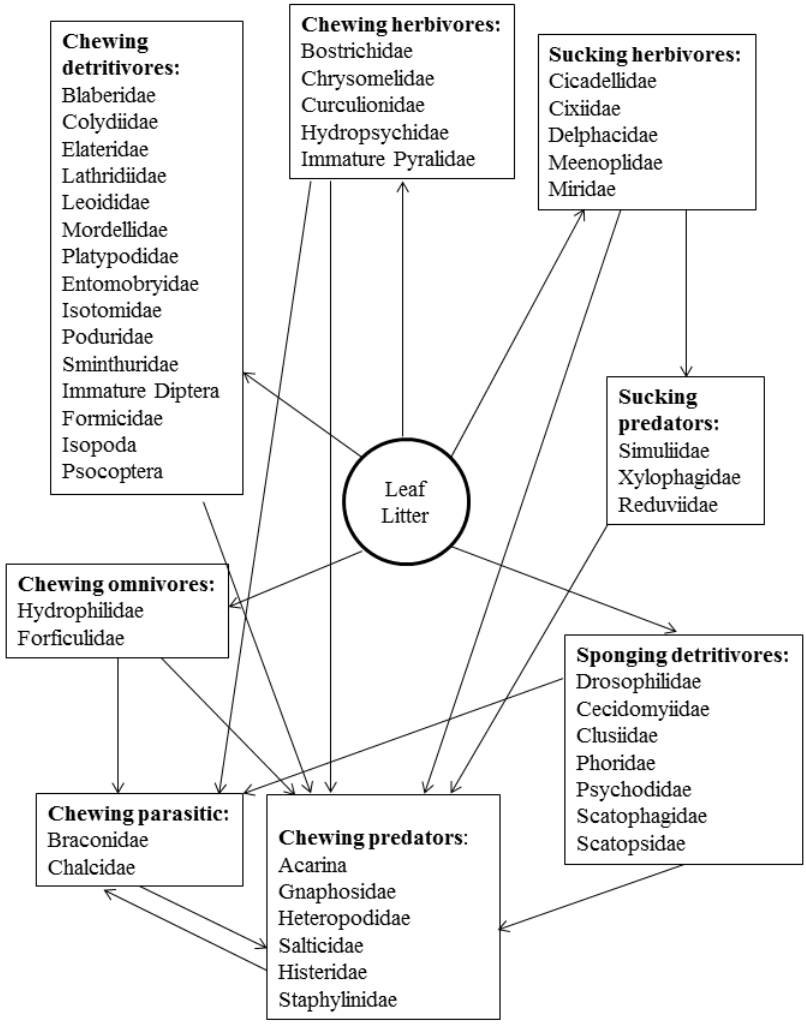

Fig. 2. Simplified foodweb of the arthropods in leaf litter

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Table 2. Trophic category of the arthropods found in leaf litter

Order	Family	Trophic Category
Acarina	*sp1*	Chewing predator
Araneida	Gnaphosidae	Chewing predator
	Heteropodidae	Chewing predator
	Salticidae	Chewing predator
Blattodea	Blaberidae	Chewing detrivore
Coleoptera	Bostrichidae	Chewing herbivore
	Colydiidae	Chewing detritivore
	Chrysomelidae	Chewing herbivore
	Curculionidae	Chewing herbivore
	Elateridae	Chewing detritivore
	Histeridae	Chewing predator
	Hydrophilidae	Chewing omnivore
	Lathridiidae	Chewing detritivore
	Leoididae	Chewing detritivore
	Mordellidae	Chewing detritivore
	Platypodidae	Chewing detritivore
	Staphylinidae	Chewing predator
	immature	Chewing detritivore
	sp1	Chewing detritivore
Collembola	Entomobryidae	Chewing detritivore
	Isotomidae	Chewing detritivore
	Poduridae	Chewing detritivore
	Sminthuridae	Chewing detritivore
Dermaptera	Forficulidae	Chewing omnivore
Diptera	Drosophilidae	Sponging detritivore
	Cecidomyiidae	Sponging detritivore
	Clusiidae	Sponging detritivore

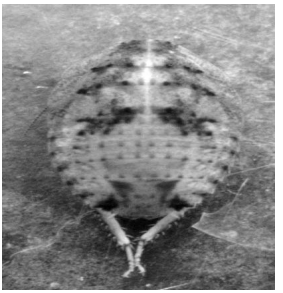
	Phoridae	Sponging detritivore
	Psychodidae	Sponging detritivore
	Scatophagidae	Sponging detritivore
	Scatopsidae	Sponging detritivore
	Simuliidae	Sucking predator
	Xylophagidae	Sucking predator
	immature	Chewing detritivore
Hemiptera	Cicadellidae	Sucking herbivore
	Cixiidae	Sucking herbivore
	Delphacidae	Sucking herbivore
	Meenoplidae	Sucking herbivore
	Miridae	Sucking herbivore
	Reduviidae	Sucking predator
	immature	Sucking herbivore
	sp1	Sucking herbivore
Hymenoptera	Braconidae	Chewing parasitic
	Chalcididae	Chewing parasitic
	Formicidae	Chewing detritivore
Isopoda	*sp1*	Chewing detritivore
Lepidoptera	Pyralidae	Chewing herbivore
Psocoptera	*sp1*	Chewing detritivore
Trichoptera	Hydropsychidae	Chewing herbivore
	immature	Chewing herbivore
	sp1	Chewing herbivore

A - Acarina 30x

B - Araneida: Heteropodidae 60x

C - Araneida: Salticidae 60x

D-Araneida: Gnaphosidae 60x



E-Blattodea: Blaberidae 60x

F- Collembola: Entomobryidae 80x

G- Collembola: Poduridae 80x

H- Coleoptera: Staphylinidae 60x

I- Coleoptera: Bostrichidae 60x

Fig. 3. Representative arthropods collected from leaf litter; **A-D**. piercing sucking predators; **E-H**. chewing detritivores; **I**. chewing herbivore

Blattodea. Family Blaberidae (Fig. 3E) is comprised of mainly tropical cockroaches of world-wide distribution and commonly found under bark or in leaf litter. These detritivores mostly feed on decaying animal and plant matter (Mackerras, 1970; Romoser and Stoffolano, 1994).

Coleoptera. Most beetles are herbivorous (Fig. 3I) or predatory and very few are parasitic (Romoser and Stoffolano, 1994). Of the 14 families of beetles sampled from leaf litter, two predatory families were identified. These were: Histeridae and Staphylinidae (Fig. 4E).

Dermaptera. One family of earwigs represented Dermaptera (Fig. 4D). According to Romoser and Stoffolano (1994) Forficulidae are mostly omnivorous and feed upon small living or dead insects, decaying plant material, and tender parts of living plants.

Diptera. Another large insect order found in leaf litter is Diptera Fig. 4A-C). Seven families of collected dipterans were classified as sponging detritivores while two families (i.e. Simuliidae and Xylophagidae) were categorized as sucking predators.

Hemiptera. Except for the family Rediviidae, all other hemipterans from the leaf litter samples were determined to be sucking herbivores (Fig. 4G-I).

Hymenoptera. The families Chalcididae and Braconidae are known to be parasites of larvae and pupae of insects like lepidopterans (Mackerras, 1970 and Stehr, 1998). Formicidae meanwhile was classified as a chewing detritivore responsible for cutting up leaf litter into smaller components, thereby hastening the decomposition process.

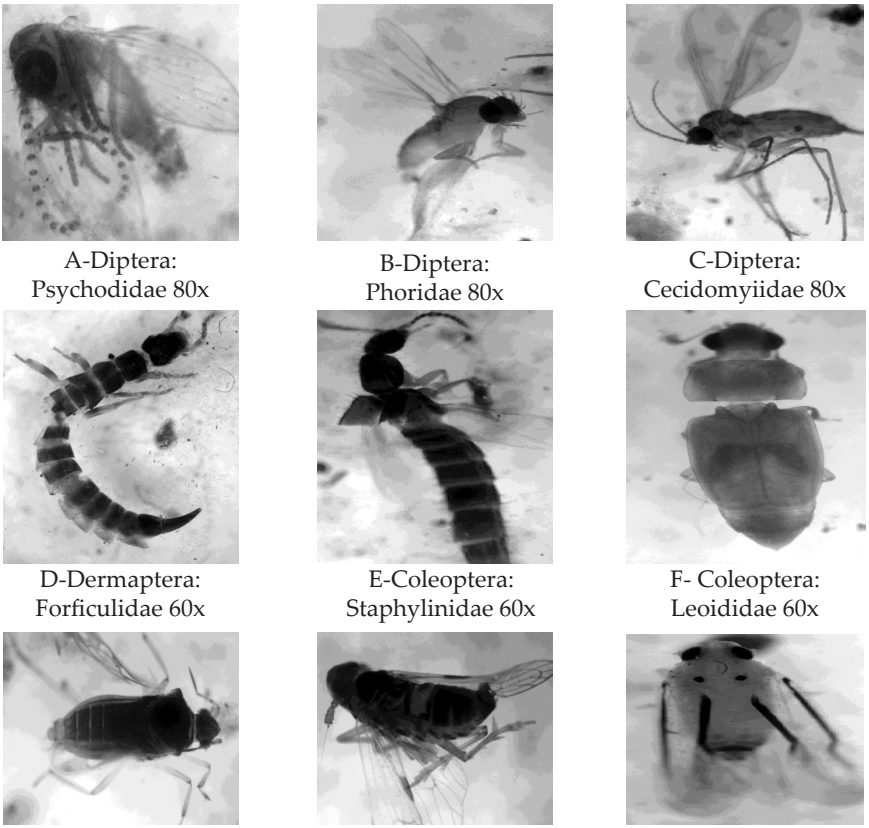
Isopoda. Sow bugs are found mostly in moist places like leaf litter, soil and the underside of barks and stones. They have chewing mouthparts that cut leaf litter into smaller pieces.

Lepidoptera. Larvae of family Pyralidae, are commonly found in shelters of webbed leaves or shoots, or tunnels in shoots, stems, seed heads, fruits, or galls, in silken galleries amongst mosses, herbaceous plants, fallen leaves, and aquatic plants in freshwater. This particular larva is known to feed on fungi (Lit, *pers. comm.*; Stehr, 1998).

Psocoptera. Booklice live in a variety of terrestrial habitats which include the underside of bark amid vegetation, and in bird and mammal nests. Outdoor species such as those collected in this study,

characteristically feed on organic matter, including fungi, algae, lichens, pollen and fragments of decaying organic material (Romoser and Stoffolano, 1994). Only one unknown Psocoptera family was collected in this study.

Trichoptera. Trichopterans or caddisflies are found mostly in clear water streams. The males fly in bright sunlight, over the bushes bordering the stream while the females shelter in the bushes and are rarely seen on the wing (Mackerras, 1970).



A-Diptera: Psychodidae 80x

B-Diptera: Phoridae 80x

C-Diptera: Cecidomyiidae 80x

D-Dermaptera: Forficulidae 60x

E-Coleoptera: Staphylinidae 60x

F- Coleoptera: Leoididae 60x

G- Hemiptera: Veliidae 80x

H- Hemiptera: Delphacidae 80x

I- Hemiptera: Cixiidae 80x

Fig. 4. Representative arthropods collected from leaf litter; **A-C**. sponging detritivores; **D**. chewing omnivore; **E**. chewing predators; **F** chewing detritivore; **G-I**. sucking herbivores

The caddis flies collected are classified as chewing detritivores. Their presence in the leaf litter samples may have also been influenced by the location of the study site. The leaf litter samples were laid out in an area wherein a stream is situated just a few hundred meters.

CONCLUSIONS

Based on the family-level identification used in this study, leaf litter during the early stages of decomposition supports a wide array of arthropod groups---51 families in 13 orders, to be exact. It is also clear that this initial study shows that the arthropod community structure in forest leaf litter is very complex as exemplified by the various trophic categories inferred from the mouthparts of collected specimens. However, to truly gauge the complexity of these arthropod communities and the relationships that exist between trophic guilds, species-level identification is still a must.

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