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ORIGINAL ARTICLE **OPEN ACCESS**

Faunal Composition of Leaf-Dwelling Pholcids (Araneae: Pholcidae) in Selected Areas of Autonomous Region in Muslim Mindanao, Philippines

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ABSTRACT
This study was conducted to determine the faunal composition of leaf-dwelling pholcids in selected areas of Autonomous Region in Muslim Mindanao, Philippines. Using the active diurnal manual technique, this study has recorded 180 (53.77%) adult leaf-dwelling pholcids and 156 (46.43%) juveniles in seven sampling localities. Ten species were recorded where six species belong to the genus Belisana Thorell, 1898, two species were of genus Pholcus Walckenaer, 1805, and one species each of genus Calapnita Simon, 1892, and Panjange Deeleman-Reinhold & Deeleman, 1983. Estimated species richness was between 10.5 (Chao1) to 30 (ICE) species. Mt. Baya was the most species-rich among the seven sampling sites. The results of this study provide a baseline data on the faunal composition of leaf-dwelling pholcids necessary to better understand their species richness and community structure.
Keywords: *Belisana, community structure, Pholcus, Species Richness Estimators, spiders.*

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INTRODUCTION

Spiders of family Pholcidae are among the most diverse spiders that inhabit a variety of habitats. Currently, Pholcidae consists of 79 genera and 1455 species [1]. Pholcids are important part of the food web in a given ecosystem as they can serve as both prey and predator and can be used as possible biocontrol for mosquito vectors of dengue virus [2]. Their species richness could be used as good health indicator of the terrestrial ecosystem. Some species of pholcids have become valuable model organisms for experimental research such as sexual selection and evolution of sociality [3, 4, 5]. Leaf-dwelling pholcids are pholcids that are more abundant in the tropics. There are five genera (*Belisana*, *Calapnita, Leptopholcus*, *Panjange*, and *Pholcus*) of leaf-dwelling pholcids known to occur in the tropical rainforest of Southeast Asia [6]. Leaf-dwelling pholcids are morphologically and behaviorally cryptic. They have pale green coloration resembling the color of the leaves and very long and thin legs with an elongated body. They are sedentary, spending the day tightly pressed and well-hidden on the underside of the leaves. These attributes make them hard to collect. Obviously the only effective method of collection is manual technique which requires turning the leaves upside-down one by one. There are inventories on spiders that resulted to a very small percentage of pholcids and subsequently categorize them as rare or very rare [7, 8, 9]. In most cases, this small percentage was collected accidentally. This clearly underestimates their true species richness and diversity. However, a more specific survey can provide a realistic result. Manhart [10] for example has recorded pholcids (62%) as the most abundant in the spider fauna on the bark of Peruvian rainforest trees. Sorensen *et al*. [11] also recorded pholcidae as a dominant family in the montane forest of the Uzungwa Scarp Forest Reserve, Tanzania.

Species level diversity of leaf-dwelling pholcids in the Philippines is almost untouched. However, representatives of the leaf-dwelling four genera *Belisana, Calapnita, Panjange*, and *Pholcus* were recorded and collected in Mindanao and some part of Visayas in February and March 2014 [12]. Many of these collected species especially from *Belisana, Panjange*, and *Pholcus* are still undescribed. Hence, it can be assumed from these data that the actual species richness of leaf-dwelling pholcids is much higher with rigorous and more specific collection of samples. This study was conducted primarily to provide baseline

data on faunal composition of leaf-dwelling pholcids in selected areas of Autonomous Region in Muslim Mindanao, Philippines. Documenting the leaf-dwelling pholcids before the total loss of natural habitat is important especially in Basilan where conversion of forest cover to monoculture rubber tree (*Hevea brasiliensis)* plantation is at alarming rate.

MATERIALS AND METHODS

Study area

Autonomous Region in Muslim Mindanao (Figure 1) has a total forest cover of 30,189.4 km^2 and is divided into two main geographical areas: Mindanao mainland and the Sulu archipelago. The sampling sites located in the Mindanao mainland were: Mt. Mupo, Marawi City (8.0120^{0}N, 124.01751^{0}E); Mt. Baya, Pualas, Lanao del Sur (7.7829^{0}N, 124.0847^{0}E); Camp Abubacar, Barira, Maguindanao (7.5698^{0}N, 124.3198^{0}E), and Dimapatoy Watershed, Datu Odin Sinsuat, Maguindanao (7.1407^{0}N, 124.2018^{0}E) whereas Maluso, Basilan (6.5665^{0}N, 121.8993^{0}E); Sanga-Sanga, Bongao, Tawi-Tawi (5.0688^{0}N, 119.7729^{0}E) and Bud Bongao, Tawi-Tawi (5.0163^{0}N, 119.7469^{0}E) are separate islands that are part of Sulu archipelago.

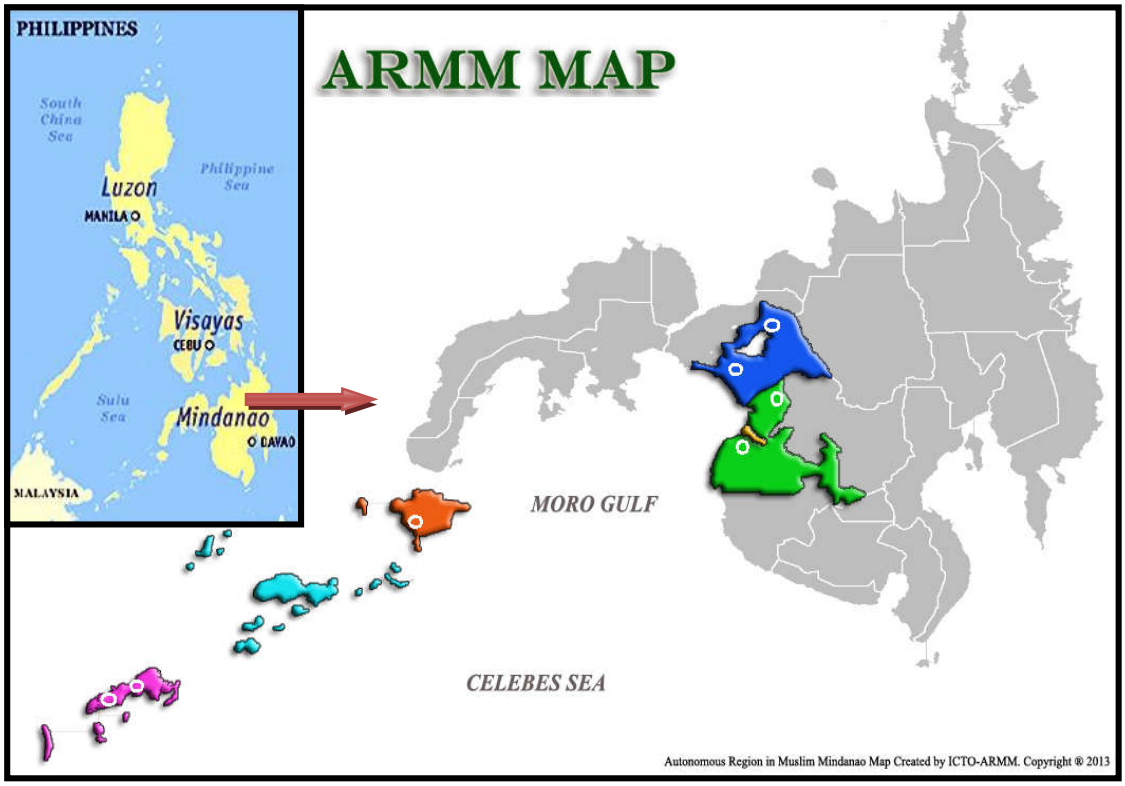

Figure 1. Geographical location of the study area as marked in white circle [13].

Mt. Mupo (also known as Sacred Mountain) is a secondary forest located at barangay Guimba and Papandayan, Marawi City, Philippines (8.0120^{0}N, 124.01751^{0}E) with an elevation of 1128 meters above sea level (masl). It is a protected area designated as National Park on August 5, 1965, by virtue of Republic Act no.4190.

Mt. Baya is a dormant volcano with secondary forest situated at Pualas and Ganassi, Lanao del Sur with an elevation of 1484 masl. Camp Abubacar, Barira, Maguindanao is a former stronghold of Moro Islamic Liberation Front (MILF) with a relatively small secondary forest at an elevation of 747masl. Dimapatoy Watershed, Datu Odin Sinsuat, Maguindanao is a reforested area of 37.65km^2 with an elevation of 157 masl. Maluso, Basilan with an elevation of 59 masl has only very small forest patches with the major land area converted to rubber tree (*Hevea brasiliensis)* plantation. Bud Bongao is the highest peak in Tawi-Tawi with a land area of 2.4 km^2 and an elevation of 409 masl. It is one of the few remaining moist forests in Sulu archipelago. It is locally protected although being a tourist destination brought anthropogenic disturbance in the area. Sanga-Sanga is an outlying barangay of Bongao, Tawi-Tawi with an elevation of 93 masl. It has only small forest patches with most land area cultivated for agricultural use.

In each sampling locality, 1 km transect line was made and was extended to 10m to both sides in order to maximize the sampling area.

Collection of samples

Active diurnal field sampling was done from Sept. 7-8, 2014 (8-man hours) in Sanga-Sanga, Sept. 9 -10, 2014 (8-man hours) in Bud Bongao, Sept. 12-13, 2014 (8-man hours) in Maluso, Nov. 16-17 and Nov.19-22, 2014 (24-man hours) in Mt. Mupo, Dec. 1-2, 2014 (8-man hours) in Mt. Baya, Dec. 14-15, 2014 (8-man hours) in Camp Abubacar, Dec. 12 and Dec. 17, 2014 (8-man hours) in Dimapatoy Watershed.

Leaf-dwelling pholcids are cryptic and well-camouflaged which make collection of samples quite difficult. Manual technique employing visual searching or cryptic searching was used [9, 11, 14]. Manual technique is a practical sampling method for leaf-dwelling pholcids which demands to turn thousands of leaves upside down. Each specimen was collected using a small disposable sauce cup by sliding it underneath the spider then covered. Specimen was preserved in 70-75% ethanol in a 10ml glass vial [15]. Samples were identified by Bernhard A. Huber who is currently doing a revision of Southeast Asian pholcids. Hence, species that are probable new records were assigned with specific codes to make comparability across studies possible. Voucher specimens will be deposited at Alexander Koenig Zoological Research Museum, Bonn, Germany and MSU-IIT CSM Natural Science Museum, Iligan City, Philippines.

Statistical Analyses

Distribution of species was illustrated using multivariate seriation. Analysis was done using PAleontological STatistics (PAST) version 2.17. Four common nonparametric estimators Chao 1, Chao 2, ACE (Abundance-based Coverage Estimator) and ICE (Incidence-based Coverage Estimator) were used to estimate species richness in order to minimize undersampling bias. Chao1 and Chao2 were recommended by Cardoso *et al.* [16] for short-term sampling programs. For validity, the estimated sample completeness should be at least 50%. Chao 1 is dependent on singletons and doubletons while Chao2 is sensitive to unique species in a given area. ACE and ICE were modifications of Chao1 and Chao2 based on species with ≤ 10 individuals in the sample and on species found in ≤ 10 sampling units respectively [17, 18]. Chao1 and ACE are abundance-based whereas Chao2 and ICE are both incidence-based richness estimators. Estimates were computed using EstimateS version 9 [19]. Species accumulation curve and estimated species richness curves were derived using Igor Pro version 4.08. Curves that asymptote imply a complete survey whereas rising curves denote an incomplete survey.

RESULTS AND DISCUSSION

Species composition

This study has recorded 180 (53.57%) adult leaf-dwelling pholcids and 156 (46.43%) juveniles in seven sampling localities. Overall there were 10 species which belong to four genera: *Belisana, Calapnita, Panjange, and Pholcus* (Figure 2). The richest genus was *Belisana* where six species were recorded. *Pholcus* has two species, and one species of *Calapnita* and *Panjange*. *Calapnita subphyllicola* is the numerically dominant species which represents 80.65% of the total sample as shown in Table 1. Males were less than females in species where both males and females were collected. The total male-female ratio is 1:2.

Figure 2. Representatives of the four genera of leaf-dwelling Pholcids collected from Mt. Baya (*Belisana* Thorell, 1898), Mt. Mupo (*Calapnita* Simon, 1892 and *Panjange* Deeleman-Reinhold & Deeleman, 1983), and Damapatoy Watershed (*Pholcus* Walckenaer, 1805).

Table 1. Species composition and relative abundance (RA) of leaf-dwelling pholcids.

Species	Male	Female	Juvenile	Total	Relative Abundance %
Belisana					
Belisana apo	1	0	0	1	0.30
Belisana sp. PSt513	3	0	0	3	0.90
Belisana sp. PSt520	3	0	0	3	0.90
Belisana sp. PSt52	0	1	0	1	0.30
Belisana sp. PSt247	10	15	2	27	8.04
Belisana sp. PSt545	2	3	0	5	1.49
Calapnita					
Calapnita subphyllicola	41	89	141	271	80.65
Panjange					
Panjange sp. PSt171	1	0	1	2	0.60
Pholcus					
Pholcus sp. PSt531	1	4	6	11	3.27
Pholcus sp. PSt501	2	4	6	12	3.57
Total	64	116	156	336	
Relative Abundance %	19.05	34.52	46.43		

The current number of reported Pholcid species in the Philippines is 28 excluding synanthropic species [12]. These species are mostly undescribed. Leaf-dwellers include only five known genera in Southeast Asia: *Belisana, Calapnita, Leptopholcus, Panjange*, and *Pholcus* [6, 20, 21, 22]. The total 10 species recorded in this study could be regarded a good number considering that this study focused only on leaf-dwellers. This number is far greater compared to leaf-dwelling pholcid species recorded from Guinea (seven species representing six genera) [14] and Indonesia (7 genera). *Belisana* has recorded the highest number of species. *Belisana* ranked as third largest pholcid genus having 64 described species [22] and considered as one of the most common pholcid spiders in Southeast Asia [6]. On the other hand the poor species richness of *Panjange* in this study is not surprising because previously there is only one species recorded in the Philippines [22] and this species is often difficult to find [10]. It may seem surprising that *Pholcus* has only two species in this study. *Pholcus* with 294 species is notable as the largest pholcid genus [23]. However, there are only three species of *Pholcus* previously described from the Philippines which are all endemic to the country [23]. Another consideration is that *Pholcus* is not all strictly leaf-dweller. There are species that dwell among rocks, tree buttresses, cavities under logs and roots. A typical strict leaf-dweller is represented by *Calapnita.* There are two known record of *Calapnita* species in the Philippines and the current unpublished data of Huber and Nuñeza, [12] suggested that the genus seems to be low in species richness. This may explain why there were only two species collected in this study. On the other hand, *Leptopholcus* has no record yet in the Philippines, however, general distribution data support the probability of its occurrence in the country. *Leptopholcus* is still absent in this study.

The high number of females could be attributed to the tendency of males as in most spiders to wander searching for females. Mate-searching is highly risky for males as they are exposed to predators and can alter the sex-ratio at any given time [24, 25]. The chivalrous behavior of some male pholcids [26] could also contribute to untimely death among males thus reducing their population. A female-biased population was also recorded in *Metagonia osa* pholcid [26] and in *Metagonia trauma* and *Mesabolivar sp*. [28]. Meanwhile, the high abundance of juveniles is presumed to have resulted from the high mortality of the immature stages [29]. Consideration might also be given on how long the development of the juvenile stage because if juveniles live longer than adult then this will result in more juveniles than adults. In an experimental study, *Crossopriza lyoni* mature and deposited their first egg sac at 74-80 days old. Wild caught mature female were observed to live up to 120 days [2].

Table 2 shows the species composition, relative abundance, and sex of the leaf-dwelling pholcids in seven sampling localities. Among the seven sampling localities, Mt. Baya has the highest number of species (4 spp.). However, on generic level Mt. Mupo has the highest number of genus (3). *Pholcus sp.PSt531* (61.11%) is the most abundant species in Mt. Baya and *Calapnita subphyllicola* (98.73%) in Mt. Mupo. Camp Abubacar, Dimapatoy Watershed, Bud Bongao, Sanga-Sanga, and Maluso have recorded only one species. The highest number of males (35), females (72), and juveniles (233) of the species *Calapnita subphyllicola* was recorded in Mt. Mupo, Marawi City. The high number of juveniles may suggest a certain

idea on the life cycle of *Calapnita subphyllicola.* Reproduction time might be on its peak during the months of November-December.

Table 2. Species composition of leaf-dwelling pholcids per locality.

Locality	Species	Male	Female	Juvenile	Total
Mt.Baya	*Belisana apo*	1			1
	Belisana sp. Pst513	3			3
	Belisana sp. PSt520	3			3
	Pholcus sp. PSt531	1	4	6	11
				Total	**18**
Mt.Mupo	*Belisana sp. PSt52*		1		1
	Calapnita subphyllicola	35	72	126	233
	Panjange sp. PSt171	1		1	2
				Total	**236**
Camp Abubacar	*Calapnita subphyllicola*	6	17	15	38
Dimapatoy	*Pholcus sp. PSt501*	2	4	6	12
Bud Bongao	*Belisana sp. PSt247*	7	7	2	16
Sanga-Sanga	*Belisana sp. PSt247*	3	8		11
Maluso	*Belisana sp. PSt545*	2	3		5
Grand Total					**336**

Among the seven sampling sites, Mt. Baya is the most species-rich. Species richness is affected by habitat structure [30]. Various studies confirmed the effect of the tree and herbaceous species richness on spiders [31, 32, 33, 34]. However, there is no robust data on vegetation collected during the study to support this. Based on direct observations, Mt. Baya and Mt. Mupo have very similar vegetation structure. Both are secondary forests with elevation nearly equal and both are the least disturbed areas among the seven sampling sites. Camp Abubacar was relatively small in terms of forest cover. Dimapatoy Watershed and Bud Bongao were relatively disturbed due to anthropogenic activities in the areas. Sanga-Sanga and Maluso have only forest patches with an extreme case in Maluso where a large portion of land mass had been converted to rubber tree (*Hevea brasiliensis)* monoculture. Conversion of natural forests to rubber tree plantation has a detrimental effect on species richness and species composition [35, 36, 37]. This is evident in Maluso which has very poor species richness.

Figure 3 is the result of multivariate seriation illustrating the distribution and shared species in seven sampling sites. Shared species is shown between Bud Bongao and Sanga-Sanga, and between Camp Abubacar and Mt. Mupo. Mt. Baya, Dimapatoy Watershed, and Maluso have unique species. Geographical proximity may explain this because shared species was recorded among closely related sites. Autonomous region in Muslim Mindanao spans two geographical areas. Lanao del Sur (Mt. Mupo, Mt. Baya) and Maguindanao (Camp Abubacar, Dimapatoy Watershed) are in the mainland part of Mindanao while Basilan (Maluso) and Tawi-Tawi (Bud Bongao, Sanga-Sanga) are two separate islands. Pholcids are sedentary and do not disperse through ballooning [38]. Hence, they are usually confined to one geographical area and cosmopolitan species are unusual.

	Mount Mupo	Mount Baya	Camp Abubacar	Dimapatoy Watershed	Bud Bongao	Sanga-Sanga	Maluso
Panjange sp.PSt171							
Belisana sp.PSt52							
Belisana apo							
Belisana sp.PSt520							
Calapnita							

subphyllicola							
Pholcus sp.PSt531							
Belisana sp.PSt513							
Pholcus sp.PSt501							
Belisana sp.PSt247							
Belisana sp.PSt545							

Figure 3. Seriation showing the distribution of species in seven sampling sites.

Species richness estimates

Under sampling bias was addressed in this study with the use of four common species richness nonparametric estimators Chao1, Chao2, ICE, and ACE (Table 3). The species richness in all sampling localities was estimated to be between 10.5 (Chao 1) to 30 species (ICE). Inventory completeness (observed richness/Chao 1 estimate) [37] is 95.24% and sampling intensity (no. individual/no. spp) is 33.6. In Figure 4, the species accumulation curve behaves almost the same with richness estimators Chao 1 and ACE showing a tendency to asymptote but still indicates that inventory was still not complete by the end of sampling. This indicated that a complete survey of species is not feasible within a short sampling period [40]. Chao 2 and ICE reached the peak but eventually decreased.

Table 3. Summary table of results and species richness estimates.

Samples	7	Estimates	
Individuals	336	Chao1	10.5
Individuals/sample	48	Chao2	18
Species	10	ACE	11.2
Sampling intensity	33.6	ICE	30
Singletons	2(0.60%)	Inventory Completeness	95.24%

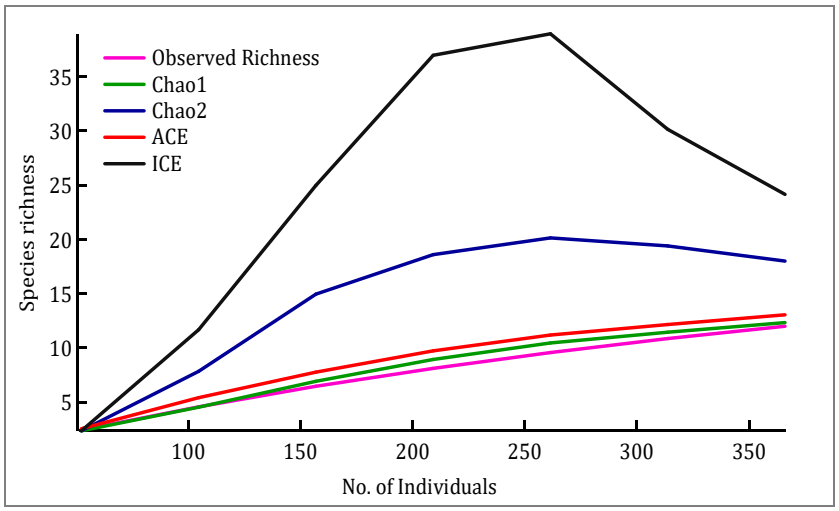

Figure 4. Species accumulation curves.

CONCLUSION

The four known leaf-dwelling genera *Belisana, Calapnita, Panjange,* and *Pholcus* are the leaf-dwelling pholcids documented in selected areas of Autonomous Region in Muslim Mindanao. *Belisana* was the

most species- rich genus and Mt. Baya was the most species-rich site. Predicted species richness suggested that there are still undiscovered species in the area. Thus, a more extended sampling program is necessary for future species inventory of leaf-dwelling pholcids in the region. This was the first study conducted in the region for pholcidae and, therefore, served as a baseline data for future studies.

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