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Microhabitats of pholcid spiders (Araneae: Pholcidae) in Marilog District and Mount Hamiguitan, Davao, Philippines

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Key words: Bodenheimer's constancy, Forest, Ground-dwelling, Leaf-dwelling, *Schismatoglottis* sp.

Abstract

Most spider groups use plants and ground as their microhabitats. In this study, microhabitats of pholcid spiders were investigated in Marilog and Mount Hamiguitan Wildlife Sanctuary in Davao, Philippines to determine the microhabitat utilization of leaf-dwelling and forest ground-dwelling pholcids. Based on quantitative analysis, pholcid spiders were documented mostly on plants. Vegetation-dwelling pholcids were recorded in 134 plants belonging to nine different plant species of monocotyledonous plants and various species of dicotyledonous plants. Based on Bodenheimer's Constancy, highest constancy was recorded for *Schismatoglottis* sp. (C= 39.55%) which means that *Schismatoglottis* sp. is used as an accessory form of microhabitat. In addition, results of the Chi-Square test showed that both *Schismatoglottis* sp. ($X^2 > 213.26$; p-value < 0.001) and dicot seedlings ($X^2 > 85.4$; p-value < 0.001) were both utilized by these spiders. Results suggest that leaf size and structural leaf complexity are not considered as important factors that dictate the microhabitat choice of leaf-dwelling pholcids.

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Introduction

Spiders are among the most abundant invertebrates in any habitat (Coddington and Levi, 1991). The distribution of spiders in a macro-scale is directly related to their susceptibility to abiotic conditions and biotic factors (Mineo *et al.*, 2010). In addition, the vegetation structure of each habitat contributes a lot to the distribution of spiders. Due to the combination of different factors influencing the spider's microhabitat choice, its underlying mechanism is definitely difficult to resolve (Huber and Schutte, 2009).

Most spider groups use plants or ground as a substrate. For the pholcid spiders, a wide variety of microhabitats, ranging from leaf litter to higher vegetation have been documented. In the Philippines, four genera of pholcid spiders are previously classified as forest ground dwellers which include *Aetana*, *Pholcus*, *Spermophora,* and *Uthina* (Huber, 2005). On the other hand, Deeleman-Reinhold and Deeleman, (1983) listed four genera of vegetation dwellers: *Belisana*, *Calapnita*, *Panjange*, and few species of *Pholcus*. However, Southeast Asian countries like the Philippines remain among the most poorly studied as to pholcid biology specifically ecology which limits the understanding of their microhabitats. According to Huber (2009), the study of microhabitats is essential to determine if convergent shifts between microhabitats have occurred.

In forested areas, ground-dwelling pholcids are found in leaf litters in webs between buttresses, in small holes in trees, or fallen logs. The dark environment provides an important environment for ground-dwelling pholcids (Huber, 2000). Spiders are well-hidden in dark places to make them difficult to see and difficult for their main predators to capture (Huber, 2005). On the other hand, leaf-dwelling pholcids are known to reside on the underside of huge leaves. They are characterized by their pale greenish color and delicate long legs. These pholcids usually spend the day tightly pressed against the undersides of leaves rather than whirling and dropping from the web (Deeleman-Reinhold, 1986). Thus, they are well camouflaged by their morphology and behavior to avoid predation. The association of spiders with particular plant types or species has been considered to be unusual even though some studies have demonstrated specific relationships between spiders and particular plant species (Romero, 2006; Vasconcellos-Neto *et al.,* 2007). For the vegetation-dwelling pholcids, they are previously documented in monocotyledonous plants and some eudicots. In this case, monocotyledonous plants are preferred by *Metagonia* pholcid spiders based on quantitative analysis. However, the exact reason for such preferences was not clear (Huber and Schutte, 2009).

Basic ecological data of pholcid spiders like microhabitats in Southeast Asia are not yet available. Hence, the microhabitats of pholcid spiders were investigated in this study in two pristine areas of Davao, Philippines: Marilog District and Mount Hamiguitan Wildlife sanctuary. The study was conducted to document the host plants of leaf-dwelling pholcids and the microhabitats of ground-dwelling pholcids.

Materials and methods

Study area

The study area is situated in Davao Region (Region XI) in Mindanao, Philippines. The sampling areas are located in Marilog District, Davao City and Mt. Hamiguitan Wildlife Sanctuary in Davao Oriental (Fig. 1). In Marilog District, two specific sampling sites were selected which include the rainforest of Barangay Baganihan (7.458205 N; 125. 227554 E) and Epol falls (7.455851 N; 125.236992 E). On the other hand, two access points of Mt. Hamiguitan Wildlife Sanctuary in the municipalities of San Isidro (6.719674 N; 126.171512 E) and Governor Generoso (6.690136 N; 126.153417 E) were also selected as sampling sites.

Sampling sites

Site 1 is located in Brgy. Baganihan, Marilog district which is approximately 60 kilometers (km) away from the heart of Davao City. Three sampling points were selected in this site at different altitudes: 900 meters above sea level (masl), 1000 masl, and 1100 masl. The first two sampling points have an undulating slope which are surrounded by medium trees (12-19.9" in diameter) with a canopy height of >10m. Canopy epiphytes, vines, and *Ficus* are rare (20%) in these sampling points while most of the understory plants found are aroids (*Aglaonema* sp. and *Schismatoglottis* sp.). In the last sampling point, emergent trees with height ranging from 20-35 meters (m) were present. The understory plants are tree seedlings (moderate abundance at 40%) and some plants belonging to families Zingiberaceae and Arecaceae.

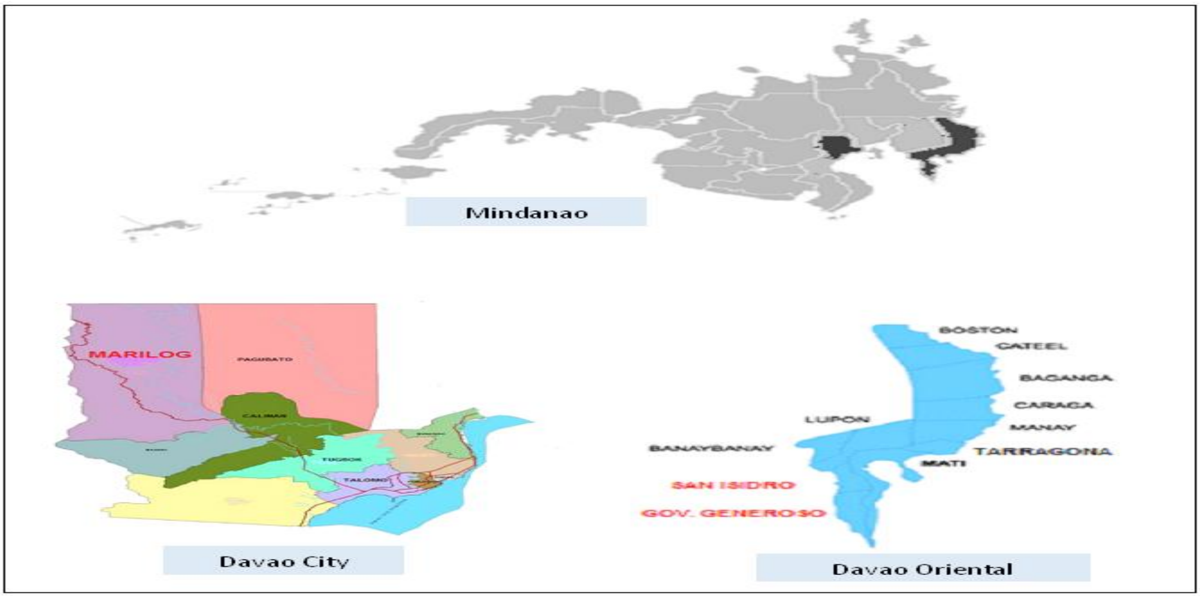

Fig. 1. Map of the sampling areas located in Marilog Davao City and Davao Oriental, Mindanao, Philippines (https://en.wikipedia.org, 2016; http://www.davaocity.gov.ph, 2011; http://davaocitybybattad.blogspot.com, 2012).

Site 2 is located along Epol falls of Marilog District. It is approximately 1 km away from the Baganihan sampling area. Sampling sites in this area have an elevation ranging from 1100-1200 masl. All sampling points are surrounded by medium trees (12-19.9" in diameter) which have moderate (40%) canopy vines and epiphytes. Tree ferns and ground ferns are also found in the area, approximately 40% in abundance. Forest understory plants found are aroids (*Homalomena philippinensis*, *Schismatoglottis* sp.) and different species of shrubs. Exposed rocks and fallen logs are also present approximately 40 % in abundance. Lastly, leaf litter cover was abundant in all sampling points.

Site 3 is at Mt. Hamiguitan Wildlife Sanctuary located at San Isidro, Davao Oriental. Three sampling points in this area were at different elevations: 490 masl, 786 masl, and 1250 masl. Medium trees (12-19.9" in diameter) are found in the first two sampling points with a canopy height of >15 m. However, the second sampling site is 200 m away from a small natural body of water. The understory plants covered in these sampling points were mostly tree seedlings and a few aroids (*Schismatoglottis* sp.). *Curculigo* sp. and *Alpinia* sp. were also present in these sites with 20% in abundance. On the other hand, the third sampling point is located on a forest edge in which a mossy forest vegetation type is located at the lower portion and the upper portion is an early succession of the pygmy forest. Pygmy forest is a unique feature of this mountain where naturally grown pygmy or commonly called "bonsai" trees are found.

Site 4 is situated at Governor Generoso, Davao Oriental which is the second entry point to Mt. Hamiguitan. It is approximately 4 km away from the first entry point in the municipality of San Isidro, Davao Oriental. Sampling points in this site are all in lowland areas which have an elevation of 250 masl, 360 masl, and 580 masl. *Artocarpus* and *Cocos nucifera* were found in this site. The second point is very near to a natural water body in which aroids were commonly found. Saplings or tree seedlings and other shrubs were also present in this area.

Sampling method

Three transect lines per sampling area were established for microhabitat observation. Sampling areas were described according to the habitat description form of the HARIBON Foundation (Mallari *et al*., 2001). In each sampling point, aerial hand searching and ground hand searching methods were employed to observe the microhabitats of pholcid spiders (Chetia and Kalita, 2012). These two methods are called cryptic searching (Sorensen *et al.,* 2002) as pholcid spiders tend to dwell in well-hidden places like leaf litters, in webs between buttresses, in small holes in trees or fallen logs, and on the undersides of large leaves (Huber, 2005). Each searching method was applied for about two hours active sampling in each sampling point excluding interruptions. In addition, pholcid spiders were inspected at both sides of the transect line (approximately 5 meters away) to provide an extensive area of sampling.

Statistical analysis

The Concentration Relative Dominance (CRD) was calculated to evaluate the pholcid concentration per microhabitat based on the formula: CRD= $(i/t) \times 100$ where: i is the total number of pholcids found in specific plant, and t is the total number of sampled pholcids in all plants (Silveira Neto *et al.,* 1976). Bodenheimer's Constancy was also measured with the formula: C= $(p \times 100)/N$ where: p is the number of specific plant species occupied by leaf-dwelling pholcids and N is the total number of plants with pholcids to evaluate the occupation choice of leaf-dwelling pholcids. The presence of leaf-dwelling pholcid per occupied host plant was considered: Constant > 50%; Accessory 25-50% and rare < 25%. Additionally, Chi-Square Test was used to find out whether the distribution of pholcids is dependent on their microhabitats. Furthermore, Canonical Correspondence Analysis (CCA) was performed using Paleontological Statistics Software Package (Hammer *et al*., 2001) to visualize the distribution of pholcids according to their microhabitats.

Results and discussion

Pholcid spiders were documented more on leaves than ground microhabitats. Both monocotyledonous and dicotyledonous plants were found to be the microhabitats of leaf-dwelling pholcids in all sampling areas. Microhabitats of leaf-dwelling pholcids recorded in this study comprised four species of host plants belonging to Family Araceae: *Aglaonema* sp., *Alocasia zebrina*, *Homalomena philippinensis* and *Schismatoglottis* sp. Different plant microhabitats were also recorded from different families: Family Arecaceae (*Pinanga* sp.), Zingiberaceae (*Alpinia* sp.), Hypoxidaceae (*Curculigo* sp.), Pteridophytes (*Pteris* sp.; *Doryopteris* sp.), and different species of dicot seedlings. Plant species of the Family Araceae are characterized by their huge heart-shaped leaves with a sheathing base and parallel leaf venation. *Pinanga* sp., *Alpinia* sp., and *Curculigo* sp. are characterized by their elongated parallel leaves. Few terrestrial pteridophytes were also recorded which have erect woody stems and upright leaves. Saplings or dicot seedling microhabitats belong to different species which mostly have smaller leaves and reticulated leaf venation. Furthermore, microhabitats observed for ground-dwelling pholcids were rocks, buttresses, leaf litters, and fallen logs.

A total of 375 individuals of pholcid spiders belonging to six genera were distributed on both leaves and ground in all sampling areas. Leaf-dwelling pholcids observed were *Belisana*, *Calapnita*, *Panjange,* while *Aetana* and *Spermophora* are ground-dwellers. Highest occurrence of leaf-dwelling pholcids (113 individuals) was observed in the plant species *Schismatoglottis* sp. Fig. 2 shows that the Concentration of Relative Dominance (CRD) of phocid spiders is highest on *Schismatoglottis* sp. in four sampling areas. On the other hand, highest concentration of ground-dwelling pholcids was observed in buttresses for the ground microhabitats.

Table 1. The occurrence of pholcid spiders per microhabitat in four different sampling areas.

Plant species	Epol falls	Baganihan	Governor Generoso	San Isidro
Homalomena philippinensis	+	-	-	-
Rocks	+	-	-	-
Leaf litter	+	-	-	-
Doryopteris sp.	+	-	-	-
Fallen logs	-	+	-	-
Aglaonema sp.	-	+	-	-
Pteris sp.	-	+	-	-
Buttress	+	+	-	+
Schismatoglottis sp.	+	+	+	+
Dicots	+	+	+	+
Pinanga sp.	+	-	-	+
Curculigo sp.	+	-	+	+
Alpinia sp.	+	+	-	+
Alocasia zebrina	-	-	-	-

+ and - indicate the presence or absence of the pholcid spider in a particular microhabitat in the area, respectively.

Table 2. Occupation choice of leaf-dwelling pholcid spiders through Bodenheimer's Constancy.

Plant Taxon	N	Bodenheimer's Constancy (%)	Occupation Choice
Aglaonema sp. (Araceae)	3	2.24	rare
Alocasia zebrina (Araceae)	1	0.75	rare
H. philippinensis (Araceae)	6	4.48	rare
Schismatoglottis sp. (Araceae)	53	39.55	accessory
Curculigo sp. (Hypoxidaceae)	14	10.45	rare
Pinanga sp. (Arecaceae)	6	4.48	rare
Pteris sp. (Pteridaceae)	1	0.75	rare
Doryopteris sp. (Pteridaceae)	16	11.94	rare
Alpinia sp. (Zingiberaceae)	7	5.22	rare
Dicot seedlings	27	20.15	rare

N –total number of plants.

Table 1 shows the multivariate seriation analysis of microhabitats of pholcids in four sampling area. It shows that *Schismatoglottis sp*. and dicots were the shared plant microhabitats of pholcids among four sampling areas. Dicots observed in this study consisted of different species and were only categorized into one group of dicots. This means that leaf-dwelling pholcids are also able to utilize dicots aside from monocots where they are usually found. For ground-dwelling pholcids, they were mostly found in buttresses which are present in three sites; Epol falls, Baganihan, and San isidro. The rest of microhabitats were present in one or two sites only.

Table 2 shows the occupation choice of leaf-dwelling pholcids in different host plants. Leaf-dwelling pholcids were found in a total of 134 plants in which highest constancy was recorded on *Schismatoglottis* sp. (C= 39.55%). Based on Bodenheimer's constancy, leaf-dwelling pholcids use *Schismatoglottis* sp. as an accessory form of microhabitat while the rest of the host plants were used as a rare or accidental form of microhabitat. In the study of Dacar and Nuñeza (2016), *Schismatoglottis* sp. is utilized by leaf-dwelling pholcids also as an accessory form of microhabitat. According to Pederassi *et al.* (2012), plants that are used as an accessory form of microhabitat may provide a well suitable place for refuge against predators than those plants that are used as an accidental form or rare microhabitat.

Table 3. Chi-Square Test of Independence of leaf-dwelling pholcid spiders in Marilog and Mt. Hamiguitan.

Plant taxon	Observed	Expected	Chi-square (X^2)
Aglaonema sp. (Araceae)	8	31.3	17.34
Alocasia zebrina (Araceae)	5	31.3	22.1
H. philippinensis (Araceae)	13	31.3	10.7
Schismatoglottis sp. (Araceae)	113	31.3	213.26**
Curculigo sp. (Hypoxidaceae)	33	31.3	0.09
Pinanga sp. (Arecaceae)	17	31.3	6.53
Pteris sp. (Pteridaceae)	2	31.3	27.43
Doryopteris sp. (Pteridaceae)	19	31.3	4.83
Alpinia sp. (Zingiberaceae)	20	31.3	4.08
Dicots	83	31.3	85.4**

** Significant preferred microhabitats ($p<0.001$).

However, results of the Chi-Square test in this study revealed that *Schismatoglottis* sp. ($X^2 > 213.26$; p-value < 0.001) and different species of dicotyledonous plants ($X^2 > 85.4$; p-value < 0.001) were both highly utilized by plant-dwelling spiders (Table 3). Structural leaf complexity has been considered in our previous study as one factor that determines the microhabitat choice of leaf-dwelling pholcids (Responte and Nuñeza, 2015).

Thus, *Schismatoglottis* sp. has been chosen by leaf-dwelling pholcids as their microhabitat as it has the most simple leaf structure that is suitable for foraging, mating, and as egg-laying sites for leaf-dwelling spiders and shelter for adults and juvenile spiders. However, based on what has been observed in this study, both monocotyledonous plants like *Schismatoglottis* sp. and dicots were chosen by these spiders as their microhabitats. *Schismatoglottis* sp. and dicot seedlings obviously have different characteristics of leaves. *Schismatoglottis* sp. has simple, large, and smooth leaves, while dicot plants recorded in this study have smaller leaves, prominent leaf venations, and some plants have rough leaf surface. It clearly demonstrates that leaf size and structural leaf complexity are disregarded as important factors that dictate the microhabitat choice of leaf-dwelling pholcids. Similarly, Huber and Schutte (2009) reported in their study that leaf size and structure are irrelevant factors for the microhabitat choice of leaf-dwelling *Metagonia* pholcids of Costa Rica.

For the ground-dwelling pholcids, it was observed that the two genera, *Aetana* and *Spermophora* were found on different microhabitats. Fig. 3 shows the distribution of pholcid genera according to their microhabitats using canonical correspondence analysis (CCA). Based on the ordination plot, genus *Aetana* is correlated mostly with fallen logs and buttress microhabitats in Baganihan sampling area. On the other hand, quadrant 3 shows that *Spermophora* is mostly correlated with the leaf litter found in Epol falls. The correlation between a specific genus of ground-dwelling pholcids to a particular microhabitat has been also observed in our previous study (Mondejar and Nuñeza, 2015). This would probably mean that a particular genus of ground-dwelling pholcids has its own desired microhabitats.

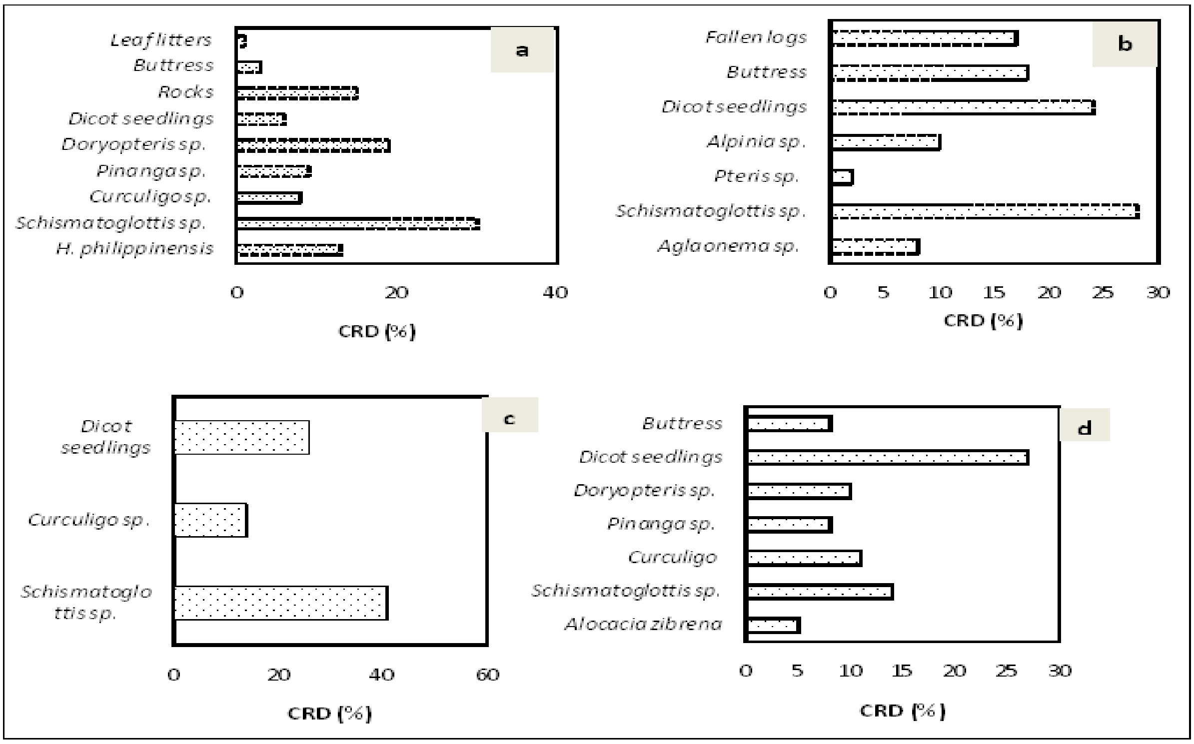

Fig. 2. Concentration Relative Dominance (CRD) per microhabitat in Marilog and Mt. Hamiguitan. Baganihan (a); Epol falls (b); Governor Generoso (c); San Isidro (d).

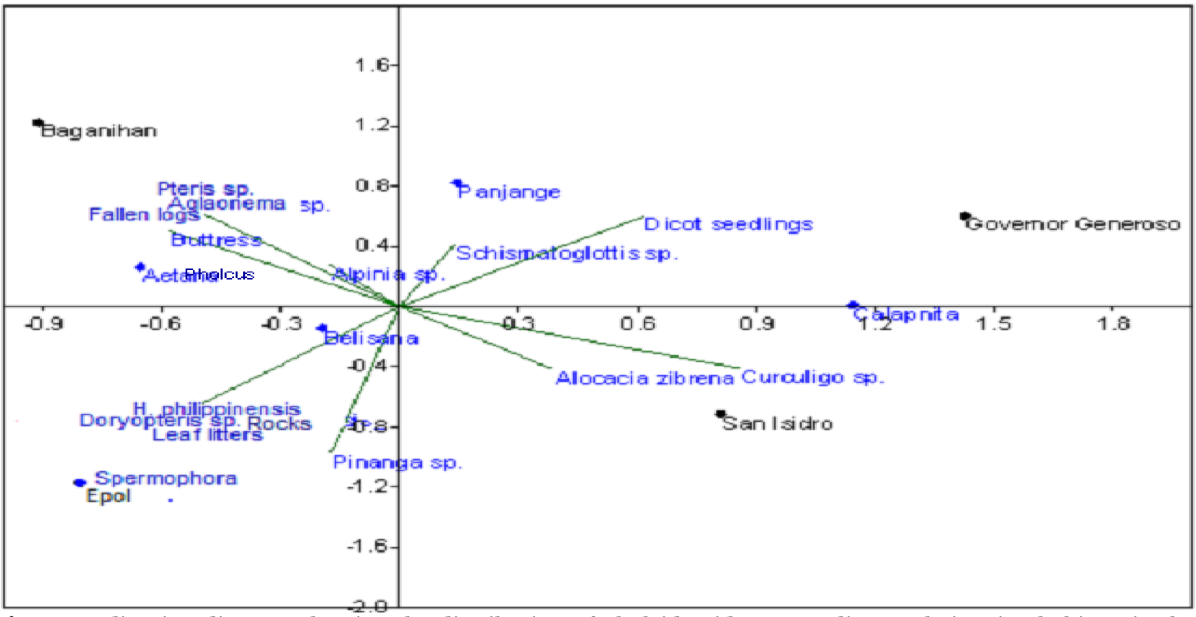

Fig. 3. Ordination diagram showing the distribution of pholcid spiders according to their microhabitats in the four sampling areas using Canonical Correspondence Analysis.

Conclusion

Leaf-dwelling pholcids were mostly found on the host plant, *Schismatoglottis* sp. However, both *Schismatoglottis* sp. and dicot seedlings were utilized by leaf-dwelling pholcids regardless of leaf size and structural leaf complexity. Furthermore, specific microhabitats were preferred by different genera of ground-dwelling pholcids which would probably mean that each genus of ground-dwelling pholcids has its own particular microhabitat.

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