

***Philautus* (Bush Frogs) Species from Montane Forest of Marilog District, Davao City, Southern Mindanao, Philippines**

**Elsa May Delima-Baron^{*1,2}, Alma B. Mohagan², Emmanuel P. Leano²
and Victor B. Amoroso^{2,3}**

¹Biology, Natural Sciences, and Math Division, Arts and Sciences Department, San Pedro College,
Davao City 8000, Philippines

²Biology Department, College of Arts and Sciences, Central Mindanao University, Musuan, Bukidnon 8714, Philippines

³Center for Biodiversity Research and Extension in Mindanao, Central Mindanao University, Musuan,
Bukidnon 8714, Philippines

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*** Corresponding author:**

E-mail: elimaelsa@yahoo.com

ABSTRACT

Despite herpetological surveys conducted in Mindanao, scanty data are known about the *Philautus* species in montane forests as well as its account in southern Mindanao. Species accounts of *Philautus* sampled from the montane forest of Marilog District in Southern Mindanao with notes on its microhabitats were provided. Belt-transect sampling and microhabitat searches were employed in three different sites. A total of 124 individuals representing four species of *Philautus* were accounted, three of which are currently known only from forested areas of Mindanao. *Philautus acutirostris* is the most encountered species. Thirty-four genera of plants associated with microhabitats of *Philautus* species were accounted. Although the majority of the frog individuals appear to use the plants for perching, other notable activities were also noticed. Further observations may reveal data that will unravel other significant roles of these associated plants in microhabitats of *Philautus* species.

1. INTRODUCTION

Tropical forests harbor more species due to the habitat and microhabitat conditions suited to support a diverse group of species including frogs (Angelini et al., 2011). The Philippine tropical forests have also been persistently reported to be home to several species of frogs with pronounced high rate of endemism and with increasing discovery of new species (McLeod et al., 2011; Brown et al., 2012; Brown et al., 2015; Sanguila et al., 2016; Supsup et al., 2017).

One of the frog genera inhabiting the Philippine tropical forests is *Philautus*, a group of diminutive frogs that thrive in higher elevations forests, montane and mossy (Brown and Alcalá, 1994). These tree frogs are often observed perched on various tree species either on their branches or atop leaves of bushes and small trees that are situated far from bodies of water. Their dependence on plants may be attributed to the aerial direct development of their froglets without going through the aquatic tadpole stage (Bossuyt and Dubois, 2001). *Philautus* species are also dependent on a

moist environment and their presence can be an indicator that moisture in the forest habitat is still within an acceptable range that can accommodate not just frog species but other organisms that are directly affected by desiccation. Reduced moisture in ground and above-ground microhabitats in forested habitats has also been used as an indicator of forest fragmentation (Alcalá et al., 2012). Currently, only nine species of *Philautus* are recognized in the Philippines and only three of these species are currently not known to exist geographically in localities of Mindanao (Frost, 2018). Due to their cryptic nature and highly variable morphological features (Bossuyt and Dubois, 2001), the current taxonomy of Philippine *Philautus* warrants an intensive review to fully unravel the diversity of these forest bush frogs.

Although previous studies accounted for the presence of *Philautus* species in several sites in Mindanao (Delima et al., 2007; Warguez et al., 2013; Sanguila et al., 2016; Supsup et al., 2017; Bruno et al., 2017), only one published study, Dacalus et al. (2017), reported accounts of *Philautus*

species from the forested area of Marilog District. Data on the ecology of Philippine *Philautus* species also remain depauperate despite the fact that it may provide valuable insights into the organisms' sustenance and can possibly be utilized for crafting appropriate conservation measures. Such gaps lead us to account for *Philautus* species and identify plants that are associated with the microhabitats of these bush frogs in the montane forest of Marilog District.

2. METHODOLOGY

2.1 Sampling sites

Three different sites within Marilog District were surveyed from March to July 2018 (Figure 1). The sites were chosen because of the presence of remaining few forest habitats of Davao City, mainly upper elevation forests. These sites are also relatively unexplored with regards to published data on biodiversity studies. Moreover, anthropogenic activities are very visible in the sites manifested by the presence of shifting agricultural practices and construction of various resorts both for commercial and personal use, thus warrants timely documentation of its flora and fauna.

Marilog District is around 53 kilometers from the city center of Davao, in the southern side of Mindanao, Philippines. Average temperature during the sampling period is 21 °C while relative humidity is 90%. All sites surveyed were classified as montane forest characterized by the presence of tall trees dominated by *Lithocarpus* spp. Tree trunks and branches, as well as the forest floor, are partly covered with moss. Sites visited have an altitudinal range of 900-1,350 m.a.s.l. Description of each site surveyed is given below.

Site 1: This site is situated in So. New Calinan, Barangay Baganihan, Marilog District, Davao City (7°27' 13.74" N, 125°15' 1.12" E). The survey site is located at the back and adjacent section of Lawi-Lawi Adventure Park. *Lithocarpus* spp. were common in the site along with several species of ferns. Leaf littering on the forest floor was relatively thick and moderately dry. Weather conditions during the sampling period switched from sunny to rainy towards late afternoon but rain showers did not persist during the nocturnal sampling. The wind was persistently strong during the night transect walks evidenced by swaying of the trunks and branches of the trees. The site is close to

an access road used by inhabitants of the neighboring barangay to get to the center of Barangay Baganihan. Forest clearings were also observed in some areas covering the sampling site. Transects were established in areas close to netting sites of birds and bats. The area was surveyed on March 5-10, 2018.

Site 2: The second site is situated in Busay Falls, Barangay Datu Salumay, Marilog District, Davao City (7°29' 31.1" N, 125°15' 5.80" E). The survey site covers a portion of the interior as well as foothills of Mt. Malambo Dako and the adjacent areas of Busay Falls. Tall trees were abundant inside the forest interior but thickets of *Gleichenia* spp. and *Nephrolepis* abound the forest edge. *Medinilla* species were also found near the edge and on the entrance to the interior of Mt. Malambo together with stands of *Musa textilis*. The forest floor is covered with relatively thick leaf litter, which was a bit moist during the survey. Weather was relatively good during the first three nights of the survey but heavy rains followed the subsequent nights where visibility was really poor. Several rest houses surround the area sampled. Evidence of human encroachment is further highlighted by the presence of patchy plots planted with vegetables such as cabbage. The area was surveyed on May 7-12, 2018.

Site 3: The third site is situated in So. Epol, Barangay Baganihan, Marilog District, Davao City (7°27' 19.73" N, 125°14' 33.37" E), at the back of Lola Mommy's Resort. *Lithocarpus* spp. dominated the site and stands of tree ferns such as *Sphaeropteris* were also evident. Leaf litter was not so thick on this site. Some transects also bisected streams and limpid pools of water in the forest interior. Bamboo Thickets were also observed in some areas surveyed. Weather was generally good except for intermittent rain showers that contribute to the fog during nocturnal surveys. The area was surveyed on July 23-28, 2018.

2.2 Collection of *Philautus* species

Belt-transect sampling covering 10 meters by 5 meters on both sides each transect and microhabitat searches (Heyer et al., 1994) were employed to document *Philautus* species. Frog individuals were handpicked whenever encountered during the diurnal (0900-1400) and nocturnal (1900-2200) searches. Vouchers of the samples were collected following the Gratuitous Permit issued by

the Department of Environment and Natural Resources Region XI. For identification of the

specimens, morphological characters described by Brown and Alcala (1994) were followed.

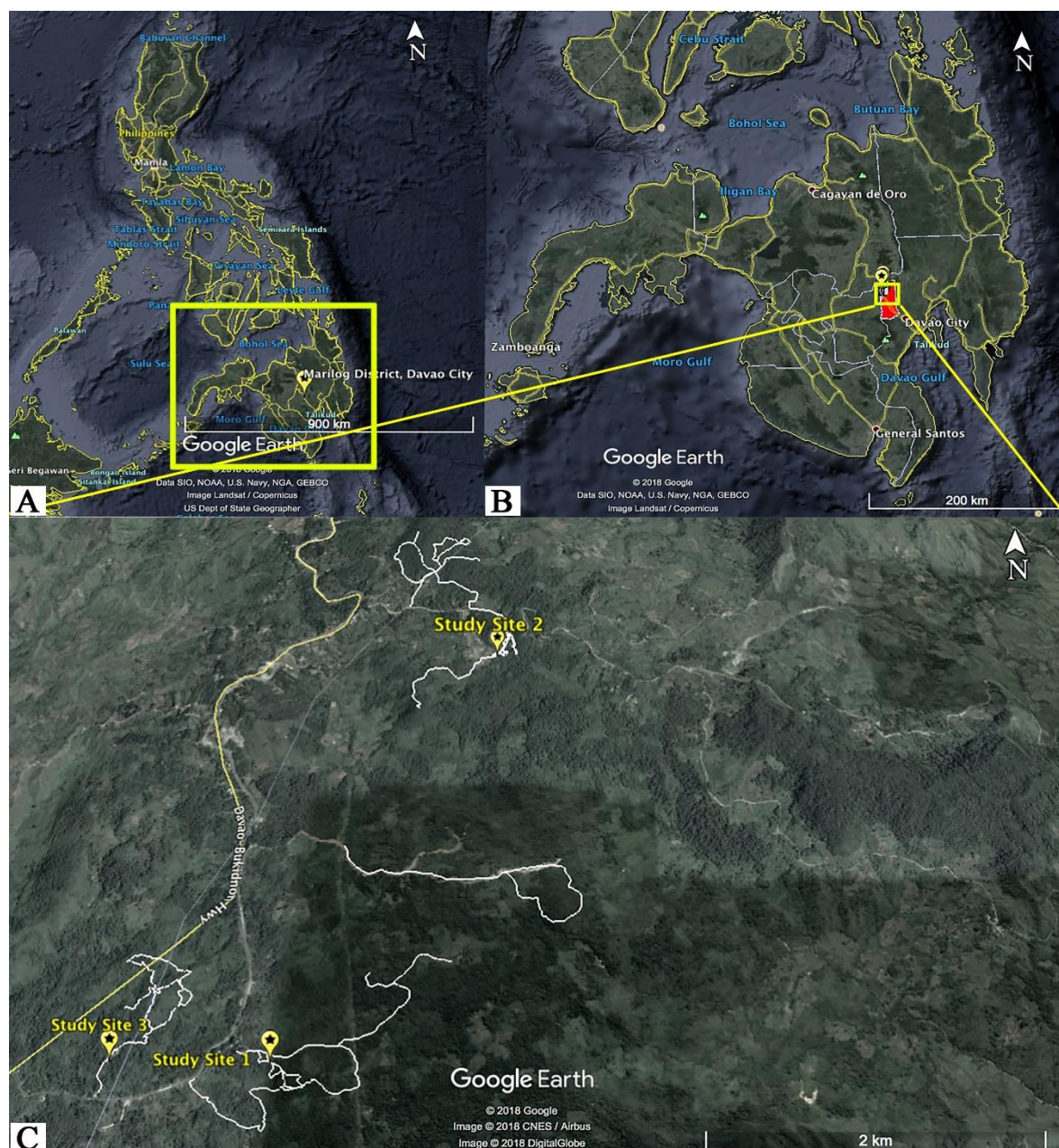


Figure 1. Map of study sites in Marilog district, Davao city, Philippines. (A) Philippine map showing Mindanao Island; (B) Mindanao Island showing Marilog District. (C) Sites surveyed within Marilog. (Source: ©2018 Google Earth)

2.3 Composition, relative abundance, microhabitats and ecological notes

Information on altitudinal distribution, relative abundance, and microhabitats of *Philautus* species were recorded. Relative abundance is expressed as a percentage and was computed as the number of individuals per species divided by the total number of individuals observed for all species multiplied by 100.

The sites where individuals were first encountered/observed were considered as the microhabitat of that individual. Microhabitats were classified as aquatic, ground, and terrestrial following Delima et al. (2007). The location of the microhabitat, whether on edge or inside forest interior was also noted. The activity of the frog individual when it was first spotted was also recorded as the observed activity. The plant associated with the microhabitat, as

well as the vertical distance from the ground to the spot where the individual frog was first encountered, was also recorded.

3. RESULTS AND DISCUSSION

3.1 Composition and relative abundance of *Philautus* species

Four out of nine species of *Philautus* currently known from the Philippines were encountered from the sites surveyed based on existing morphological distinguishing characters (Table 1; Figure 2). Although only three out of the nine species are not known from Mindanao Island (Brown and Alcala, 1994; Frost, 2018), *P. surrufus* and *P. poecilus* were not encountered in the study sites. Aside from earlier accounts that these species have limited known current distribution, the former known from Western Mindanao while the later from Northeastern Mindanao, type specimens of these species were encountered from 1,600-1,900 m.a.s.l. (Brown and Alcala, 1994). Since the elevation of the sites surveyed is only from 900-1,350 m.a.s.l., it is very likely that individuals of these species will not be encountered. Moreover, these species seem to be restricted to higher elevation forests, mostly confined to perch sites from 4-8 meters (Brown and Alcala, 1994). Extensive search beyond five meters from the ground or canopy sampling was not done, thus making this added possible reason for not encountering these species.

All four species: *P. acutirostris*, *P. leitensis*, *P. surdus* and *P. worcesteri* were encountered in all sites surveyed. Most frequently encountered was *P. acutirostris* with 43 individuals followed by *P. surdus* with 37 individuals while only 9 individuals of *P. worcesteri* were recorded during the entire duration of the sampling. Among the species

encountered, *P. acutirostris* appeared very common in the area. The current data parallel those of a previous report where *P. acutirostris* appears very common in secondary forests and in dense aggregates inside the forest interior (Sanguila et al., 2016). The minimal number of *P. worcesteri* individuals encountered despite early accounts that these species are common in many montane habitats in Mindanao Island (Brown and Alcala, 1994), is possibly due to the limited effort to sample microhabitats beyond five meters from the ground. It was also noted that these species seem to prefer higher perch sites and are relatively silent during drier atmospheric conditions (Sanguila et al., 2016). Moreover, frog calls were not recorded during the sampling, so there were no other means of verifying the extent of the presence of these species in the sites surveyed.

No distinct pattern for altitudinal distribution can be deduced from the current data given the unequal number of representative individuals per species per elevation. However, the current data support previous reports that *Philautus* species may be confined to higher elevation forests (Brown and Alcala, 1994; Nuneza et al., 2010; Plaza and Sanguila, 2015; Frost, 2018).

Philautus acutirostris and *P. leitensis* are currently listed as threatened species under the vulnerable category of IUCN. However, Diesmos et al. (2014) suggested that the threatened status of *P. acutirostris* may be incorrect since no actual data supports the declining population of this species. Moreover, individuals of this species were encountered in both forest edges and interior in the sites surveyed. Similar observations were also reported in forested areas of Northeastern Mindanao (Sanguila et al., 2016).

Table 1. *Philautus* species accounted from the three montane forest sites of Marilog District, Davao City, Southern Mindanao, Philippines.

Species	RA (%)	Site ^a	Altitudinal distribution ^b	N ^c	Status ^d
<i>Philautus acutirostris</i> **	35	3	1,100	12	VU
		3	1,150	1	
		1, 2	1,200	3	
		1	1,232	3	
		1	1,245	18	
		1	1,312	7	

Table 1. *Philautus* species accounted from the three montane forest sites of Marilog District, Davao City, Southern Mindanao, Philippines (cont.).

Species	RA (%)	Site ^a	Altitudinal distribution ^b	N ^c	Status ^d
<i>Philautus leitensis</i> **	28	3	1,100	19	VU
		1	1,115	2	
		3	1,150	1	
		2	1,196	1	
		1, 2	1,200	7	
		1	1,245	1	
		1	1,312	4	
<i>Philautus surdus</i> *	30	3	1,100	10	LC
		3	1,150	4	
		2,3	1,200	11	
		2	1,215	1	
		1	1,232	2	
		1	1,245	5	
		1	1,295	1	
		1	1,312	3	
<i>Philautus worcesteri</i> **	7	2,3	1,100	4	LC
		1	1,115	1	
		2	1,200	4	

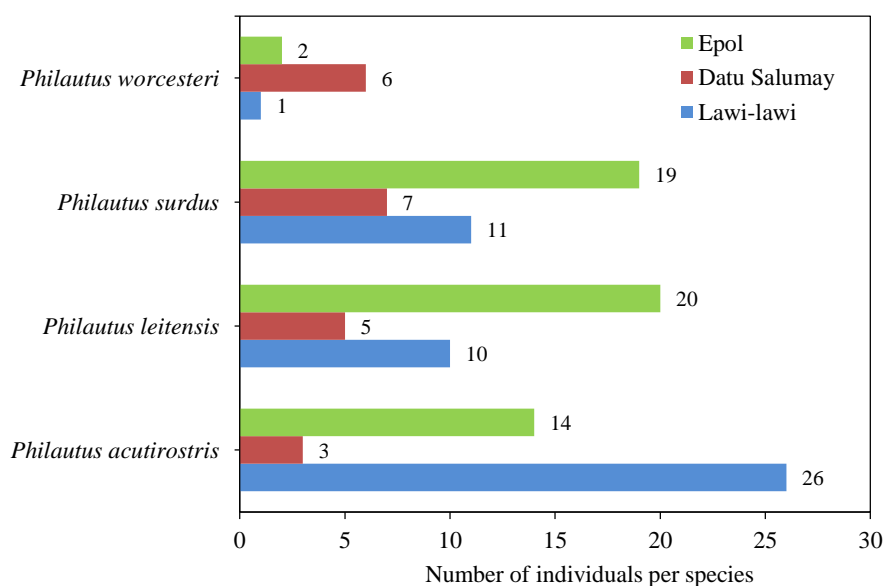
** Mindanao Faunal Region Endemic; * Philippine Endemic; RA=Relative abundance

^aSites: 1=Lawi-Lawi; 2=Datu Salumay; 3=Epul

^bAltitudinal distribution is based on the covered altitudinal range per site surveyed, m.a.s.l.

^cN=Number of individuals observed per elevation

^dStatus conforms to IUCN 2018 (redlist.org): LC=Least concern; VU=Vulnerable

**Figure 2.** Number of individuals per *Philautus* species accounted per sampling site.

3.2 Microhabitats, associated plants and observed activities of *Philautus* species

All individuals of the *Philautus* species accounted in the sites surveyed were encountered on

ground microhabitats (Table 2). Plaza and Sanguila (2015) also reported that *Philautus acutirostris*, *P. surdus* and *P. worcesteri* were found on terrestrial and arboreal microhabitats while Delima et al.

(2007) and Ates and Delima (2008) reported that *Philautus* species were accounted from arboreal microhabitats in Mt. Hamiguitan and Mt. Sinaka, respectively. Variations in microhabitats where *Philautus* species are observed as supported also by varying vertical distance from the ground of the microhabitats may possibly indicate utilization of multiple microhabitats by *Philautus* species for their sustenance.

Frog individuals were not solely encountered inside the forest but some were encountered in forest edge and on vegetation surrounding open clearings and those intentionally planted for resort beautification. Such observation conforms to previous reports where *Philautus* species were recorded from secondary growth, agricultural areas, and vegetation near clearings (Plaza and Sanguila, 2015; Sanguila et al., 2016; Dacalus et al., 2017). Studies to validate if such occupancy may entail adaptation to declining original forest habitats may be imperative.

Thirty-four taxa of plants were observed to be associated with the microhabitats of *Philautus* species. Eleven of the associated plants were ferns while the bulk are angiosperms. Most individuals observed were seen perched either on leaves, leaf axils, stipe or branch of these associated plants. Some individuals while perched, were randomly sticking out its tongue. This activity was observed when some insects, assumed to be potential prey, were found in close proximity to the leaf or stipe where the frogs were perched. Other individuals

were observed to be vocalizing while perched on stipe of ferns or on branches of angiosperms. Previous accounts have been noted of plant-frog associations as observed in the wild (Alcala et al., 1997; Diesmos et al., 2003; Sanguila et al., 2016). The use of *Asplenium nidus* by *P. acutirostris* as a microhabitat was previously reported among samples from Mt. Kalatungan in Bukidnon. Aside from the bird's nest fern, *Musa sapientum*, *Musa textiles*, *Trema orientalis* and *Cyathea contaminans* were also accounted as plants used by this frog species as possible refuge, a site for egg deposition, and as perch plants (Warguez et al., 2013). Individuals of *P. surdus* in Mt. Banahao were also documented to make use of *A. nidus* as a climate-contingent refuge as well as diurnal microhabitats and breeding sites (Scheffers et al., 2014). *P. surdus* perched on fronds of this fern species was encountered. The association of *Philautus* species with angiosperms in forest sites appears scanty and often reported as part of habitat or microhabitat descriptions as indirect associations (Warguez et al., 2013; Sanguila et al., 2016; Supsup et al., 2017). Although it can be deduced that frogs that have direct aerial development will be dependent on plants for deposition of their eggs and subsequent development of their young, plants also appear to be used by frogs as refuge to conceal themselves from predators, and perch sites while waiting for prey item to feed on as revealed in the field observations of this study.

Table 2. Microhabitats, associated plants and observed activities of *Philautus* species from Marilog District.

Species	N ^a	M ^b	Distance ^c	Associated plants	Observed activity
<i>P. acutirostris</i>	1	G, FI	1.0	<i>Castaniopsis</i> sp.	Atop leaf and vocalizing
	2	G, FI	0.3	<i>Sacandra glabra</i>	Perched on leaf axil, tongue sticking out; possibly feeding
	6	G, FI	0.2	<i>Sacandra glabra</i>	Perched on leaf axil
	2	G, FI	2.0	<i>Asplenium nidus</i>	Partially hidden between fronds
	4	G, FI	1.0	<i>Asplenium nidus</i>	Perched atop fronds
	1	G, FI	0.5	<i>Asplenium decorum</i>	Perched on frond
	1	G, FE	0.3	-	Atop twig of dried plant
	11	G, OF	0.5	<i>Nephrolepis hirsutula</i>	Perched on fronds
	1	G, FE	0.2	<i>Dicranopteris linearis</i>	Atop stipe
	3	G, FE	0.5	<i>Cordyline fruticosa</i>	Perched on leaf
	2	G, FI	1.0	<i>Calamus</i> sp.	Perched on leaf
	2	G, FI	0.5	<i>Etlingera</i> sp.	Perched on leaf

Table 2. Microhabitats, associated plants and observed activities of *Philautus* species from Marilog District (cont.).

Species	N ^a	M ^b	Distance ^c	Associated plants	Observed activity
	1	G, FE	0.2	<i>Nephrolepis biserrata</i>	Perched on stipe
	1	G, FI	0.5	<i>Cyrtandra</i> sp.	Perched on leaf axil
	3	G, FI	0.5	<i>Turpenia</i> sp.	Perched on leaf
	1	G, FI	0.5	<i>Homalomena</i> sp.	Perched on leaf
<i>P. leitensis</i>	2	G, FE	0.3	<i>Nephrolepis hirsutula</i>	Perched atop stipe
	1	G, OF	0.5	<i>Nephrolepis biserrata</i>	Perched on frond
	3	G, FI	1.0	<i>Asplenium decorum</i>	Perched on frond
	3	G, FI	2.0	<i>Asplenium nidus</i>	Perched on frond, vocalizing
	1	G, OF	0.5	<i>Dicranopteris linearis</i>	Perched on stipe
	4	G, FI	1.0	<i>Calamus</i> sp.	Perched on leaf
	1	G, FI	1.0	<i>Melastoma malabatricum</i>	Perched on leaf
	1	G, FI	1.0	<i>Cyathea davaoensi</i>	Perched on stipe
	2	G, OF	0.5	<i>Cordyline fruticosa</i>	Partially hidden between leaves
	1	G, FI	0.5	<i>Palaquium</i> sp.	Perched atop leaf
	3	G, FI	0.3	<i>Pilea</i> sp.	Perched on leaf axil
	2	G, FI	0.5	<i>Poikilospermum</i>	Perched on stipe
	1	G, FI	0.5	<i>Elaeocarpus</i> sp.	Perched on leaf
	1	G, FI	0.2	<i>Cyrtandra</i> sp.	Perched on leaf axil
	1	G, FI	1.0	<i>Syzygium</i> sp.	Perched on leaf
	4	G, FI	0.3	<i>Hymenophylloides</i> sp.	Perched on frond
	1	G, FI	0.5	<i>Mackinlaya celebica</i>	Perched on leaf
	1	G, FI	0.5	<i>Homalomena</i> sp.	Perched on leaf axil
	2	G, FI	1.0	<i>Ficus</i> sp.	Perched on leaf, vocalizing
	1	G, FI	1.0	<i>Lithocarpus</i> sp.	Perched on leaf
<i>P. surdus</i>	4	G, FI	0.5	<i>Melastoma malabatricum</i>	Perched atop leaf
	1	G, FI	1.0	<i>Polyosma</i> sp.	Perched on leaf and vocalizing
	2	G, FI	0.4	<i>Polyosma</i> sp.	Perched on leaf axil
	4	G, FE	0.2	<i>Nephrolepis hirsutula</i>	Perched atop stipe
	2	G, FI	1.0	<i>Calamus</i> sp.	Perched on leaf
	1	G, FI	0.5	<i>Oleandra</i> sp.	Perched on leaf
	1	G, FI	1.5	<i>Medinilla</i> sp.	Perched on branch facing another frog individual
	1	G, FE	1.0	<i>Piper aduncum</i>	Perched on leaf
	3	G, FI	0.2	<i>Sarcandra glabra</i>	Perched on leaf axil
	2	G, FE	1.0	<i>Musa textilis</i>	Perched on stipe
	4	G, FI	1.0	<i>Asplenium nidus</i>	Perched on frond
	1	G, FI	1.0	<i>Pilea</i> sp.	Perched on leaf
	1	G, OF	0.2	<i>Cordyline fruticosa</i>	Partially hidden between leaves
	1	G, FI	0.5	<i>Cyrtandra</i> sp.	Perched on leaf
	1	G, FE	0.2	<i>Nephrolepis biserrata</i>	Perched on frond
	2	G, FI	0.4	<i>Syzygium</i> sp.	Perched atop leaf
	2	G, FI	0.3	<i>Homalomena</i> sp.	Perched on leaf axil
	1	G, FI	0.4	<i>Mackinlaya celebica</i>	Perched on leaf
	1	G, FI	1.0	<i>Angipteris palmiformis</i>	Perched on stipe
	1	G, FI	0.3	<i>Aglaomorpha splendens</i>	Atop frond
	1	G, FI	1.0	<i>Ficus</i> sp.	Perched on leaf

Table 2. Microhabitats, associated plants and observed activities of *Philautus* species from Marilog District (cont.).

Species	N ^a	M ^b	Distance ^c	Associated plants	Observed activity
<i>P. worcesteri</i>	1	G, FI	0.3	<i>Perotrichia</i> sp.	Perched on the leaf
	1	G, FI	1.0	<i>Medinilla</i> sp.	Perched on leaf
	2	G, FI	1.0	<i>Asplenium nidus</i>	Perched on frond
	2	G, FI	1.0	<i>Ascarina philippensis</i>	Perched on leaf axil
	1	G, FI	0.5	<i>Diplazium davaoensi</i>	Perched on stipe
	1	G, OF	0.5	<i>Cordyline fruticosa</i>	Partially hidden between leaves
	1	G, FI	0.3	<i>Aglaomorpha splendens</i>	Perched on frond

^aN=Number of individuals observed^bMicrohabitats: G=Ground (0-5 meters from the ground); FI=Forest interior; FE=Forest edge; OF=Area outside the forest, clearing^cDistance is based on the approximate vertical distance of the sample from the ground, meters.

4. CONCLUSIONS

One hundred twenty four individuals representing four species of *Philautus* were documented from the montane forests of Marilog District. *Philautus acutirostris* was the most encountered species with 43 individuals. All species have representatives documented in forest interior and in areas outside the forest. All samples were documented on ground microhabitats. Thirty-four genera of plants were documented on microhabitats of *Philautus*. Aside from merely perched on these plants, other activities were also accounted. The presence of *Philautus* species in areas outside forest interior warrants further studies to assess if these frogs are possibly adapting to effects of forest fragmentation. Moreover, the documentation of *Philautus* individuals from ground microhabitat as compared to previous reports that they occur in arboreal habitats may be indicative of multiple microhabitat uses for sustenance. The presence of different plant species associated with microhabitats of *Philautus* also highlights the key role of plants in various maintenance activities of these frogs.

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