

A New Species of *Callulops* (Anura: Microhylidae) from Papua New Guinea¹

Fred Kraus^{2,3} and Allen Allison²

Abstract: We describe a new species of *Callulops* from the vicinity of Crater Mountain Biological Station in south-central Papua New Guinea. The species may be distinguished from its congeners by its unique dorsal color pattern, moderately expanded digital disks bearing circummarginal grooves, smooth skin, relatively long legs, and relatively short snout. The species is currently known only from the type locality, and its nearest relatives remain obscure.

THE ASTEROPHRYINE microhylid genus *Callulops* currently consists of 15 species of frogs that are restricted to New Guinea ($n = 11$) and the Maluku Islands ($n = 4$). The latest revision of the genus was by Zweifel (1972), under the name *Pbrynomantis*. Since that time, the generic name has been changed to *Callulops* (Dubois 1988), three species have been removed to *Mantophryne* (Burton 1986), and one new species of *Callulops* has been named (Richards et al. 1995).

Callulops appears to be monophyletic and is diagnosed by the following synapomorphies: (1) the *M. intermandibularis* comprises two slips, the anterior with a tendinous, and the posterior with a muscular, origin; and (2) the dorsal surface of the otic ramus of the squamosal is continuous with its lateral surface, and the medial flange of the squamosal is poorly developed (Burton 1986). In addition, *Callulops* is unique among asterophryines in having the *M. depressor mandibulae* arising from the entire ventral margin of the tympanic ring; however, this state is also found among many genyophryines (Burton 1986) and so may be plesiomorphic. Externally, the

genus is notable for its stout habitus, short snout, and large eyes relative to other Papuan microhylids. Most species are terrestrial, but at least one, *C. slateri* (Loveridge), is arboreal (A.A., pers. obs.; S. Richards, pers. comm.), and other species with expanded digital disks may be as well.

In 1992, the Bishop Museum received a collection of frogs obtained by Wayne Crill from the vicinity of the Crater Mountain Biological Station, Chimbu Province, Papua New Guinea. The collection contains several specimens of new frog species, including a new *Callulops*, and we take this opportunity to describe the latter.

MATERIALS AND METHODS

Specimens were fixed in formalin and then transferred to 70% ethanol for storage. All measurements were made with digital calipers or an optical micrometer to the nearest 0.1 mm, with the exception that disk widths were measured to the nearest 0.03 mm. We followed the measurement methodology of Zweifel (1972, 1985): body length from snout to vent (SV), tibia length from heel to skin fold of knee (TL_{fold}), tibia length from heel to outer surface of flexed knee (TL_{knee}), diameter of eye (EY), distance from anterior corner of eye to tip of snout (SN), distance from anterior corner of eye to center of nares (EN), internarial distance, between centers of external nares (IN), head width at widest point, typically at the level of the tympani (HW), tympanum diameter (TY), interocular width, between the bases of the eyelids (IO), width of disk on third finger (3rdF),

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² Bernice P. Bishop Museum, 1525 Bernice Street, Honolulu, Hawai'i 96817.

³ Correspondence: phone: 808-848-4118; fax: 808-847-8252; E-mail: fkraus@hawaii.edu.

width of disk on fourth toe (4thT). The two different measures of TL are provided because measurement technique varies in the literature: the first will facilitate comparison with data provided in Zweifel (1972), the second with data provided by Richards et al. (1995). The latter measurement is generally the more reliable across a variety of microhylid genera and is the standard in more recent taxonomic treatments, but the former measurement is published for a much wider array of taxa (Zweifel 1972).

The structure of recorded calls was analyzed using the computer programs Speech Analyzer (Summer Institute of Linguistics, version 1.06a) [www.sil.org] and Spectrogram (version 5.1.6, R. S. Horne) [www.visualizationsoftware.com].

We confirmed generic assignment of the frogs by the presence of symphygnathine maxillae (Zweifel 1972), the origin of the *M. depressor mandibulae* along the entire ventral margin of the tympanic ring, and two slips (anterior tendinous, posterior muscular) to the *M. intermandibularis* (Burton 1986). Type specimens are deposited in the Bernice P. Bishop Museum, Honolulu (BPBM).

Callulops marmoratus Kraus & Allison, n. sp.

Figures 1A, 2, 3, 4

HOLOTYPE. BPBM 14222, an adult male, collected by Wayne Crill from the vicinity of the Crater Mountain Biological Station, 9.6 km E Haia, 850 m elevation, 6° 43' S, 145° 05' E, Chimbu Province, Papua New Guinea, 23 July 1991.

PARATYPES. BPBM 14221, an adult female, same data as holotype except collected 22 July; BPBM 14226, an adult female, same data as holotype except collected 22 August 1990; BPBM 14227, immature, same data as holotype except collected 25 April 1990; BPBM 14225, juvenile, same data as holotype except collected 8 April 1990; BPBM 14223, juvenile, same data as holotype except collected at 900 m on 6 August; and BPBM 14224, juvenile, same data as holotype except collected at 900 m on 24 August.

DIAGNOSIS. A medium-sized (SV = 50.8–

53.3 mm in adults) species of *Callulops* having expanded digital disks with circummarginal grooves, long legs ($TL_{fold} = 0.38–0.44$, $TL_{knee} = 0.45–0.49$), a relatively short snout ($EN/SV = 0.068–0.077$, $EN/IN = 0.79–0.88$), smooth skin, a brown (in preservative) dorsum with an irregular pattern of dark brown mottling, and a mottled ventrum.

DESCRIPTION OF THE HOLOTYPE. Head moderately wide ($HW/SV = 0.38$), merging with body with no constriction at neck; oblique loreal region, concave posterior to the external nare; canthus rostralis rounded; nostrils closer to tip of snout than to eyes; internarial distance greater than distance from external naris to eye ($EN/IN = 0.88$, $IN/SV = 0.087$, $EN/SV = 0.077$); snout truncate when viewed from above, rounded in side profile; eyes fairly large ($EY/SV = 0.14$), set close together, eyelid width greater than interorbital distance; tympanic ring indistinct, horizontal diameter less than half the width of eye.

Dorsal and ventral surfaces smooth. A narrow supratympanic fold runs from the eye to above the forearm.

Fingers unwebbed, relative lengths $3 > 4 > 2 = 1$, all fingers with moderately large disks ($3rdF/SV = 0.033$), each bearing a circummarginal groove (Figure 1A); inner and outer metacarpal tubercles present. Toes unwebbed, relative lengths $4 > 3 > 5 > 2 > 1$; all toes with expanded disks, each bearing a circummarginal groove; inner metatarsal tubercle present, outer absent. Hind legs moderately long ($TL_{fold}/SV = 0.38$, $TL_{knee}/SV = 0.45$).

Color in preservative: dorsal ground color of body and limbs tan, irregularly mottled with darker brown, which is formed into weak ocelli in the lumbar region (Figure 2); lateral surfaces lighter and with less dense brown mottling; supratympanic fold not clearly differentiated in color from adjacent areas; sides of face slightly darker than areas immediately posterior (Figure 3). Ventral ground color yellowish beige, mottled with brown stippling, which is densest on chin, throat, sides, and limbs and becomes sparse on abdomen. Palms and soles uniformly brown.

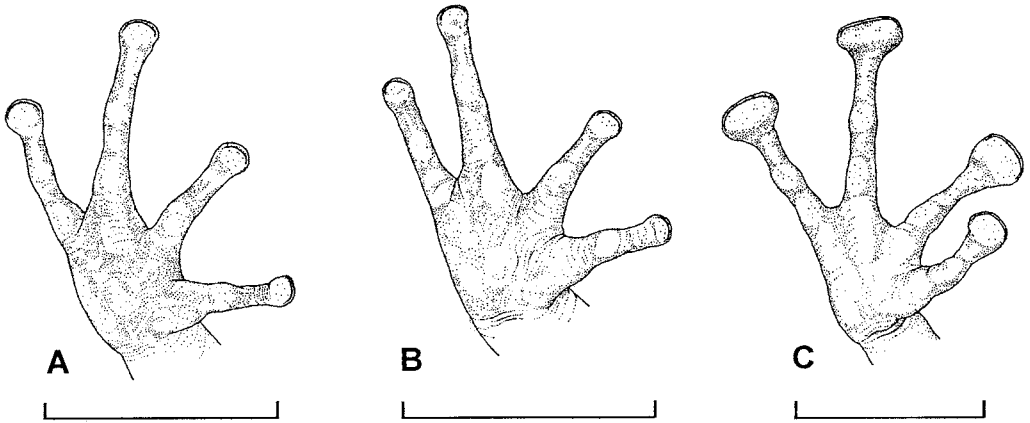


FIGURE 1. Palmar views of right hands of *Callulops* (scales = 1 cm): (A) *C. marmoratus*, BPBM 14222, holotype; (B) *C. robustus*, BPBM 10895; (C) *C. slateri*, BPBM 13223. Drawings by Art Kodani.

MEASUREMENTS (IN MM). SV = 53.3, TL_{fold} = 20.3, TL_{knee} = 24.2, HW = 20.4, IN = 4.6, EN = 4.1, SN = 6.0, EY = 7.2, TY = 2.6, IO = 3.5, 3rdF = 1.8, 4thT = 2.0.

VARIATION. Of the six paratypes, two are adult (both female), one is approximately half-grown, and three are juveniles. Variation in mensural characters is shown in Table 1. In one adult (BPBM 14226) and two juveniles (BPBM 14223–24) the supratympanic fold is indistinct.

The adult paratypes and immature specimens have a greater contrast between the dorsal ground color and the brown mottling than that seen in the holotype; none has lumbar ocelli. All three specimens have more invasion of brown mottling on the abdomen than does the holotype, and BPBM 14221 and BPBM 14227 are evenly mottled across the abdomen with brown. Chin and throat of BPBM 14226 and BPBM 14227 are darker than those of the holotype and BPBM 14221.

The dorsal patterns of the juvenile frogs are more obscure than those in the adults, with poor contrast between a light brown ground color and darker brown stippling that coalesces into irregular mottling. All have abdomens mottled with brown.

The frogs exhibit apparent ontogenetic variation in some mensural characters. In particular, TL appears on average relatively smaller in the juveniles, and TY, EY, HW,

and 3rdF/4thT appear on average relatively larger (Table 1).

CALL. The call consists of a sequence of four to six pulsed notes delivered at an average rate of about 0.60 notes per second (Table 2, Figure 4). Each note averages 225 msec in duration ($n = 57$), and the internote intervals average 386 msec ($n = 46$). The first note is consistently much shorter in duration (mean duration 116 msec) and of lower amplitude than the other notes (mean duration 250 msec), and there is a slight trend for the duration of the notes to lengthen over the course of the call. The mean dominant frequency of nine calls by the holotype (BPBM 14222) was 1091 Hz. Two calls by an additional uncollected animal had a somewhat higher dominant frequency of 1582 Hz (Table 2). The overall impression of the call is a series of harsh quacking notes.

Males call frequently; the holotype called on average every 41 sec over a nine-call sequence and between calls occasionally delivered low-amplitude single notes similar to the first note of the call.

COMPARISON WITH OTHER SPECIES. *Callulops marmoratus* is readily distinguished from all other known members of the genus. The new species differs from *C. glandulosus* (Zweifel), *C. sagittatus* (Richards et al.), *C. stictogaster* (Zweifel), and *C. wilhelmanus* (Loveridge) in having expanded digital disks

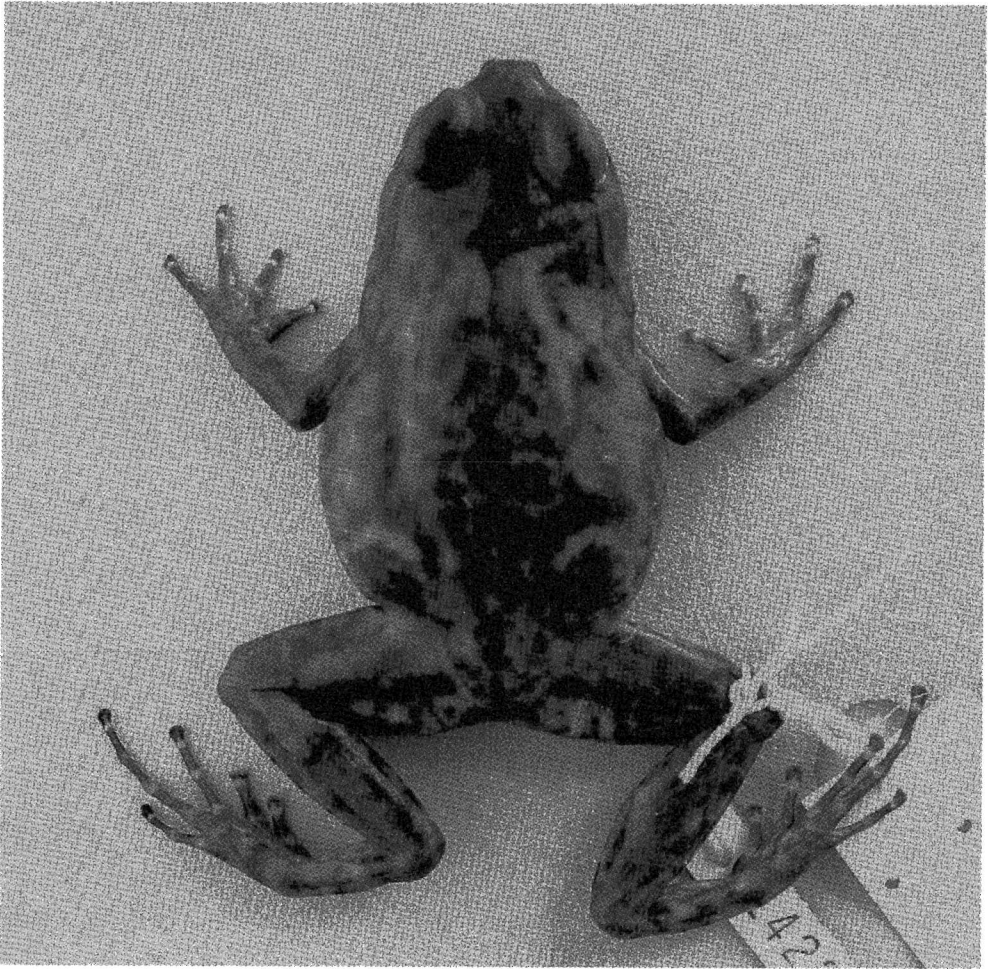


FIGURE 2. Dorsal view of holotype of *C. marmoratus* (BPBM 14222) showing the distinctive mottled color pattern and weak lumbar ocelli.

with circummarginal grooves (versus no disks); from *C. boettgeri* (Méhely), *C. eurydactylus* (Zweifel), and *C. slateri* in having moderately (versus widely) expanded digital disks (Figure 1); from *C. dubius* (Boettger) in its shorter legs ($TL_{\text{fold}}/SV = 0.48$ in *C. dubius*) and much larger size (24 mm in *C. dubius*); from *C. doriae* Boulenger in its much smaller size (up to 100 mm in *C. doriae*) and lack of white spots in the dorsal coloration; from *C. fuscus* (Peters) in its longer average leg size ($TL_{\text{fold}}/SV = 0.36\text{--}0.39$ in *C. fuscus*), larger eyes ($EY/SV = 0.10\text{--}0.13$ in *C. fuscus*),

and mottled (versus uniform) dorsal color pattern; from *C. kopsteini* (Mertens) in its longer legs ($TL_{\text{fold}}/SV = 0.36\text{--}0.38$ in *C. kopsteini*), wider head ($HW/SV = 0.34\text{--}0.37$ in *C. kopsteini*), larger eye ($EY/SV = 0.11\text{--}0.12$ in *C. kopsteini*), larger EN/IN ratio ($0.70\text{--}0.79$ in *C. kopsteini*), and mottled dorsal color pattern (versus uniform except for lumbar ocelli in *C. kopsteini*); from *C. comptus* (Zweifel) in its longer legs ($TL_{\text{fold}}/SV = 0.30\text{--}0.39$ in *C. comptus*), smooth (versus slightly rugose) dorsum, mottled (versus uniform) dorsal color pattern, and absence (versus presence)

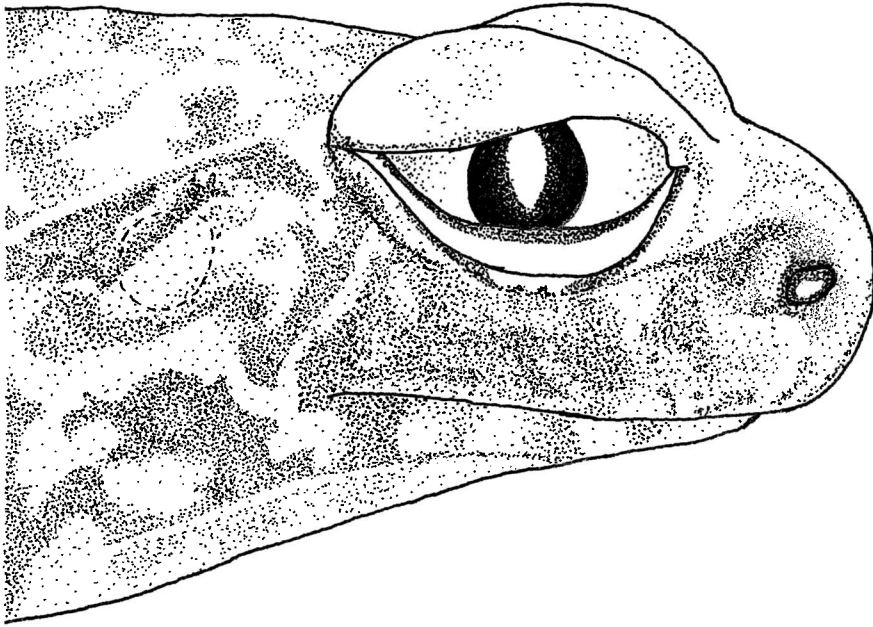


FIGURE 3. Lateral view of head of paratype of *C. marmoratus* (BPBM 14226).

TABLE 1
 Mensural Data for the Type Series of *Callulops marmoratus*, n. sp.

Character	Adults (n = 3)		Juveniles (n = 3)		Immature (n = 1)
	Mean	Range	Mean	Range	
SV	52.0	50.8–53.3	23.8	21.4–25.9	40.0
TL _{fold} /SV	0.41	0.38–0.44	0.39	0.39	0.37
TL _{limb} /SV	0.47	0.45–0.49	0.44	0.43–0.45	0.43
EN/SV	0.071	0.068–0.077	0.069	0.066–0.075	0.061
IN/SV	0.086	0.083–0.088	0.089	0.081–0.093	0.081
SN/SV	0.11	0.10–0.11	0.11	0.10–0.12	0.094
TY/SV	0.045	0.039–0.048	0.061	0.052–0.067	0.050
EY/SV	0.14	0.14	0.15	0.14–0.15	0.13
HW/SV	0.38	0.37–0.38	0.41	0.39–0.43	0.38
3rdF/SV	0.030	0.028–0.033	0.034	0.033–0.035	0.032
4thT/SV	0.038	0.033–0.043	0.037	0.036–0.039	0.036
EN/IN	0.83	0.79–0.88	0.78	0.73–0.81	0.75
3rdF/4thT	0.81	0.71–0.88	0.91	0.84–0.95	0.91

of an orange postocular stripe; from *C. humicola* (Zweifel) in its smooth (versus slightly rugose) dorsum, wider digital disks (versus equal or scarcely wider than penultimate phalanx), presence (versus absence) of an outer metacarpal tubercle, and mottled (ver-

sus uniform) dorsal color pattern; from *C. personatus* (Zweifel) in its smaller size (up to 72 mm SV in *C. personatus*), longer legs (TL_{fold}/SV = 0.34–0.38 in *C. personatus*), and mottled dorsal color pattern (versus reddish brown with a black forehead and face); and

TABLE 2
Call Details for *C. marmoratus*

BPBM No.	Call No.	Call Length (sec)	No. Notes	Notes/sec	Note Length (msec)	Range	Internote Length (msec)	Range	Dominant Frequency (Hz)
14222	1	1.95	4	1.75	213	128–272	367	332–422	1,100
14222	2	1.88	4	1.84	205	96–247	353	329–388	1,065
14222	3	2.60	4	1.29	197	102–252	604	451–753	1,123
14222	4	2.89	5	1.52	219	132–257	448	323–621	1,100
14222	5	2.56	5	1.72	212	105–243	375	332–496	1,065
14222	6	2.35	5	1.95	222	90–290	311	266–357	1,088
14222	7	2.96	6	1.95	236	100–296	309	278–346	1,100
14222	8	2.96	6	1.85	235	124–274	309	299–335	1,077
14222	9	3.00	6	1.83	244	127–298	306	253–421	1,100
—	1	3.35	6	1.67	268	161–302	349	289–433	1,593
—	2	4.11	6	1.29	204	127–298	577	383–1078	1,570

Note: BPBM 14222 (holotype) was recorded at 1830 hours on 23 July 1991 and the uncollected animal was recorded on 22 July 1991. Both recordings were made by Wayne Crill at 850 m in the Crater Mountain Wildlife Management Area. Temperature at both calling sites was approximately 20°C.

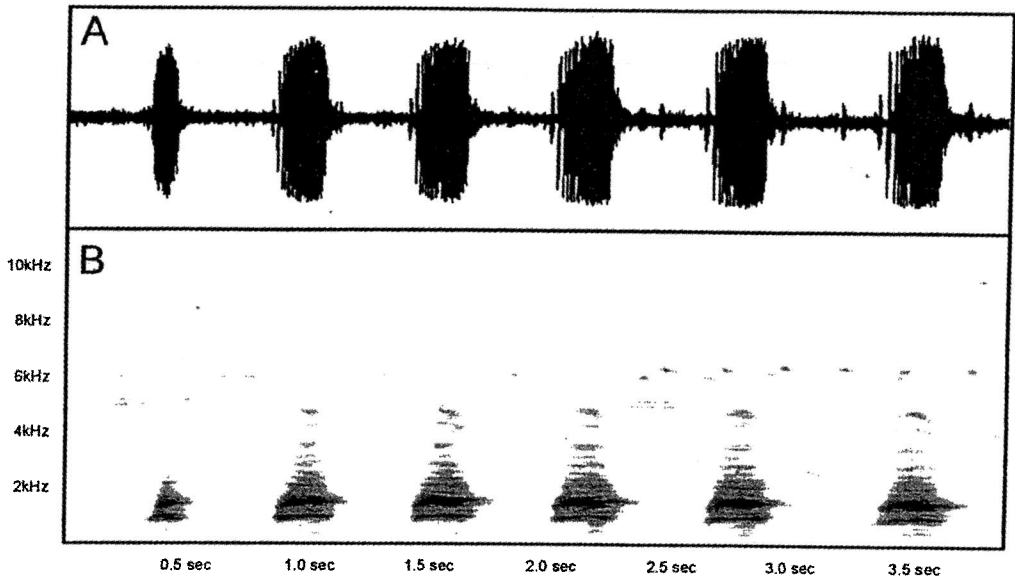


FIGURE 4. Call details for *C. marmoratus* (holotype) recorded at 1830 hours on 23 July 1991 at 850 m elevation in the vicinity of the Crater Mountain Biological Station, Chimbu Province, Papua New Guinea: (A) waveform; (B) spectrogram. Recording made by Wayne Crill. Air temperature was 20°C.

from *C. robustus* (Boulenger) in its smaller size (up to 73 mm in *C. robustus*), shorter call (Table 3), and mottled (versus uniform) dorsal and ventral color patterns.

The diffusely mottled dorsal color pattern of *C. marmoratus* appears unique within *Cal-*

lulops. The only other species superficially similar to this is *C. slateri* (e.g., fig. 53 of Zweifel 1972), which may readily be distinguished from *C. marmoratus* by its larger digital disks; longer, more pointed snout (EN/IN = 1.1–1.3 in *C. slateri* versus 0.79–

TABLE 3
Comparison of the Calls of Four Species of *Callulops*

Species	Total Notes	Initial Call Note (sec)	Subsequent Call Notes (sec)	Internote Intervals (sec)	Call Length (sec)	Dominant Frequency	Air Temperature (°C)
<i>Callulops marmoratus</i>	4–6	0.11	0.25	0.39	2.78	1,180	20
<i>Callulops personatus</i>	5	~0.1	~0.3	0.3–0.6	3	~1,500	24.0–25.3
<i>Callulops robustus</i>	5–7	~0.1	~0.2	~0.2	1.6–2.1	1,500	24.7
<i>Callulops sagittatus</i>	11–12	~0.12	0.15	—	5.4	609	13.5

Note: Most data for *C. personatus* were obtained from Zweifel (1972:493); the dominant frequency was estimated from fig. 52 of Zweifel (1972:498). Data for *C. robustus* were obtained from Zweifel (1972:499). Most data for *C. sagittatus* were obtained from Richards et al. (1995:159); the duration of the initial call note was obtained by measuring the wave form of the first note shown in fig. 5 of Richards et al. (1995:161). Data for *C. marmoratus* are from this study and are means based on the 11 calls presented in Table 2.

0.88 in *C. marmoratus*); presence of tubercles on the snout; dark ventral surfaces; and sharper contrast in dorsal color pattern.

Callulops marmoratus shares with most species of the genus the attribute of having the trigeminal nerve passing superficially to the *M. adductor mandibulae posterior longus* instead of penetrating that muscle. This further serves to distinguish *C. marmoratus* from *C. humicola* and *C. sagittatus*.

ECOLOGICAL NOTES. The specimens were collected in hill forest at 850–900 m elevation. One adult was found underground by digging; the other two adults were collected in a ditch. Two juveniles were sitting at entrances to small burrows. These data suggest that the species is largely terrestrial/fossorial, consistent with its only slightly expanded digital-disk structure.

Mean annual rainfall at the type locality is 6400 mm and is fairly evenly distributed throughout the year. Diurnal temperatures range from 15 to 28°C (Wright et al. 1997). The forests are extremely diverse and are classified as evergreen hill forest to sub-montane forest (Paijmans 1976, Wright et al. 1997).

BPBM 14226 apparently exhibited defensive behavior when unearthed, because the collection tag states that “frog inflated its body to nearly spherical.”

ETYMOLOGY. The name for this species is Latin for “mottled,” referring to its distinctive color pattern.

DISTRIBUTION. *Callulops marmoratus* is

known only from the vicinity of the Crater Mountain Biological Station located in the Crater Mountain Wildlife Management Area in southwestern Chimbu Province on the southern escarpment of the Central Range, Papua New Guinea, at elevations of 850 to 900 m (Figure 5).

DISCUSSION

The relationships of *Callulops marmoratus* are not immediately evident. The new species bears some resemblance to *C. slateri* in having enlarged digital disks and a mottled color pattern, but the two species differ greatly in snout size and shape and disk size (Figure 1), and the color pattern is only superficially similar. *Callulops marmoratus* appears more similar in body size and general proportions to *C. humicola* and *C. robustus* but seems to have somewhat larger digital disks, longer legs, and larger eyes than those two species and differs considerably in color pattern. It further differs from *C. humicola* in having, like most species of *Callulops* (Burton 1986, Richards et al. 1995), the trigeminal nerve passing superficially to the *M. adductor mandibulae posterior longus* instead of penetrating that muscle. *Callulops marmoratus* also differs from *C. robustus* in its shorter call (see later in Discussion) and may differ further from *C. humicola* and *C. robustus* in having a less well-developed postocular skin fold, but additional material is needed to decide this. Judging from fig. 33 of Zweifel (1972), *C. marmoratus*

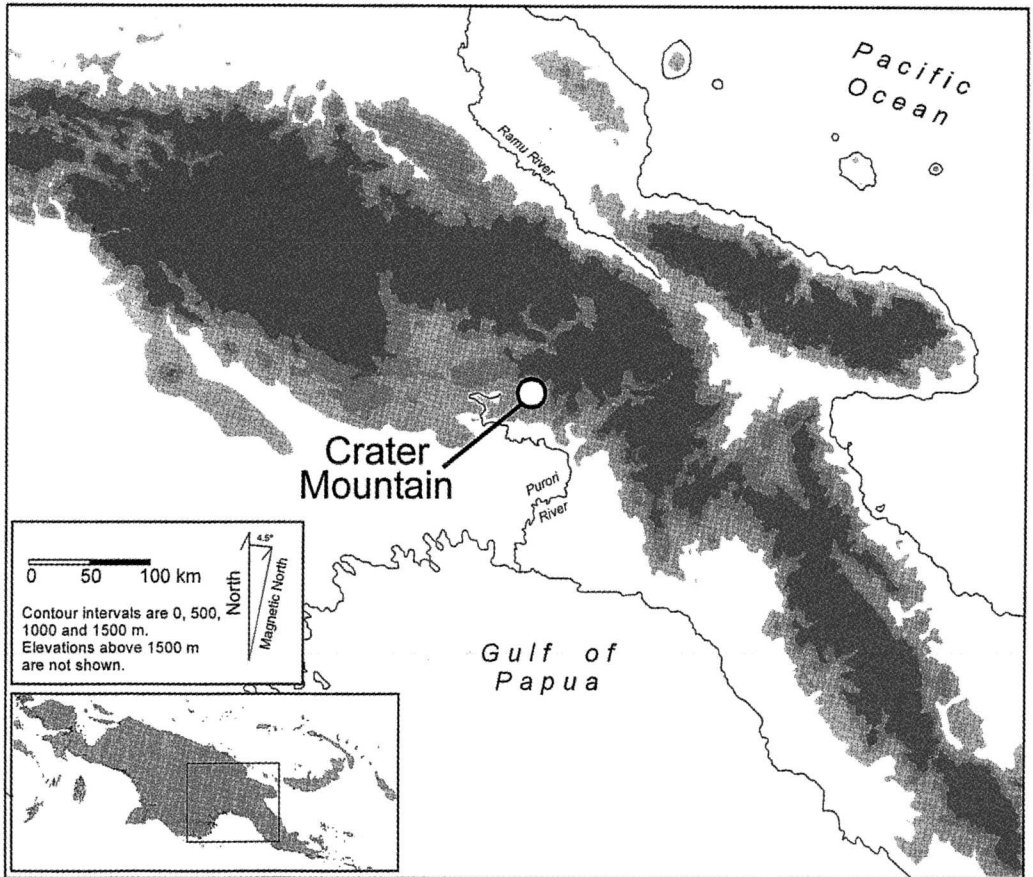


FIGURE 5. Map of eastern New Guinea showing the type locality of *C. marmoratus*.

is sympatric with at least *C. humicola* and possibly with *C. comptus* as well.

Although our data are limited, ontogenetic variation seen in *C. marmoratus* provides some interesting contrasts with that seen in *Mantophryne lousiadensis* (Parker), the only other asterophryine for which data have been presented (Zweifel 1972). As seen in *M. lousiadensis*, relative EY size is greater in young animals of *C. marmoratus* than in adults (Table 1). However, in contrast to *M. lousiadensis*, relative TL is smaller in juvenile *C. marmoratus* than in adults, and relative HW is greater. We stress that our data are very preliminary, but they do suggest that once sufficient samples become available, comparisons

of ontogenetic trajectories may provide useful diagnostic or phylogenetic features for understanding the evolution of New Guinea microhylids.

The call of *Callulops marmoratus* is similar to that of the three other species of *Callulops* for which the call is known (Table 3). In each, the initial note of the call is about 100 msec in duration and subsequent notes are longer, although only slightly so in *C. sagittatus*. This latter species produces a call of 11–12 notes compared with 4–7 notes in *C. marmoratus*, *C. personatus*, and *C. robustus*. The call of *C. marmoratus* appears most similar to that of *C. personatus*, a species restricted to the north coast of New Guinea (Table 3).

The call of *C. marmoratus* is also similar to that of *C. robustus*, which occurs throughout much of New Guinea, but appears to differ from it in having slightly longer notes, much longer internote intervals, and therefore a much longer call. A six-note call produced by *Callulops robustus* takes about 2 sec (Zweifel 1972: fig. 52) compared with 3.2 sec ($n = 5$) for *C. marmoratus*. However, the call data available for comparison among these species were not all taken at similar temperatures, and it could be that some apparent call differences are artifacts of temperature instead and not diagnostic features.

Other *Callulops* species seem even more clearly divergent from *C. marmoratus* than those discussed here and do not warrant consideration as close relatives with the scarce information currently to hand. Resolution of relationships will require detailed phylogenetic investigation of the genus. However, as for so many Papuan microhylids, sufficient museum material to support such an endeavor is currently lacking for many members of this genus.

SPECIMENS EXAMINED

Callulops comptus ($n = 3$): Papua New Guinea: Western Highlands Prov.: Wahgi Dividing Range near Nondugl, 2460 m (8000 ft) (AMNH 65316–18, paratypes).

Callulops eurydactylus ($n = 1$): Indonesia: Irian Jaya: Fak Fak Dist.: Danowaria (BPBM 1014, holotype).

Callulops humicola ($n = 3$): Papua New Guinea: Eastern Highlands Prov.: Kotuni, S slope Mt. Otto, 2150–2460 m (7000–8000 ft) (AMNH 66244, 66258–59, paratypes).

Callulops personatus ($n = 4$): Papua New Guinea: West Sepik Prov.: Bewani Mts., Mt. Menawa, Agpo Creek, 8.5 km N, 14 km E of Utai (BPBM 14220); Torricelli Mts., Miliom, 3.2 km (2 mi.) E Lumi, 460 m (1500 ft) (AMNH 78094–95, paratypes); East Sepik Prov.: Maprik (AMNH 74902, paratype).

Callulops robustus ($n = 6$): Papua New Guinea: Gulf Prov.: E branch Avi Avi River, 5.5 km S and 5.6 km W Tekadu Airstrip, 7.735° S, 146.496° E, 120 m (BPBM 13155,

13169, 13212); Morobe Prov.: vic. Frieda Mining base camp, 4.698° S, 141.782° E, 600–1200 m (BPBM 10895); Kalolo, 750 m (BPBM 3688–89).

Callulops slateri ($n = 4$): Papua New Guinea: Gulf Prov.: E branch Avi Avi River, 5.5 km S and 5.6 km W Tekadu Airstrip, 7.735° S, 146.496° E, 120 m (BPBM 13109–10, 13223); Tekadu Airstrip, 7.684° S, 146.548° E, 400 m (BPBM 13207).

Callulops stictogaster ($n = 6$): Papua New Guinea: Eastern Highlands Prov.: Moife, SW of Kainantu, 2100 m (BPBM 1002, paratype); Morobe Prov.: Poverty Creek, Mt. Missim, 1550 m (BPBM 9367), Mt. Missim, 1600 m (BPBM 14217–19), 1950 m (BPBM 8511).

Callulops wilhelmanus ($n = 4$): Papua New Guinea: Chimbu Prov.: Keglsugl, 2850 m (BPBM 2275); Eastern Highlands Prov.: Mt. Michael, 2830 m (BPBM 5305); Southern Highlands Prov.: S slope Mt. Giluwe, 2900 m (BPBM 5632); Western Highlands Prov.: Lake Sirunki, 2580 m (BPBM 3031).

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