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## Results of the Archbold Expeditions. No. 83 Frogs of the Microhylid Genus *Cophixalus* from the Mountains of New Guinea

BY RICHARD G. ZWEIFEL<sup>1</sup>

### INTRODUCTION

Prior to World War II, the herpetology of the central mountainous region of the Territory of New Guinea (variously known in the past as Kaiser Wilhelm's Land, Northeast New Guinea, and Australian New Guinea) was virtually unknown. In 1944 P. J. Darlington climbed Mt. Wilhelm and collected a number of amphibians and reptiles which were described as new or otherwise discussed by Loveridge (1945a, 1945b, and 1948). Collections made for the American Museum of Natural History by E. Thomas Gilliard on Mt. Hagen and in the Kubor Range, and by both Gilliard and O. Shelly in the Wahgi Valley, were reported in part by Zweifel (1956a, 1956b, and 1958). The only other papers on the herpetology of this region were published by Forcart (1953) and Tyler (1961).

Some aspects of the geography of the Highlands region are discussed by Anas (1960) and Reiner (1960). Robbins (1961) provided a general description of the vegetation. A summary of the activities of the Sixth Archbold Expedition is being prepared for publication by L. J. Brass. In 1959 the Sixth Archbold Expedition made large collections of amphib-

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<sup>1</sup> Associate Curator, Department of Herpetology, the American Museum of Natural History.

ians and reptiles at several camps in the central mountainous region, including areas from which no herpetological specimens previously were available. Among the specimens are hundreds of individuals of the genus *Cophixalus*, including representatives of two undescribed species. In addition to these, we have a smaller number of *Cophixalus* collected by William Hosmer on the Spalding-Peterson Expedition in 1959 on the Wahgi-Sepik Dividing Range, and also some from this locality collected and donated by Michael Tyler. The purpose of the present paper is to describe the new species and to add to what is known of the distribution and variation of the five other species inhabiting the area of the Hagen, Bismarck, and Kratke ranges.

## METHODS

Frogs of the genus *Cophixalus* are mostly very small, even among the microhylids. The largest known species (described herein) rarely exceeds 50 mm. from snout to vent, and the smallest may become adult at 15 mm. or even smaller. There is considerable intraspecific variation in color pattern, at least in most species, so color and pattern (especially of preserved specimens) are usually of little use to the taxonomist. Probably someone with the opportunity to study live frogs could find differences among mating calls and possibly pigmentation that would serve to characterize the species. The taxonomist working with preserved specimens must, however, depend largely on measurements for distinguishing between the species.

The standard data recorded for most specimens studied include the sex (always determined by dissection), the relative development of the ova or oviducts (indicative of sexual maturity), the presence or absence of vocal sac openings, the snout to vent length, the tibia length, the head width, the tympanum size, the eye size, the internarial distance, the distance from the eye to the naris, the widths of the discs of the third finger and the fourth toe, the relative length of the first finger, and the relative lengths of the third and fifth toes.

The tibia length is taken as the distance from the fold of skin at the knee to the heel. The head width is taken at the widest part. The tympanum size is the greatest horizontal diameter, including the tympanic ring. Frequently in *Cophixalus* the tympanum is hidden or scarcely distinguishable, so the measurement may be only approximate. The eye size is the distance from the posterior to anterior corner, with the eye forced (by probing through the roof of the mouth) into a life-like protruding state if retracted. The internarial distance is taken from center



The body size (as indicated by the snout to vent length) is a valuable character when adequate series of sexually mature specimens are available. Species similar in other ways may be quite distinct in maximum size and the size at which sexual maturity is attained. The use of body size as a specific character must, of course, be tempered by the realization that a widely ranging species may attain different maximum sizes in various parts of the range.

The tibia length expressed as a percentage of the snout to vent length (abbreviated TL/S-V) is a useful index of relative length of the hind legs and is greatly to be preferred over the practice of bending the hind leg forward to determine the point reached by the heel. Within a local population of a species, the variation in leg length is usually relatively slight, so leg length is most useful in a comparison of sympatric populations. Geographic variation is often found, so leg length in the characterization of a widely distributed species must be used with caution.

Species (or rarely subspecies) of frogs often differ in the shape of the snout, but the differences are difficult to describe objectively. Ruibal (1957), studying geographic variation of snout shape in *Rana pipens*, compared populations in terms of the ratio of the distance from the nostril to the upper lip to the distance from the eye to the nostril. Zweifel found that differences in snout shape among the species of the hylid genus *Nyctimystes* (Zweifel, 1958) and among species of the ranid genus *Platymantis* (Zweifel, 1960) could be expressed in terms of the ratio of the distance from the eye to the naris to the internarial distance. The same ratio (abbreviated E-N/IN) is useful in the characterizing of species of *Cophixalus*.

The relative expansion of the toe pads may differ (only one species, *C. pansus*, has toes without at least slightly expanded tips), but this character is difficult to evaluate. Most species (*C. oxyrhinus* is the only exception currently recognized) have the discs of the fingers clearly broader than those of the toes. It is not difficult to express this relationship, as the width of the pads can be measured by an ocular micrometer or calipers and a ratio calculated. Species comparisons can be made first by a relating of the width of the pad to the thickness of the penultimate phalanx and then by a comparison of ratios. The toe pads are quite susceptible to drying, and even slight shrinkage may throw the ratios far off. In general, I take the individuals with the broadest pads as more typical of what the structure was in life.

The measurements cited in this paper were made with vernier calipers, viewed through a dissecting microscope when necessary, or with an ocular micrometer.

## ACKNOWLEDGEMENTS

My primary debt of gratitude is due to Mr. Hobart M. Van Deusen, who personally collected many of the frogs obtained on the Sixth Archbold Expedition and who supervised the collecting by native assistants. Dr. Ernest Williams kindly made available specimens in the Museum of Comparative Zoölogy. Mr. Michael Tyler donated specimens from his personal collection. The illustrations of the new species are the work of Mrs. Frances Zweifel, who has my sincere thanks.

## SPECIES ACCOUNTS

*Cophixalus cryptotympanum* Zweifel

*Cophixalus cryptotympanum* ZWEIFEL, 1956a, pp. 36–38, fig. 9; type locality, north slope of Mt. Dayman, 1370 meters elevation, Maneau Range, Territory of Papua.

DIAGNOSIS: The assignment to this species of specimens from the Highlands region together with increased knowledge of variation in other species necessitates modification of the original diagnosis of *cryptotympanum*.

The characters that, in combination, distinguish *Cophixalus cryptotympanum* from other Papuan species of the genus are these: body size moderate, maximum snout-vent length probably varying in different populations but reaching at least approximately 38 mm.; TL/S-V average, about 0.44–0.46; E-N/IN average, about 0.88–0.89; finger discs larger than toe discs; first finger approximately one-half of length of second, with a small but distinct disc; third toe longer than fifth; toes unwebbed; tympanum hidden or slightly distinct; loreal region almost vertical; anterior and posterior surfaces of femora not contrastingly mottled with dark and light or with a prominent light patch.

Some specific ways in which *cryptotympanum* differs from other Papuan species are these: *ateles* and *shellyi* have the first finger greatly reduced in size; *darlingtoni*, *rostellifer*, and *variegatus* have the fifth toe longer than the third; *pansus* has fingers and toes without discs; *geislerorum* has webbed toes; *oxyrhinus* has toe discs larger than finger discs; sympatric *daymani* is a smaller species, with oblique lores and shorter legs; both *nubicola* and *parkeri* have lower E-N/IN and TL/S-V ratios (see figs. 3 and 5 and table 1); *riparius* is larger and has lower E-N/IN ratios and TL/S-V ratios and more oblique lores; *verrucosus* has longer legs and mottled or spotted thighs; *cheesmanae* has a prominent light patch (red or pink in life) on the anterior and posterior surface of the thigh; *biroi* has shorter legs and a dark streak along the side of the head.

REMARKS: Mount Dayman, the only previously recorded locality for the species, is some 400 miles southeast of the Highlands region (fig. 1). Specimens from the new localities differ significantly from the topotypic series in only one important way, size. The largest in the type series of 37 specimens is a gravid female 28.4 mm. from snout to vent. Many individuals in the series of 113 specimens from Mt. Michael exceed this size, the largest measuring 36.3 mm. The difference is probably not due merely to sample size, for among only 11 specimens from the Kratke Mountains there are two that are approximately 38.5 mm. in length.

In other instances I have stressed the importance of body size as a specific character, but in these cases there are always independent characters that correlate with size and lend supporting evidence. I can find no such supporting characters in the present case and must conclude that there is marked geographic variation in maximum size. The general features of pigmentation and body form offer no differences, and the TL/S-V and E-N/IN ratios are very similar (table 1).

In the original description of *cryptotympanum* I placed emphasis on the lack of distinctness of the tympanum as a diagnostic character. Among the newly acquired specimens the distinctness appears to vary somewhat with size, the larger individuals having more distinct eardrums. This insight into variation together with the difficulty of presenting the variation objectively leads me to deemphasize the nature of the tympanum as a specific character.

Seven specimens from the Wahgi Dividing Range (A.M.N.H. Nos. 65265–65270, 65275) are assigned to this species but with hesitation. Three have E-N/IN ratios (0.76, 0.76, and 0.77) slightly below the minimum (0.78) in 25 specimens from Mt. Michael, and one has much shorter legs than seen elsewhere,  $TL/S-V = 0.35$ . The seven appear to belong to the same species and may prove to be distinct from *cryptotympanum* of Mt. Michael, the closest population.

Some similarity of *cryptotympanum* to the Australian (and doubtfully Papuan) species *ornatus* was implied in my earlier account. Since then I have had the opportunity to examine specimens of *ornatus* and now do not doubt the specific distinctness of the two. I defer discussion of *ornatus* for a projected study of the Australian Microhylidae.

DISTRIBUTION: *Cophixalus cryptotympanum* ranges along the central mountainous ridge of New Guinea from Mt. Dayman at the southeastern end of the island to the Wahgi-Sepik Dividing Range more than 400 miles to the northwest. Specimens were collected by the Sixth Archbold Expedition at the following localities: Territory of New Guinea: Arau, Kratke Mountains, 4600 feet in elevation (A.M.N.H. Nos. 66704–66707, Oc-

tober 19–25, 1959); Purosa Camp, 15 miles (by road) south-southeast of Okapa, 6400 feet in elevation (A.M.N.H. Nos. 66619–66625, September 25–26, 1959); Gono, west slope of Mt. Michael, 6400 feet in elevation (A.M.N.H. Nos. 66515–66518, August 28–29, 1959); northeast slope of Mt. Michael, 6500 feet in elevation (A.M.N.H. Nos. 66519–66545, plus 82 untagged specimens, September 3–12, 1959). The following specimens were collected by William Hosmer on the Spalding-Peterson Expedition: Wahgi-Sepik Dividing Range, 8000 feet in elevation (A.M.N.H. Nos. 65265–65270, August 10, 1959); 9000 feet in elevation (A.M.N.H. No. 65275, August 6, 1959).

*Cophixalus darlingtoni* Loveridge

*Cophixalus biroi darlingtoni* LOVERIDGE, 1948, pp. 423–424; type locality, Toromanbanau (Toromambuno), southeast slope of Mt. Wilhelm, elevation 7500 feet, Bismarck Range, Territory of New Guinea.

*Cophixalus darlingtoni*, ZWEIFEL, 1956a, p. 44; 1956b, pp. 5–7, fig. 2.

DIAGNOSIS: Differs from all other *Cophixalus* except *variegatus* and *rostellifer* in having fifth toe longer than third. Snout of *rostellifer* long and pointed, at least twice length of eye; in *darlingtoni* snout blunt and approximately equal in length to eye. *Cophixalus variegatus* smaller, maximum snout-vent length about 21 mm. compared to about 27 mm. in *darlingtoni*, with higher E-N/IN ratio; range 1.07–1.31 in *variegatus*, 0.82–1.07 in *darlingtoni* (internarial distance shorter than eye-naris distance in *variegatus*, equal or longer in *darlingtoni*).

REMARKS: This species is closely similar and probably closely related to *C. variegatus*. Although the two species are not yet known to occur at the same locality, they occur on the same mountain (Mt. Michael). Specific status seems indicated by the consistent differences in body size and snout shape.

A specimen from an elevation of 10,200 feet on Mt. Michael appears to represent this species rather than *C. variegatus* which was collected in abundance at 6500 feet on this mountain. The specimen in question has an E-N/IN ratio of 0.93, which is close to the average of 0.945 calculated for 21 specimens of *darlingtoni* and is well below the minimum of 1.07 found in 27 *variegatus* from Mt. Michael. Although the leg lengths of these species are not sufficiently different to be of much diagnostic value, the TL/S-V ratio of the questionable specimen, 0.311, is closer to the average of *darlingtoni* (0.301) than to that of *variegatus* (0.335).

DISTRIBUTION: *Cophixalus darlingtoni* has been reported from Kondiu in the Wahgi Valley (Zweifel, 1956b, p. 5) and the type locality, Toromanbanau, about 25 miles to the east on the southeast side of Mt. Wilhelm.

Specimens collected on the Sixth Archbold Expedition include a large number from Mt. Wilhelm and others that extend the range about 45 miles south-southeast to Mt. Michael and about 30 miles southeast to Mt. Otto: Territory of New Guinea: Kotuni, south slope of Mt. Otto, 7000–8000 feet in elevation (A.M.N.H. Nos. 66296–66305, August 8–18, 1959); east slope of Mt. Wilhelm, 8000–9100 feet in elevation (A.M.N.H. Nos. 65929–65968, plus 129 untagged, July 12–30, 1959); Pengagl Creek, 9100 feet in elevation, east slope of Mt. Wilhelm (A.M.N.H. Nos. 65969–65973, plus four untagged, July 3–11, 1959); ridge on Mt. Michael, 10,200 feet in elevation (A.M.N.H. No. 66578, September 6, 1959).

***Cophixalus nubicola*, new species**

TYPE: A.M.N.H. No. 66581, collected by Hobart M. Van Deusen at an elevation of 10,200 feet on a ridge of Mt. Michael, Territory of New Guinea, on September 6, 1959.

DIAGNOSIS: Characterized by combination of relatively short legs, TL/S-V mean 0.360, and low E-N/IN ratio, mean 0.689. Most similar species is *C. parkeri*, from which *nubicola* differs on average, but not totally, in two characters mentioned and in having less well-developed discs on fingers. More extended comparison is made below.

DESCRIPTION OF TYPE SPECIMEN: Adult female with the following measurements (in millimeters): snout to vent length, 29.2; tibia length, 10.1; head width, 11.6; eye diameter, 3.3; internarial distance, 3.0; distance from eye to naris, 1.9; horizontal diameter of tympanum, 1.8; width of disc of third finger, 1.9; width of penultimate phalanx of third finger, 0.8; width of disc of fourth toe, 1.5; width of penultimate phalanx of fourth toe, 0.8.

There are no teeth. The upper jaw is eleutherognathine, the maxillae overlapping the premaxillae only slightly. There is no precoracoid, clavicle, or omosternum.

The tongue is one-half or slightly more than one-half free behind. A single, serrate, palatal ridge is present.

The dorsal surfaces of body and limbs are slightly rugose, the ventral surfaces granular.

The snout is bluntly rounded and approximately equal to the eye in length. The canthal region is rounded, and the lores are oblique. The interorbital region is slightly wider than an upper eyelid. The pupil is horizontally elliptical. The tympanum is not well marked, but the tympanic ring is visible except in the upper rear quadrant, where it is hidden by a weak supratympanic fold.

In order of decreasing length, the fingers are  $3 > 4 > 2 > 1$ , the toes





FIG. 2. Dorsal view of type specimen of *Cophixalus nubicola*, A.M.N.H. No. 66581.  $\times 2.5$ .

$4 > 3 > 5 > 2 > 1$ . Discs are present on all fingers and toes and are best developed on the fingers. The disc of the third finger is slightly more than twice the width of the penultimate phalanx, and that of the fourth toe is slightly less than twice the width. The disc of the fourth toe is 79 per cent of the width of the disc of the third finger. The first finger is more than one-half of the length of the second and has a well-developed disc. There are low, rounded, subarticular tubercles on the hands and feet, but no metatarsal or metacarpal tubercles. The fingers and toes are unwebbed.

The dorsal color is reddish brown, darkest in the ill-defined lateral bands and palest in the groin, on the anterior and posterior surfaces of the femora, and in light spots on the back (fig. 2). There is a fine vertebral line from nose to vent. The chest and abdomen are lightly mottled, but the melanic pigment is more uniformly distributed on the gular region. A median light line is present on the chin but is not continued posteriorly.

**VARIATION IN TYPE SERIES:** The variation in the seven specimens in TL/S-V and E-N/IN ratios is given in table 1 and graphed in figures 3 and 5. The tympanum is sufficiently distinct to be measured in four specimens and averages 0.465 of the diameter of the eye, range 0.39–0.54. The ratio of the width of the disc of the fourth toe to the disc of the third finger averages 0.846, range 0.74–0.96. The ratio of the width of the penultimate phalanx to the width of the third toe disc averages 0.471, range 0.40–0.54.

The ill-defined, dark, dorsolateral bands of the type specimen are more or less well developed in the paratypes. None shows such prominent light spotting as the type, but spots are faintly seen in one of the darkest paratypes. The light color of the groin and anterior and posterior surfaces of the femur is common to all specimens, though developed in varying degree. Only one of the paratypes has a fine vertebral light line. The ventral surfaces are essentially similarly patterned in all specimens. Two paratypes have the throat mottled rather than uniform, and another has pale ventral surfaces, with little melanic pigment posteriorly. None of the paratypes has a midgular light line such as is present in the type.

There is no external sexual dimorphism. Males possess a median subgular vocal sac, with slit-like openings in the floor of the mouth lateral to and near the posterior edge of the base of the tongue. The vocal sac is not apparent externally.

The largest of the seven specimens is the type, 29.2 mm. from snout to vent, which is gravid. Males 22.4–24.3 mm. in length have vocal slits and probably are sexually mature.

**COMPARISON WITH OTHER SPECIES:** Extensive comparison with many of the Papuan species is not necessary, as certain distinctive characters are immediately diagnostic: *ateles* and *shellyi* have the first finger very small, without a well-developed disc; *darlingtoni*, *rostellifer*, and *variegatus* have the fifth toe longer than the third; *oxyrhinus* has the toe discs larger than the finger discs; *pansus* is without discs; and *geislerorum* has webbed toes.

The differences in TL/S-V ratio between *nubicola* (mean 0.360) and *cheesmanae* (0.489), and *verrucosus* (0.518) are greater than would be expected within a species and, hence, are of diagnostic value.

*Cophixalus daymani* does not differ significantly from *nubicola* in relative tibia length. It is much smaller than *nubicola*, with a maximum snout to vent length of less than 22 mm. in 79 specimens, and while size in itself may not necessarily be indicative of specific difference (see account of *C. cryptotympanum*), the absence of a vocal sac in *daymani* and its presence in *nubicola* favor specific allocation.

I have not examined specimens of *Cophixalus biroi*, but to judge from Parker's (1934, p. 174) account, *biroi* differs in having relatively longer legs, vertical lores, and a distinctive pattern (dark streak along side of head and body).

The two species that appear most closely related to *nubicola* are *parkeri* and *riparius*. The higher E-N/IN ratio of *riparius*, together with its much larger size, should afford complete separability. The differences between *nubicola* and *parkeri* are of lesser magnitude but are none the less real.

TABLE 1  
RATIOS OF TIBIA LENGTH TO SNOUT TO VENT LENGTH AND OF EYE TO NARIS DISTANCE  
TO INTERNARIAL DISTANCE IN SEVEN SPECIES OF THE GENUS *Cophixalus*

|                       | TL/S-V            |            |             |    | E-N/IN            |            |             |    |
|-----------------------|-------------------|------------|-------------|----|-------------------|------------|-------------|----|
|                       | Mean              | $\sigma_m$ | Range       | N  | Mean              | $\sigma_m$ | Range       | N  |
| <i>cryptotympanum</i> |                   |            |             |    |                   |            |             |    |
| Mt. Dayman            | 0.455 $\pm$ 0.005 |            | (0.43-0.49) | 18 | 0.889 $\pm$ 0.009 |            | (0.86-0.95) | 13 |
| Mt. Michael           | 0.436 $\pm$ 0.006 |            | (0.39-0.48) | 25 | 0.879 $\pm$ 0.012 |            | (0.78-1.10) | 25 |
| <i>darlingtoni</i>    | 0.301 $\pm$ 0.003 |            | (0.26-0.34) | 26 | 0.945 $\pm$ 0.016 |            | (0.82-1.07) | 21 |
| <i>nubicola</i>       | 0.360 $\pm$ 0.005 |            | (0.35-0.38) | 7  | 0.689 $\pm$ 0.015 |            | (0.63-0.74) | 7  |
| <i>parkeri</i>        | 0.385 $\pm$ 0.004 |            | (0.35-0.44) | 30 | 0.780 $\pm$ 0.009 |            | (0.67-0.92) | 30 |
| <i>riparius</i>       | 0.383 $\pm$ 0.003 |            | (0.35-0.43) | 42 | 0.877 $\pm$ 0.008 |            | (0.79-0.97) | 42 |
| <i>shellyi</i>        | 0.436 $\pm$ 0.008 |            | (0.40-0.47) | 10 | 0.628 $\pm$ 0.009 |            | (0.58-0.67) | 10 |
| <i>variegatus</i>     | 0.335 $\pm$ 0.004 |            | (0.29-0.37) | 27 | 1.188 $\pm$ 0.012 |            | (1.07-1.31) | 27 |

The wide range of variation in the E-N/IN ratio of *parkeri* includes much of the range of *nubicola*, but the means are distinctly different. Again, in the TL/S-V ratio there is broad overlap, with the range of *nubicola* falling within that of *parkeri*. However, here too the means are distinctly different.

*Cophixalus parkeri* evidently has larger finger discs than *nubicola*. In 10 *parkeri* the penultimate phalanx averages 0.374 (0.32-0.43) of the width of the third finger, whereas in seven *nubicola* the phalanx averages 0.471 (0.40-0.54) of the width of the disc. Put in another way, the disc is about three times the width of the penultimate phalanx in *parkeri* and about two times in *nubicola*.

The different sizes of the discs are also evident when finger and toe discs are compared. The ratio of the width of the disc of the fourth toe to that of the third finger in 15 *parkeri* averages 0.705 (0.64-0.77) and, in seven *nubicola*, 0.846 (0.74-0.96).

The vast majority of specimens of *parkeri* and *nubicola* should be assignable to species on the combined weight of evidence provided by the TL/S-V and E-N/IN ratios together with the relative size of the discs.

REMARKS: The type series was collected by Hobart M. Van Deusen and native assistants on a cloud-swept (hence the specific name chosen) ridge of Mt. Michael in subalpine forest and alpine grassland. Other frogs collected at the same place were *Asterophrys* sp. and *Cophixalus darlingtoni*.

DISTRIBUTION: *Cophixalus nubicola* is known only from the type locality, Mt. Michael, 10,200 feet in elevation, Territory of New Guinea (A.M.N.H. Nos. 66579–66585, September 6, 1959, type and paratypes).

*Cophixalus parkeri* Loveridge

*Cophixalus variegatus parkeri* LOVERIDGE, 1948, pp. 425–426; type locality, Mt. Wilhelm, 8000 feet elevation, Territory of New Guinea.

*Cophixalus parkeri*, ZWEIFEL, 1956a, p. 44. 1956b, p. 8, fig. 3.

DIAGNOSIS: Differs from all other known *Cophixalus* in following combination of characters: maximum snout-vent length about 31 mm.; finger discs broader than those of toes; first finger more than one-half of length of second and with well-developed disc; toes unwebbed; third toe slightly longer than fifth, or the two equal in length; TL/S-V, 0.35–0.44, mean, 0.385; E-N/IN, 0.67–0.92, mean, 0.780; loreal region oblique, canthus not strongly marked; snout less than twice length of eye.

REMARKS: This species had been known only from the type specimen and two additional specimens reported by Zweifel (1956a, 1956b). The 64 specimens collected on Mt. Otto by the Sixth Archbold Expedition give a much better concept of variation in the species than was before attainable.

The averages and ranges of variation for the TL/S-V and E-N/IN ratios are given in table 1 and graphed in figures 3 and 5. The terminal phalanges are T-shaped (seen on a cleared and stained specimen). The finger discs are consistently broader than those of the toes; the disc of the third finger is about three times the width of the penultimate phalanx, the average ratio of phalanx to disc being 0.374 (0.32–0.43, 10 specimens). In most specimens the third toe is slightly longer than the fifth, though in others the two toes are virtually identical in length. In none, however, is the fifth distinctly longer than the third.

Loveridge (1948, p. 425) characterized the type specimen as having an angular canthus rostralis and vertical loreal region. I would describe the canthus as abrupt but not sharp, and the loreal region as slightly oblique, in order to differentiate *parkeri* from *cryptotympanum*, in which species the canthus is sharper and the loreal region more nearly vertical. Admittedly, the differences are subtle and not readily presented in objective fashion even though clearly evident to the eye.

Only a minority of the specimens from Mt. Otto possess the broad, pale, interocular bar that Loveridge describes for the type and that Zweifel (1956b, fig. 3) illustrates for another specimen. Few specimens show a distinct dorsal pattern; in most, the pale reddish tan flanks grade rather abruptly into the darker brown dorsum. In occasional pale specimens some darker spots with no definite arrangement can be distinguished on the back. The throat, chest, and abdomen are usually mottled with

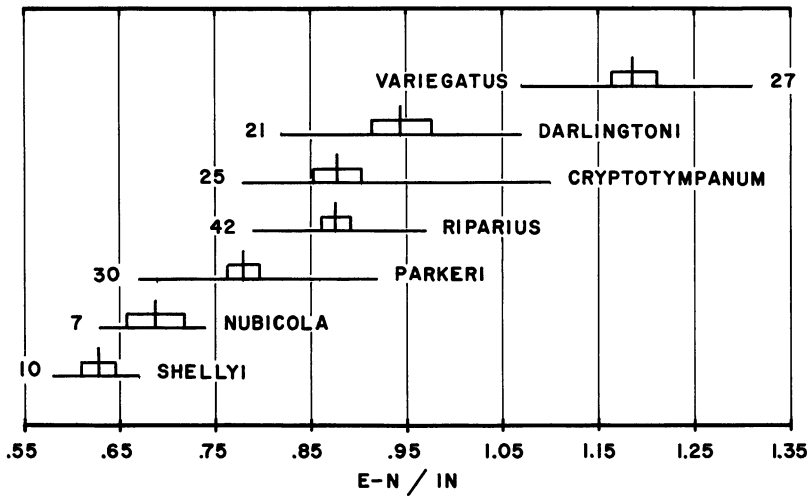


FIG. 3. Variation in ratio of distance from eye to naris to internarial distance in seven species of *Cophixalus*. Horizontal line spans range of variation, vertical line indicates mean, and rectangles enclose two standard errors of mean on each side of mean. Numbers indicate sizes of samples.

dark gray on a light tan background. Rarely is the venter as nearly uniform as in *Cophixalus riparius*. The groin and anterior and posterior surfaces of the thigh are immaculate or only slightly mottled, and were orange-tan in freshly preserved specimens. Though the intensity of pigment has faded, the orange tint is still detectable after more than two years in preservative and serves to characterize virtually all specimens in the series.

The male of *Cophixalus parkeri* has a median subgular vocal sac, with slit-like openings lateral to the base of the tongue.

I have compared the type specimen of *parkeri* (Museum of Comparative Zoölogy No. 25940) directly with the series from Mt. Otto as well as with specimens from Mt. Hagen and Kondiu previously (Zweifel,

1956a and 1956b) referred to this species and regard them as specifically identical. The type agrees with the others in pigmentation, and its TL/S-V (0.396) and E-N/IN (0.808) ratios are well within the range of variation of specimens from Mt. Otto. It is curious that no specimens of this species were collected on Mt. Wilhelm by the Sixth Archbold Expedition.

DISTRIBUTION: *Cophixalus parkeri* is now known to range over an arc about 90 miles long, from Mt. Hagen to Mt. Otto. Specimens collected by the Sixth Archbold Expedition extend the known range about 30 miles southeast of the type locality. Territory of New Guinea: Kotuni, south slope of Mt. Otto, 7000–8000 feet in elevation (A.M.N.H. Nos. 66312–66334, plus 41 untagged specimens, August 6–15, 1959).

### ***Cophixalus riparius*, new species**

TYPE: A.M.N.H. No. 65975, collected by Hobart M. Van Deusen at an elevation of 9100 feet beside Pengagl Creek on the east slope of Mt. Wilhelm, Territory of New Guinea, on July 1, 1959.

DIAGNOSIS: Differs from all other described species of the genus in attaining a much larger size. Snout to vent length 45 mm. in many specimens, maximum approximately 50 mm., contrasting with maximum of 40 mm. attained but rarely in two other species, *C. verrucosus* and *C. cryptotympanum*. Other features that serve together with size to characterize the new species are these: TL/S-V average, 0.383; E-N/IN average, 0.877; third toe longer than fifth; discs of fingers and toes well developed, those of fingers broadest; first finger more than half of length of second and with a well-defined disc.

DESCRIPTION OF TYPE SPECIMEN: Adult female with the following measurements (in millimeters); snout to vent length, 45.1; tibia length, 18.2; head width, 15.4; eye diameter, 4.6; internarial distance, 4.0; distance from eye to naris, 3.2; width of disc of third finger, 3.7; width of disc of fourth toe, 2.8.

There are no teeth. The upper jaw is eleutherognathine, the anterior ends of the maxillae overlapping the distal wings of the premaxillae only slightly and, hence, falling far short of forming a suture. There is no precoracoid, clavicle, or omosternum.

The tongue is approximately one-half free behind. There is a single, serrate, palatal ridge.

The dorsal surfaces of body and limbs are smooth. The ventral surfaces are nearly as smooth, with only slight granularity appearing at the posterior end of the abdomen and on adjoining parts of the hind limbs.

The snout is short, only about as long as the eye, and bluntly rounded with rounded canthus and oblique lores. The interorbital distance is slightly greater than the width of the upper eyelid. The pupil evidently was horizontal in life. Only the lower edge of the tympanum can be distinguished, and that but faintly. A weak fold of skin passes from the posterior corner of the eye across the upper edge of the tympanum and down behind it, becoming indistinguishable before reaching the insertion of the forelimb.



FIG. 4. Dorsal view of type specimen of *Cophixalus riparius*, A.M.N.H. No. 65975.  $\times 1.5$ .

In order of decreasing length, the fingers are  $3 > 2 > 4 > 1$ , the toes  $4 > 3 > 5 > 2 > 1$ . All fingers have broad discs, the disc of the third finger being three times the width of the penultimate phalanx. The first finger is distinctly more than one-half of the length of the second and has a well-developed disc. There are low, rounded, subarticular tubercles

on front and hind feet, but only a faint suggestion of metacarpal and metatarsal tubercles. Both fingers and toes are completely free of webbing.

The dorsal color in preservative is two shades of purplish brown; pale background with a darker pattern. The illustration (fig. 4) obviates the necessity of a detailed description. The ventral surfaces appear on gross examination to be slightly paler than the dorsal background. Closer examination reveals numerous tiny clear areas in the melanophore network which probably appeared as pin-point light spots in life. There is a thin midventral light line from the mandibular symphysis to the posterior end of the body.

**VARIATION IN TYPE SERIES:** The series from the type locality includes 224 specimens, two of which are cleared and stained as skeletal preparations. The variation in the TL/S-V and E-N/IN ratios is given in table 1 and graphed in figures 3 and 5. The tympanum was too indistinct to be measured accurately in 37 specimens, but an approximate measurement could be made in five others. The tympanum is 0.40–0.67 of the diameter of the eye in four adult females and 0.56 in one adult male. No sexual dimorphism is evident in this small sample.

The absence of a clavicle is confirmed in the two cleared and stained specimens and in several others dissected. Though the jaws are without teeth, the oral margins of the maxillae and premaxillae appear finely serrate in the cleared and stained specimens. The terminal phalanges are T-shaped.

The finger discs are consistently broader than the toe discs. In only one of 42 specimens measured is the disc of the fourth toe as wide as that of the third finger, and shrinkage is suspected in this instance. The ratio of fourth toe disc to third toe disc has a wide range, 0.61–1.00, but the extremes are probably related to differential shrinkage. The mean for 42 specimens is 0.729.

Though the dorsal pattern varies widely, it is basically similar in all specimens in showing irregular dark markings on a light background. In some specimens, as in the type, there is a pair of ragged dorsolateral bands; these may be more or (more commonly) less distinct than in the type specimen. Often the pattern consists of small, irregular, dark figures free or forming into a network. Rarely the dark pattern elements coalesce to such an extent that the pale background is reduced to isolated spots. There is never a distinct eyespot in the groin, though one may faintly be indicated.

No external sexual dimorphism is evident. The male has a median subgular vocal sac with short, slit-like openings lateral to the base of the tongue. There is no external indication of a vocal sac.



The largest specimen measured is a female 49.9 mm. from snout to vent. The largest male among 45 specimens of both sexes measures 45.3 mm. Two males measuring 29.7 and 35.6 mm. lack vocal slits and presumably are immature. A male measuring 40.9 mm. has slits. Many of the females are gravid, with pale yellow ova measuring up to 4.5 mm. in diameter. Presumably this species has direct development, as do all other Papuan microhylids for which information is available.

The snout to vent lengths of all 224 topotypic specimens were not measured, but the largest specimens in each series were selected for measurement, in addition to the 42 specimens on which all measurements were made. The maximum body size in this population must rarely if ever exceed 50 mm.

COMPARISON WITH OTHER SPECIES: Although adult individuals of *riparius* are distinct in size from all other known *Cophixalus*, it is desirable to mention characters other than size that will help distinguish the species.

Fourteen species of *Cophixalus* are known to occur in New Guinea (Zweifel, 1956a, p. 48; 1956b) in addition to the two new species described here. Certain of these have distinctive characters that allow their immediate separation: *geislerorum* (webbed toes); *ateles* and *shellyi* (first finger very short and without disc); *variegatus*, *rostellifer*, and *darlingtoni* (fifth toe longer than third); *oxyrhinus* (toe discs larger than finger discs); *pansus* (toes without expanded discs).

*Cophixalus cheesmanae* and *C. verrucosus* appear to be long-legged species with ranges of variation of the TL/S-V ratio that do not overlap the range of *riparius* (Zweifel, 1956a, p. 39). These species also have distinctive features of color pattern in the inguinal and posterior femoral regions—unicolored areas (pink in life) in *cheesmanae* and black and yellow spotting or mottling in *verrucosus*.

I know *Cophixalus biroi* only from the literature, but features mentioned in Parker's (1934, p. 174) description indicate that *biroi* could not easily be confused with *riparius*: "Snout obtusely pointed, somewhat longer than the diameter of the eye; canthus rostralis well marked; loreal region almost vertical; interorbital space twice as broad as the upper eyelid."

The tiny (maximum snout to vent length, 21.7 mm.) *Cophixalus daymani* differs from *riparius* in having relatively shorter legs (TL/S-V mean, 0.35), snout shorter than eye diameter, and no vocal sac in the male.

*Cophixalus cryptotympanum* has relatively longer legs than *riparius*, though there is some overlap in the ranges of TL/S-V (table 1). Despite the near-identity in mean E-N/IN ratios (table 1), the heads of the two species seem rather different, for *cryptotympanum* has nearly vertical lores and consequently a more nearly angular canthus rostralis.

A comparison of *C. riparius* with *C. nubicola* is made in the description of the latter new species.

The species most closely similar to *C. riparius* is one with which it is sympatric, *C. parkeri*. The two are virtually identical in relative leg length and have broadly overlapping E-N/IN ratios, though the means are significantly different (table 1 and fig. 3). No other proportional differences are evident to the eye or to measurement.

The maximum size of *parkeri* is about 31 mm. from snout to vent. Numerous specimens smaller than this are gravid females, so the possi-

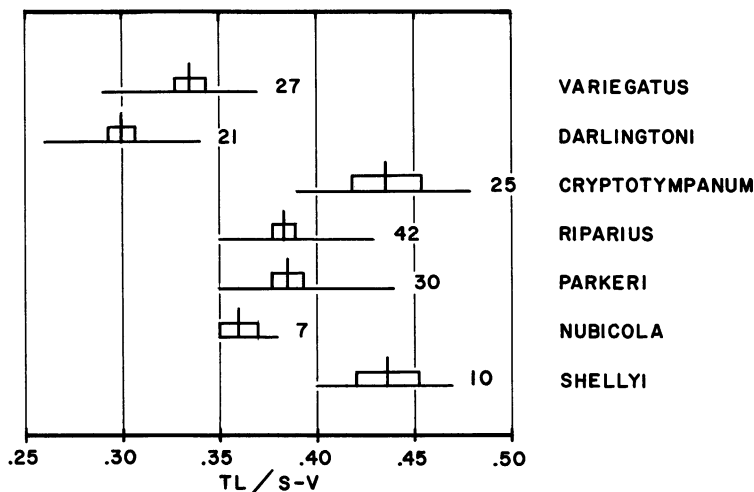


FIG. 5. Variation in ratio of length of tibia to snout to vent length in seven species of *Cophixalus*. Method of presentation as in figure 3.

bility that these are merely immature *riparius* can be dismissed. A consistent but seemingly trivial character that appears to differentiate the two is the presence of a few tiny tubercles on the dorsal surface of the tibia and tarsus of *parkeri* and their absence in *riparius*.

Probably color pattern will serve to distinguish the species in life. In first working over the collections of the Sixth Archbold Expedition, I was able to segregate all specimens later identified as *parkeri* on the basis of orange areas occupying the groin and anterior and posterior surfaces of the thigh. After two years in preservative, specimens of *parkeri* are still readily distinguishable from young *riparius* of similar size on this basis.

The similarity of the two species and the fact that the type localities of both are on Mt. Wilhelm may lead to a suspicion that the type of

*parkeri* may actually be the species described here as *riparius*. I have examined the type of *parkeri* (Museum of Comparative Zoology No. 25940) and compared it directly to *riparius*. They are not conspecific. The type of *parkeri* agrees with specimens I refer to that species in size, sexual maturity (gravid female), color pattern (though no orange pigment remains), and the presence of tiny tubercles on the tibia.

SPECIMENS FROM MT. OTTO: Four of six specimens from the south slope of Mt. Otto at 7000 to 8000 feet in elevation, about 30 miles southeast of the type locality on Mt. Wilhelm, present curious deviation from the

TABLE 2  
MAXIMUM SNOUT TO VENT LENGTH (IN MILLIMETERS) OF SEVEN  
SPECIES OF THE GENUS *Cophixalus*

| Species               | Length            | N <sup>a</sup> |
|-----------------------|-------------------|----------------|
| <i>cryptotympanum</i> |                   |                |
| Mt. Dayman            | 28.4              | 38             |
| Highlands             | 38.5              | 43             |
| <i>darlingtoni</i>    | 26.5              | 56             |
| <i>nubicola</i>       | 29.2              | 7              |
| <i>parkeri</i>        | 31.2              | 33             |
| <i>riparius</i>       | 50.8 <sup>b</sup> | 48             |
| <i>shellyi</i>        | 20.4              | 10             |
| <i>variegatus</i>     | 20.7              | 38             |

<sup>a</sup> In several instances the actual number of specimens available greatly exceeds the *N* given. The series were scanned for large individuals, and these were measured and otherwise compared with individuals on which all measurements were made.

<sup>b</sup> Maximum size in the topotypic series is 49.9 mm.; see pages 17 and 20.

topotypical series, but two of the six (A.M.N.H. Nos. 66306 and 66308) are indistinguishable from the topotypes. The color patterns of these two lie within the range of variation in the topotypes, the TL/S-V ratios (0.39 and 0.37) closely straddle the mean for the topotypes, and the E-N/IN ratios are even closer to the mean (0.87 and 0.88).

The remaining four specimens are conspicuously different in color pattern in having a pale venter grading into slightly darker sides, followed by a fairly abrupt shift to darker dorsum in which very slightly darker dorsolateral bands may be distinguished. An indistinct eyespot is consistently present in the groin. The four specimens (A.M.N.H. Nos. 66307, 66309–66311) are virtually identical in appearance and are not matched or even closely approximated in the topotypic series of more than 200 frogs.

The E-N/IN ratio averages 0.852 (0.78–0.92), a slightly lower average and range than in topotypic *riparius* but hardly significantly different in such a small sample. A slightly greater difference is seen in leg length. The TL/S-V ratio averages 0.352 (0.33–0.37), the average equaling the minimum seen in topotypic *riparius*. The apparent difference in leg length seems more significant when it is recalled that the two specimens from Mt. Otto that resemble topotypic *riparius* in pattern also have relatively high TL/S-V ratios.

One other point of possible significance relates to body size. The largest of the four questionable specimens measures 50.8 mm. from snout to vent, thereby exceeding in length all specimens in the topotypic series.

I strongly suspect that the series of six frogs from Mt. Otto includes two species, but do not feel that information presently at hand is sufficient to permit adequate diagnosis. Hence, I refer these specimens to *C. riparius* but specifically exclude them from designation as paratypes.

ADDITIONAL REMARKS: Many of the specimens in the topotypic series were collected by Hobart M. Van Deusen at night along the banks of Pengagl Creek, where they were found amid grass, low shrubs, or boulders. The specific name *riparius* was chosen with this habitat in mind. Other frogs found in the same general region were two species of *Hyla* (not yet determined as to species), *Nyctimystes narinosa*, *Asterophrys wilhelmana*, and *Cophixalus darlingtoni*.

DISTRIBUTION: *Cophixalus riparius* is known from Mt. Wilhelm and Mt. Otto. Territory of New Guinea: Pengagl Creek, 9100 feet in elevation, east slope of Mt. Wilhelm (A.M.N.H. Nos. 65974–65978, type and paratypes, July 1, 1959); east slope of Mt. Wilhelm, 8000–9100 feet in elevation (A.M.N.H. Nos. 65979–66039, plus 158 untagged, paratypes, July 11–30, 1959); Kotuni, south slope of Mt. Otto, 7000–8000 feet in elevation (A.M.N.H. Nos. 66306–66311, August 7–20, 1959).

*Cophixalus shellyi* Zweifel

*Cophixalus ateles*, ZWEIFEL, 1956a, p. 34.

*Cophixalus shellyi* ZWEIFEL, 1956b, pp. 2–5, fig. 1; type locality, Kondiu, Wahgi Valley, Territory of New Guinea.

DIAGNOSIS: “Differs from all species of *Cophixalus* except *C. ateles* in possessing a very short first finger, its length being less than one-half of the length of the second. Differs from *C. ateles* in the following ways: tympanum very indistinct; finger discs relatively smaller; side of head black, sharply contrasting with dorsal and lateral body surfaces” (Zweifel, 1956b, p. 2). *Cophixalus shellyi* is well distinguished from other species found in the same general region in combining a very low E-N/IN ratio

(mean, 0.628) with a high TL/S-V ratio (mean, 0.436).

REMARKS: The original description of this species was based on three specimens. The seven additional specimens now available, three donated by Michael Tyler and four collected by William Hosmer on the Spalding-Peterson Expedition of 1959, give a better concept of the range of variation.

The new specimens agree quite well with the type and paratypes in color and pattern, though the dark pigmentation is less intense in some specimens than is illustrated for the type (Zweifel, 1956b, fig. 1).

*Cophixalus shellyi* is a relatively long-legged form, similar (among species in the same general region) to *C. cryptotympanum* in this respect (fig. 5, table 1). These two species are abundantly distinct, however, in the E-N/IN ratio (fig. 3, table 1). This ratio averages lower in *shellyi* than in any other of the seven species discussed in this paper.

The recently acquired specimens agree with the type and paratypes in two characteristics given emphasis in the original description, small first finger and relatively small finger discs, two or less times the width of the penultimate phalanx. A male with a snout to vent length of 16.8 mm., presumably of adult size, appears to have a vocal slit on only one side, lateral to the base of the tongue. I can find no vocal slits in a presumably immature male 12.5 mm. in length. The largest specimen is a female 20.4 mm. from snout to vent length collected by Tyler. A female as small as 16 mm. has enlarging ova indicative of sexual maturity.

All specimens except the type and paratype from Kondiu are from relatively high elevations. I suspect that these specimens were actually collected in the Kubor Range above Kondiu rather than down in the Wahgi Valley.

DISTRIBUTION: *Cophixalus shellyi* ranges from the Wahgi-Sepik Dividing Range (and possibly the adjacent Wahgi Valley, see above) to Mt. Hagen (Zweifel, 1956b, p. 2). No specimens of this species were collected on the Sixth Archbold Expedition. New locality records are: Territory of New Guinea: Wahgi-Sepik Dividing Range near Nondugl, 8000 feet in elevation (A.M.N.H. Nos. 65271-65274, August 10, 1959); same, 9500 feet in elevation (A.M.N.H. Nos. 67610-67612, May 20, 1960).

#### *Cophixalus variegatus* (Van Kampen)

*Hylophorbus variegatus* VAN KAMPEN, 1923, p. 138; type locality, Digul River, Netherlands New Guinea.

*Sphenophryne loriae*, BOULENGER, 1897, p. 707 (part).

*Cophixalus variegatus*, PARKER, 1934, p. 176. ZWEIFEL, 1956a, pp. 44-45.

*Cophixalus variegatus variegatus*, LOVERIDGE, 1948, p. 425.

DIAGNOSIS: Differs from all known species of *Cophixalus* except *darlingtoni* and *rostellifer* in having fifth toe longer than third. *Cophixalus rostellifer* has a long, pointed nose, snout at least twice length of eye, whereas lengths of snout and eye are approximately equal in *variegatus*. Internarial distance in *variegatus* less than distance from eye to naris, whereas in *darlingtoni* the distances usually equal to or internarial distance greater. Also, *darlingtoni* is a larger species, reaching a snout to vent length of at least 27 mm. as compared to 21 mm. in *variegatus*.

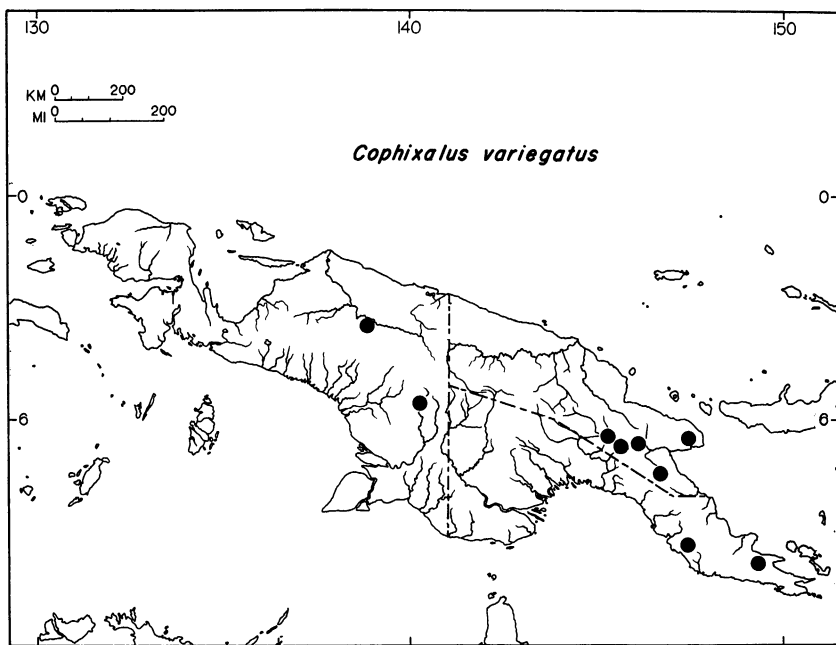


FIG. 6. Map of New Guinea, showing localities at which *Cophixalus variegatus* has been collected.

REMARKS: This species had been known from very few specimens. Parker (1934, p. 176) examined only two specimens in the preparation of his monograph; Loveridge (1948, p. 425) had a single specimen without adequate locality data; and Zweifel (1956a, p. 44) added only three specimens, one of these without adequate locality data. The extreme abundance of this species in the collection of the Sixth Archbold Expedition hence came as a surprise.

The proportions calculated for 27 specimens from Mt. Michael are given in table 1. Spot checks of specimens from other localities add little

to the ranges of variation given. A specimen from Mt. Kaindi has a TL/S-V ratio of 0.40, but others from the same locality are within the range of variation of the Mt. Michael series. If the specimen from 10,200 feet on Mt. Michael is properly identified as *C. darlingtoni* (see p. 7), then the internarial distance of *variegatus* is consistently shorter than the eye to naris distance.

The distinctness of the tympanum is variable. In some specimens the

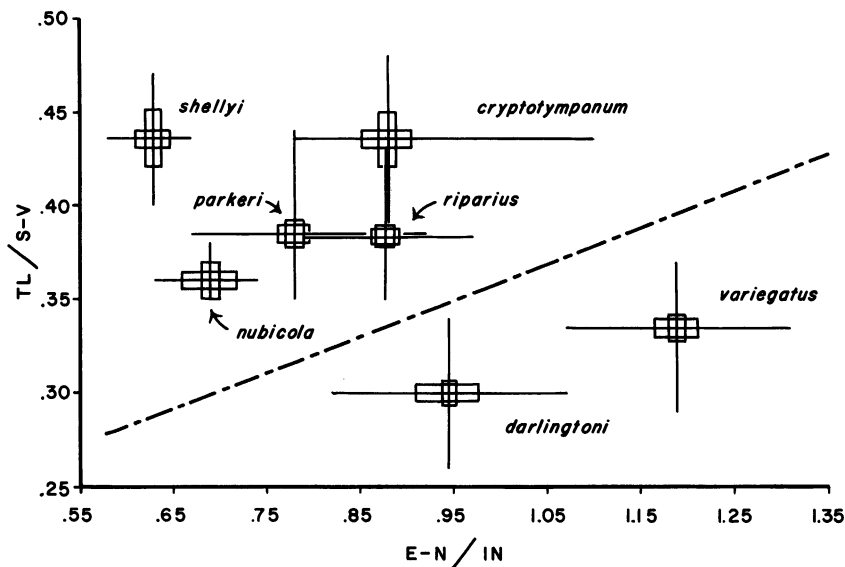


FIG. 7. Relationship of the E-N/IN and TL/S-V ratios in seven species of *Cophixalus*, combining data presented in figures 3 and 5. Species below broken line have fifth toe longer than third, those above have third longer than fifth.

outline of the tympanic ring can scarcely be made out, but in others the tympanum is distinct.

The average snout to vent length is less than 20 mm. I have not measured all specimens available, but only one among 34 exceeds 20 mm. (20.7 mm., gravid female). Males as small as 15.1 mm. from snout to vent are adult, judging from the presence of vocal slits, and a female 15.7 mm. in length is gravid.

**DISTRIBUTION:** *Cophixalus variegatus* is found in mountainous regions from the southeastern end of New Guinea (Mt. Dayman) to the region of the Idenburg River in Netherlands New Guinea (fig. 6). A specimen from Tumnang on the Huon Peninsula (Museum of Comparative

Zoölogy No. 28401) is the only one captured away from the central mountainous ridge of the island.

The following specimens were collected by the Sixth Archbold Expedition: Territory of New Guinea: Gono, west slope of Mt. Michael, 6400 feet in elevation (A.M.N.H. Nos. 66546–66547, August 27, 1959); northeast slope of Mt. Michael, 6500 feet in elevation (A.M.N.H. Nos. 66548–66577, plus 210 untagged, September 11–13, 1959); Purosa Camp, 15 miles (by road) south-southeast of Okapa, 6400 feet in elevation (A.M.N.H. Nos. 66626–66627, plus three untagged, September 21–22, 1959); Kaindi on the Wau Road, 6600 feet in elevation (A.M.N.H. No. 67000, May 17, 1959); Mt. Kaindi, 2350 meters in elevation (A.M.N.H. Nos. 66701–66703, plus five untagged, May 15–20, 1959); Arau, Kratke Mountains, 4600 feet in elevation (A.M.N.H. Nos. 66708–66709, October 9, 1959).

#### KEY TO FROGS OF THE GENUS *Cophixalus* IN THE CENTRAL MOUNTAINOUS REGION OF THE TERRITORY OF NEW GUINEA

This key will serve primarily to help orient the thinking of anyone desiring to identify *Cophixalus*. Because of the broad range of variation in several characters, identification of individuals of the last four species in the key will require a careful comparison of specimens with diagnoses and descriptions. The nature of the variation is such that it cannot adequately be covered in a brief key. Figure 7 will serve as a valuable adjunct to the key, if the user will calculate and plot the appropriate ratios of his questionable specimens.

1. Fifth toe longer than third. . . . . 2  
     Third toe longer than fifth, or the two approximately equal. . . . . 3
2. E-N/IN average 1.188, minimum 1.07; maximum snout-vent length about 21 mm. . . . . *variegatus*  
     E-N/IN average 0.945, maximum 1.07; maximum snout-vent length about 27 mm. . . . . *darlingtoni*
3. First finger less than one-half of length of second, disc poorly or not at all developed; E-N/IN average 0.628, maximum 0.67; side of head below eye level (sometimes only immediately below and posterior to the eye) dark brown or black; maximum snout-vent length less than 21 mm. . . . . *shellyi*  
     First finger one-half or more of the length of the second, disc well developed (except possibly in some juveniles); minimum E-N/IN 0.63, average 0.69 or higher; color pattern of head not as described above; most if not all adult individuals longer than 21 mm. snout-vent. . . . . 4
4. E-N/IN usually greater than 0.83; maximum snout-vent length up to 50 mm. . . . . 5



- E-N/IN usually less than 0.83; maximum snout-vent length 31 mm. . . . . 6
5. Maximum snout-vent length about 50 mm.; TL/S-V average 0.383; loreal region oblique. . . . . *riparius*  
Maximum snout-vent length about 38 mm.; TL/S-V average 0.436; loreal region nearly vertical. . . . . *cryptotympanum*
6. E-N/IN average 0.780; disc of third finger usually about three times width of penultimate phalanx. . . . . *parkeri*  
E-N/IN average 0.689; disc of third finger usually about two times width of penultimate phalanx. . . . . *nubicola*

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