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SOME AMPHIBIANS FROM THE LOWLANDS OF NORTH BORNEO

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INTRODUCTION

The topography of North Borneo is dominated by Mount Kina Balu (4,100 meters), the highest peak between the Himalayas and the Orange Mountains of New Guinea. This mountain has acted like a magnet to collectors, with the result that the amphibian fauna of Kina Balu might be mistaken for that of North Borneo, if one judged by published locality records. Forty-seven species of amphibians have been reported from North Borneo, thirty of them from Kina Balu only.

Several papers have been devoted largely or in full to the herpetology of Mount Kina Balu (e.g., Mocquard, 1890; Smith, 1931). By contrast, reports on the amphibians of lowland North Borneo have been limited to incidental references in works of more general nature (e.g., Boulenger, 1920) or to papers describing one or two species (e.g., Boulenger, 1893).

Two expeditions of Chicago Natural History Museum have made herpetological collections in North Borneo at low elevations (fig. 85). The Crane Pacific Expedition, 1929, operated a field base at Mile 8 on the North Road, Sandakan, in a complex area of cultivated land, secondary growth, and original dipterocarp forest, for three and one-half weeks. Amphibians were collected by Dr. Karl P. Schmidt, formerly Chief Curator of the Department of Zoology, and Mr. Frank C. Wonder, Taxidermist, in July and August, 1929. The Borneo Zoological Expedition, 1950, conducted by Mr. D. Dwight Davis and myself, spent two months at the head of Dewhurst Bay, about 65 kilometers southeast of Sandakan, and one month in the Sapagaya Forest Reserve, on the south side of Sandakan Harbor.

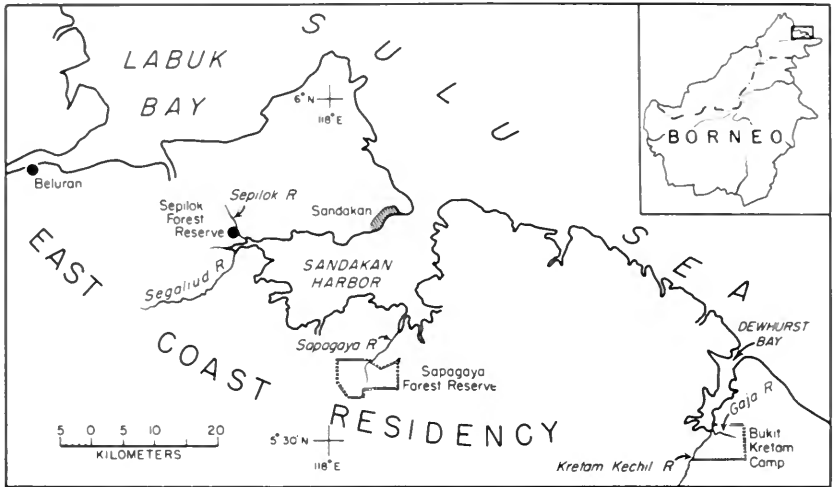


FIG. 85. Map showing localities at which collections were made.

The first field base, near the mouth of the Kretam Kechil River, was in the Bukit Kretam Camp of North Borneo Timbers, Ltd. Camp headquarters were in a clearing at the edge of a large area of undisturbed dipterocarp rain forest. Two sides of the clearing were dotted with "wells"—holes continually filled by rain. Between these wells and the forest was a belt of the characteristic tangled vegetation found at edges of rain forest (fig. 86). Parts of this transition zone were swampy. Many permanent streams flowed through the forest (fig. 87). Maximum elevation in the Kretam area is approximately 150 meters. The months of May and June were spent at the Kretam camp.

The Sapagaya Forest Reserve is largely an area of logged dipterocarp rain forest. This forest lacks the thick, continuous canopy of tall trees and the resulting dense shade and high humidity of the Kretam forest. Undergrowth at Sapagaya is denser. Small areas of undisturbed primary forest, essentially like that of Kretam, occur around the edges of the reserve. Amphibians were obtained in both types of forest. Maximum elevation at Sapagaya does not exceed 50 meters above sea level. Parts of July and August were spent at Sapagaya.

Amphibians were also collected at Sepilok Forest Reserve at the northwest end of Sandakan Harbor, in Sandakan, and in a rubber plantation at Mile 5, North Road, Sandakan. A small collection

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FIG. 86. Tangled vegetation in swampy ground at edge of Bukit Kretam camp clearing. The pool in the foreground contained tadpoles of *Rhacophorus leucomystax* and *R. otitophus*; adults of both were abundant in the surrounding vegetation. The narrow-leaved sedge in the center background is a species of *Mapania* (family Cyperaceae). The broad-leaved plants belong to the families Anonaceae, Marantaceae, Sapindaceae, and Zingiberaceae. The broadest leaf in the background is about 15 cm. wide.

from Beluran on Labuk Bay was received as a gift from Mr. J. A. Tubb, formerly Director of Fisheries, Colony of North Borneo. All of these localities are in the East Coast Residency, North Borneo.

Although rainfall in northeastern Borneo is cyclical, there is no pronounced dry season. At Sandakan the heaviest rains accompany the northeast monsoon, usually from November to February. Yet, even during the driest interval (April to August), monthly rainfall varies between 152 and 196 mm.¹ The minimum monthly total at the Bukit Kretam Camp in the 21-month period since rainfall records were begun in May, 1950, is 109 mm. The seasonal distri-

¹ Based upon a 23-year period. Rainfall statistics for Sandakan kept by Mr. H. G. Keith, formerly Conservator of Forests, Colony of North Borneo.

bution and the total annual rainfall at Kretam appear to agree with those of Sandakan (average annual total, 1918-40 = 3400 mm.).

The heaviest rains were over when the base at the Kretam camp was established. Nevertheless, frogs were still breeding. Most



FIG. 87. Typical small forest stream in the Bukit Kretam Camp. Habitat of larval *Megophrys hasselti* and adult *Rana kuhli*.

species of larvae found were kept alive in the field laboratory. Five were reared through metamorphosis.

Acknowledgment must be made to North Borneo Timbers, Ltd., for permission to work at the Bukit Kretam Camp. The members of the Borneo Zoological Expedition are particularly indebted to the managers of the camp, Messrs. O. C. Finch and J. D. H. Hedley, for hospitality and much assistance. Likewise we are grateful to Messrs. G. S. Brown and F. V. Webster of the Forestry Department, Colony of North Borneo, for the use of the Sapagaya Reserve, for transportation, and for many kindnesses. For generosity with their time and laboratory facilities we are grateful to Messrs. J. A. Tubb and A. M. Anderson, formerly of the Fisheries Department, Colony of North Borneo. I am indebted to Miss Margaret G. Bradbury for the pen and ink figures.

LIST OF SPECIES

Megophrys monticola nasuta Schlegel

Ceratophryne nasuta Schlegel, 1858, Handl. Dierk., 2: 57, pl. 4, fig. 72—Sumatra.

Megophrys monticola nasuta Inger, 1954, Fieldiana, Zool., 33: 223, fig. 37, B.

One larva of this species was found in a muddy stream in the Sapagaya Forest Reserve. It agrees well with the description of *monticola* larvae given by van Kampen (1923). This individual, which lacks hind limb buds, measures 25 mm.; tail 16 mm.

Locality.—Sandakan District, Sapagaya Forest Reserve (one larva). Mount Kina Balu is the only other North Bornean locality known (Smith, 1931).

Megophrys hasselti Müller

Leptobrachium hasselti Müller in Tschudi, 1838, Mem. Soc. Sci. Neuchâtel, 2: 81—Java.

Megophrys hasselti Smith, 1930, Bull. Raffles Mus., no. 3, p. 134.

Six adult males with vocal sacs measure 58.9–66.8 mm. snout to vent (mean, 62.50 ± 1.37 mm.).

The mean snout-vent length of four male *hasselti* from Borneo (Kina Balu) was stated to be 45.93 ± 2.17 mm. (Inger, 1954). It was also noted that four Palawan males averaged 56.23 ± 1.51 mm., a figure significantly larger, statistically, than the Kina Balu mean. The difference between the present series and the Kina Balu sample emphasizes the need for larger samples before geographic variation in size (whether inter-island or intra-island) can be demonstrated.

Five adults were collected on the banks of streams in logged dipterocarp forest and the sixth in the Sapagaya camp clearing. One of the forest specimens was found during the day; the others were caught at night.

Notes on larvae.—Many larvae fitting the description by van Kampen (1923) were collected in pools of forest streams in the Kretam area (fig. 87). Twenty-five selected at random have the following labial tooth-row counts: I:5–5/5–5:I (14 specimens), I:6–6/5–5:I (7), I:5–5/4–4:I (3 specimens), I:6–6/6–6:I (1 specimen).

Considerable change in coloration occurs with growth. Young individuals (25 mm. total length) are light olive dorsally with a pair of large black spots at the root of the tail, one spot between the eyes, and two or three on the back. The tail muscle is olive at the root,

fading distally. The fins and belly are immaculate and transparent. The amount of black spotting increases with size, spots appearing first on the tail muscle, next on the upper fin, and finally on the lower fin. Simultaneously the number of spots on the back and head increases greatly. By the time the fore limbs erupt the body is almost completely black.

Hind limb buds appear when the larvae are roughly 40 mm. total length. At 55 mm. the development of the hind limbs is complete.

In one pool larvae were observed feeding on algae growing on the rock bottom. Dead leaves were eaten by larvae in the field laboratory. Pieces of prawn were seized immediately and both small and large tadpoles fed voraciously—some being obliged to feed upside down—on the same piece of meat, without any indication of cannibalism.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (75 larvae). Sandakan District, Sapagaya Forest Reserve (6 adults). Also known from Mount Kappa (van Kampen, 1923) and Mount Kina Balu (Smith, 1931) in North Borneo.

***Bufo biporcatus biporcatus* Gravenhorst**

Bufo biporcatus Gravenhorst, 1829, Del. Mus. Zool. Vrat., Fasc. 1, p. 53—Java.

Bufo biporcatus biporcatus Dunn, 1928, Amer. Mus. Nov., no. 315, p. 2.

Seventeen adult males (vocal sacs and nuptial pads present) measure from 35.0 to 41.0 mm. snout to vent (mean 37.59 ± 0.35 mm.). Three adult females with pigmented ova measure 42.4–52.0 mm.

Color (in alcohol) brown or grayish above; most specimens (18 of 23) with a thin light mid-dorsal line; black interorbital mark connecting centers of upper eyelids, varying in depth, and having a concave front border; usually black spots on back, most often in form of two interrupted chevrons; ventral surfaces cream-colored with a few dark spots; occasionally throat infusate.

Van Kampen (1923) states that males have nuptial pads on the first finger only. Ten males in the present series have small nuptial pads on the second finger in addition to the large one on the first finger. In this respect the North Bornean population resembles *biporcatus philippinus*.

Fifteen specimens were collected in the tangled vegetation at the borders of the Kretam camp clearing; most of these were calling from

the edges of "wells" or in wet seepage areas. In addition, two specimens were found in each of the following habitats: primary rain forest, logged primary forest, rubber plantation, grass in clearing.

The specimens obtained in the open clearing and in the primary forest were caught during the day. All others were observed at night. This species begins to call several hours before sunset and continues at least until midnight. The call consists of harsh, drawn-out squawks.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (20). Sandakan District, Mile 5, North Road, Sandakan (1), Sapagaya Forest Reserve (1), Sepilok Forest Reserve (1).

Mount Kina Balu is the only other North Bornean locality (Smith, 1931). This species has been collected at various places in Sarawak and Indonesian Borneo (van Kampen, 1923).

Ansonia leptopus Günther

Bufo leptopus Günther, 1872, Proc. Zool. Soc. London, 1872: 598—Matang, Sarawak.

Ansonia leptopus Inger, 1954, Fieldiana, Zool., 33: 239.

A juvenile toad (12.8 mm. snout to vent), found on the floor of primary rain forest near a stream, probably belongs to this species.

Color in life dark brown dorsally, with black areas which enclose small red spots; subarticular tubercles of fingers and toes, palmar pad, and metatarsal tubercles orange-red.

Mocquard (1890) reported both *A. leptopus* and *A. penangensis* from Mount Kina Balu. Smith (1931) assigned Mocquard's specimens to *leptopus* and lists only the one species from Kina Balu. After examining Mocquard's *penangensis* material in the Museum d'Histoire Naturelle, Paris, as well as specimens from Kina Balu in the British Museum (Natural History) and Chicago Natural History Museum, I must confirm Mocquard's identification.

Males from Kina Balu fall into two distinct groups. The larger form (*leptopus*) has two to four rows of black tubercles on the lower surface of the mandible and a small nuptial pad not extending distally beyond the level of the subarticular tubercle of the first finger. This pad is pale brown in color, lacking black horny covering. The smaller form (*penangensis*) either lacks the mandibular tubercles or has a few white ones. Its nuptial pad is black and covers the

entire dorsal surface of the first finger up to the base of the terminal phalanx. In addition to these differences, *leptopus* has a smaller tympanum (less than the diameter of the pupil as opposed to over half the diameter of the eye in *penangensis*), two rows of interorbital tubercles (none in *penangensis*), and a relatively longer first finger (slightly shorter than the second finger as contrasted with half the length of the second finger in *penangensis*). Smith also points to a size differential between these species, although he refers all Kina Balu material to *leptopus*.

Locality.—Kinabatangan District, near mouth of Kretam Kechil River (1). Kina Balu is the only other North Bornean locality known.

Kalophrynus pleurostigma pleurostigma Tschudi

Kalophrynus pleurostigma Tschudi, 1836, Mem. Soc. Sci. Neuchâtel, 2: 86—Sumatra.

Kalophrynus pleurostigma pleurostigma Parker, 1934, Monogr. Microhylidae, p. 97, figs. 39, 40.

Three adult males, 43.2–44.0 mm. snout to vent, were collected in primary forest. Two of these were calling—one at night and one during the day—from small water-holes at the bases of trees.

All have black inguinal ocelli but no dorsal cruciform pattern. Nuptial pads are present on the first three fingers. All three have white spinules scattered over the back.

Notes on larvae.—Eggs and larvae were collected from a water-filled hole in a log in the primary forest of the Kretam area. The water never exceeded a depth of 1 cm. and a surface area of 15 × 20 cm. in the many times the site was visited. Two sets of eggs were found separated by a fifteen-day interval.

Positions of spiracle and anus and characteristics of the oral apparatus are those of microhylid larvae. Of the microhylid genera known from Borneo only *Kalophrynus* and *Gastrophrynoides* have complete procoracoids. The anterior bar of the pectoral girdle is complete in the newly metamorphosed frogs of this series. The shape and relative lengths of the digits limit the possible identifications to *K. pleurostigma*. The present series differs from the description given by Parker (1934) only in the much shorter tail.

Body subspherical, flattened above; snout truncate; eyes lateral, visible from above; spiracle median, midway between eye and end of body or nearer latter; vent median, at end of long tube; mouth terminal; no beaks; lips not expanded, without teeth or papillae.

Tail lanceolate, without terminal filament; dorsal fin beginning at end of body, thick at origin; ventral fin twice depth of dorsal in anterior quarter of tail, fins subequal distally; tail 1.33-2.0 times body. In advanced and metamorphosing larvae, digits bluntly pointed; first, second, and fourth fingers short, less than half length of third, second longer than first and fourth; third toe longer than fifth, fourth twice length of fifth; first, second, third, and fifth toes webbed almost to tips.

Color in life of larvae without hind limb buds gray, immaculate, lighter ventrally; suckers black. Specimens resorbing tail dark brownish black on back and sides, belly gray; fine green-gold flecks on head and back, so concentrated on head as to form almost a solid color.

Eggs were brought into the laboratory and the larvae reared. In the following discussion all ages are based upon the time of collection. Eggs were in mid-gastrulation upon collection; total diameter, including gelatinous envelop, was 5 mm. At 30 minutes, the eggs were in the yolk plug stage. At 3½ hours, neural folds were visible, and the tail bud stage was reached 4½ hours later. At 24 hours, round, dark suckers were present; external gills were not evident; the embryos twitched; total diameter, including gelatin, was 8 mm. All embryos hatched by the fiftieth hour, at which time external gills were prominent. A specimen preserved at hatching had a total length of 7 mm. The operculum completed its closure on the fourth and fifth days; individuals varied in this regard. During the same period the mouth opened, a single transverse coil of the intestine became visible, and hind limb buds appeared; larvae of this stage measured 8-9 mm. The suckers began to disappear on the sixth day. Larvae collected on this date were in the same stage and approximately the same size as those being reared in the laboratory. On the fifteenth day the fore limbs erupted, at which time snout-vent length was 4 mm. Resorption of the tail required one day. The temperature of the laboratory during the sixteen days varied from 24° to 29° C.

During the entire developmental period the larvae were kept in glass containers in 1 cm. of water. No food was added. The feeble coiling of the gut and the large amount of yolk it contained suggest that larval life is supported by yolk. The extremely rapid development and the dependence upon yolk are probably functionally related.

There also seems to be a relation between the feeble swimming ability of the larvae and the selection of small pools of water for

breeding sites. The latter probably favors the reduction of the length of larval life.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (2 adults, many larvae); Labuk District, near Beluran (1 adult).

Also reported from Kina Balu (Smith, 1931) and Paitan, north of Labuk Bay in the East Coast Residency (Parker, 1934).

Chaperina fusca Mocquard

Chaperina fusca Mocquard, 1892, *Le Naturaliste*, (2), 6: 35—Sintang, Borneo.

One adult, 18.8 mm. snout to vent, was collected along a stream in primary forest adjacent to the Kretam Camp.

Notes on larvae.—Tadpoles were found in the water-filled cleft of a log lying in a small forest clearing. Some were reared through metamorphosis. The presence of small dermal projections at heel and elbow in the newly metamorphosed individuals, so diagnostic of adult *Chaperina*, confirms the identification.

Body oblong; snout blunt; eyes supero-lateral; mouth terminal, lacking expanded lips, labial teeth, papillae, and horny beaks; nostrils dorsal, midway between eyes and tip of snout; spiracle median, ventral, one-fourth of distance from vent to snout; anus tubular, opening at edge of right side of ventral fin; tail tapering to a point; fins subequal to tail muscle.

Tips of digits truncate (in specimens with erupted fore limbs); first finger about half the length of second; second slightly shorter than fourth; third toe longer than fifth; fourth toe almost twice the length of fifth; first and second toes webbed to subarticular tubercle or slightly beyond; third toe webbed to basal or distal subarticular tubercle, fifth toe to distal tubercle, and fourth to middle tubercle; specimen with well-developed hind limbs lacking dermal spine at heel; dermal spine at heel and elbow in specimens with erupted fore limbs.

Color in life of specimens without erupted fore limbs: body black above, slightly lighter ventrally; tail muscle with black line at upper edge, remainder of muscle gray, darker distally; fins clear except adjacent to dark edge of muscle; eye black with conspicuous light triangle in upper part of iris in most specimens. Individuals with erupted fore limbs: black above with dense, fine green flecks on head and back; white dots on head, sides, and legs; green sparse on limbs; ventral surfaces black with fine green dots, not as dense as on back.

Specimen with hind limb buds, 20 mm. total length, body 7 mm.; specimen with distinguishable webbing between toes, 23 mm. total length, body 8 mm.; two specimens with erupted fore limbs and complete tails, 24–26 mm. total length, body 9 mm.; snout-vent 8 mm. in two specimens with almost completely resorbed tails.

Locality.—Kinabatangan District, near mouth of Kretam Kechil River (1 adult, 33 larvae). Also known from Kina Balu (Smith, 1931).

Metaphrynella sundana Peters

Calohyla sundana Peters, 1867, Monatsber. Akad. Wiss. Berlin, 1867: 35—Pontianak, Borneo.

Metaphrynella sundana Parker, 1934, Monogr. Microhylidae, p. 108.

Six males with vocal sacs measure 19.0–21.9 mm., snout to vent. One adult female with enlarged ova is 23.4 mm. long.

These agree well with Parker's description, with the following modifications: The tympanum is visible in one specimen. The inner metatarsal tubercle is always visible as a low elongate structure. Tubercles are usually scattered on the back and are always present on the sides.

The piping, low-pitched "whoot" of *Metaphrynella* is one of the characteristic sounds of the dipterocarp forests of North Borneo. Though apparently more abundant in undisturbed primary forest, it also occurs in logged areas in which many of the large, non-commercial trees are left standing. None was heard in secondary growth.

All calling individuals were in water-containing tree holes, usually one or two meters above ground. One, however, was in a short tree stump. When the stump was pushed over, a set of eggs was found in less than one centimeter of water in the hollow occupied by the adult. These eggs, presumably belonging to *Metaphrynella*, were in a strand two to three eggs in width. The eggs measure 1 mm. and when collected appeared to be white. Under magnification very fine dots of pigment are seen to be scattered uniformly over the surface, giving a pale gray cast to the egg. Unfortunately eggs brought back to the field laboratory did not develop.

Localities.—Kinabatangan District, near mouth of the Kretam Kechil River (6). Sandakan District, Sapagaya Forest Reserve (1).

This species has previously been recorded only from south-western Borneo at Pontianak, Indonesian Borneo, and at Kuching, Sarawak (Parker, 1934).

Kaloula baleata baleata Müller

Bombinator baleatus Müller, 1836, Verh. Batavia Gen., 16: 96—Krawang, Java.

Kaloula baleata Günther, 1858, Cat. Batr. Sal. Brit. Mus., p. 122.

Kaloula baleata baleata Inger, 1954, Fieldiana, Zool., 33: 427.

Two males with vocal sacs, 52.8–55.6 mm. snout to vent, were caught in a roadside ditch. A juvenile specimen, 38.7 mm., was collected in a garden.

A chorus of *baleata* was heard at night in Sandakan on two occasions, once in April and once in early September. On both dates heavy rains had fallen in the late afternoon.

Locality.—Sandakan District, Sandakan (3).

This species has been recorded from Pontianak in Indonesian Borneo and Mount Dulit in Sarawak (van Kampen, 1923), but there are no previous records from North Borneo.

Ooeidozyga laevis laevis Günther

Oxyglossus laevis Günther, 1858, Cat. Batr. Sal. Brit. Mus., p. 7, pl. 1, fig. A
—Philippine Islands.

Ooeidozyga laevis Smith, 1927, Proc. Zool. Soc. London, 1927: 204.

Oxydozyga laevis laevis Mertens, 1931, Abh. Senck. Naturf. Ges., 42: 209.

Four males have nuptial pads on the first fingers, vocal sac openings, and gular asperities. Snout-vent varies from 20.6 to 29.0 mm. (mean, 25.78 mm.). Ten females either with pigmented ova or enlarged oviducts vary from 34.6 to 44.5 mm. (mean, 37.63 ± 0.99 mm.). The largest of the females had 155 pigmented ova in the left ovary.

This thoroughly aquatic species was found in isolated pools in low areas and in streams. Eleven were collected in pools and three in streams. Six came from the Kretam camp clearing, two from primary rain forest, and three from a rubber plantation.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (7). Sandakan District, Mile 5 (3) and Mile 8 (4), North Road, Sandakan; Sapagaya Forest Reserve (1).

This species has not previously been reported from North Borneo. Other Bornean localities are Mount Dulit (1220 meters) and the Baram River in Sarawak and the Sebruang River in southwestern Indonesian Borneo (van Kampen, 1923).

Ooeidozyga baluensis Boulenger

Oreobatrachus baluensis Boulenger, Ann. Mag. Nat. Hist., (6), 17: 401, pl. 17—Kina Balu, North Borneo.

Two adult males with vocal sacs and nuptial pads on the first finger measure 18.0–24.0 mm., snout to vent. Three apparently mature females vary from 25.6 to 33.3 mm., snout to vent.

Color in life of head and mid-dorsal area blackish brown fading to tan in sacral region; sides and dorsal surfaces of limbs tan, limbs crossbarred; posterior surface of thigh and ventral surface of foot black; venter white marked with brown and black.

These specimens agree well with the type, which was examined in the British Museum. Smith (1931) has referred *baluensis* to *Phrynoglossus* Peters. Reasons for not accepting the separation of *Phrynoglossus* and *Ooeidozyga* Kuhl and van Hasselt are given elsewhere (Inger, 1954).

Three specimens were collected on the bank of a forest stream. Five were found on the forest floor, against the litter of which they are difficult to see. All were collected within 100 meters of sea level. Previously recorded specimens have all come from elevations in excess of 600 meters.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (5). Sandakan District, Sapagaya Forest Reserve (3). Mount Kina Balu is the only other North Bornean locality known.

Rana cancrivora cancrivora Gravenhorst

Rana cancrivora Gravenhorst, 1829, Del. Mus. Zool. Vrat., Fasc. 1, p. 41
—Java.

Rana cancrivora cancrivora Dunn, 1928, Amer. Mus. Nov., no. 315, p. 5.

Adult males measure 51.0–70.9 mm., snout to vent (mean of 25, 58.75 ± 0.84 mm.), adult females 52.9–82.0 mm. (mean of 19, 68.59 ± 2.02 mm.). One female (75.6 mm.) had 2415 pigmented ova, 1.0–1.5 mm. in diameter, in the left ovary.

Specimens were collected in swampy ground, on trails in rubber plantations, and in pools and ditches of towns. This is one of the most common amphibians around human habitations.

Females preserved in July and August, 1929, and in April, 1950, contained pigmented eggs. The secondary sex characters of males from the same collections were well developed.

Localities.—Sandakan District, Mile 5 (11) and Mile 8 (98), North Road, Sandakan. Labuk District, Beluran (3).

Padas, on the west coast, is the only other recorded locality in North Borneo (van Kampen, 1923).

***Rana macrodon macrodon* Duméril and Bibron**

Rana macrodon Duméril and Bibron, 1841, Erpét. Gén., 8: 382—Java.

Rana macrodon macrodon Inger, 1954, Fieldiana, Zool., 33: 276.

Adult males vary from 76.5 to 143 mm., snout to vent. Adult females vary from 90.4 to 124 mm.

All specimens for which precise data are available were caught along stream banks, thus agreeing with ecological observations for *macrodon* in the Lesser Sundas (Mertens, 1930) and the Philippines (Inger, 1954). The present series was collected in secondary growth and in primary rain forest.

Smith (1931) records specimens from 915 meters. The present material was taken within 150 meters of sea level.

Notes on larvae.—Two larvae were collected in a pool of an intermittent stream in the primary forest at the Kretam camp.

Despite the abundance of adults in various collections, larval *macrodon* have been recorded only rarely. Schijfsma (1932), reporting on two tadpoles from Java, notes several differences from the Malayan larvae described by Flower (1899). The Javanese specimens lack the inner interrupted tooth-row on the upper lip found in the Malayan larvae; the Javanese specimens have less black on the beaks and a less acutely pointed tail than the Malayan tadpoles. These minor variations may represent local differentiation, although additional specimens from Java must be examined before individual variation is ruled out.

The same reservation applies to the distinctions between the present specimens, described below, and both Javanese and Malayan larvae. The Bornean tadpoles differ from the former in having an inner interrupted tooth-row on the upper lip; from the Malayan they differ in having a single row of papillae along the lower lip rather than two or three (see fig., Flower, 1899), in having a narrower black band on the upper beak, and in lacking black bars on the ventral tail fin.

Body oval, somewhat depressed; snout broadly rounded; eyes superior; nostril nearer to tip of snout than to eye; spiracle sinistral, midway up side, closer to vent than to snout; anus dextral at end of wide tube opening near edge of ventral fin.

Mouth ventral, subterminal; papillae at sides of upper lip and entire margin of lower one; papillae in single uninterrupted row;

beaks moderate, serrated; upper beak a broad arc, slightly less than a third of depth black; upper lip with an outer continuous and an inner, broadly interrupted tooth-row; lower lip with an inner long, narrowly interrupted tooth-row, a slightly shorter and continuous middle row, and a very short (one-third length of middle row) continuous outer row.

Tail tapering to attenuated tip; muscle narrower than fins in distal half; upper fin beginning behind root of tail, rising sharply in central third of tail; ventral fin edge subparallel to ventral edge of tail muscle and of equal depth throughout its length.

Color (in alcohol) light brown above with a few irregular dark spots on head and back; a conspicuous dark bar across body at root of tail; tail with dark vertical bars across muscle; beyond center of tail, bars continue across upper fin; lower fin immaculate.

Total length of specimen with small limb buds is 26 mm., body 9 mm. A second specimen in the same stage but with damaged tail has a body length of 8 mm.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (5 adults, 2 larvae). Sandakan District, Mile 5 (4 juveniles) and Mile 8 (25 adults), North Road, Sandakan; Sapagaya Forest Reserve (13 adults).

Other North Bornean records are Mount Kina Balu (Smith, 1931) and Bettotan on the east coast (Smedley, 1931).

***Rana kuhli* Duméril and Bibron**

Rana kuhli Duméril and Bibron, 1841, *Erpét. Gén.*, 8: 384—Java.

Seven males with nuptial pads on the first fingers lack vocal sacs. Snout-vent length in these varies from 35.4 to 63.8 mm. (mean, 46.03 ± 4.18 mm.). Five females with enlarged oviducts or maturing ova vary from 46.2 to 59.3 mm. One female (51.2 mm.) had 103 pigmented ova in the left ovary.

Twenty-seven specimens were collected in the water or on the banks of forest streams (fig. 87). Twenty-two came from streams with moderate or strong currents. This current association agrees with Mertens' comments (1934) on *kuhli* from Sumatra and Java. However, Pope (1931) notes that in Fukien Province, China, this species occurs only in standing or very slowly moving water. Pope's Fukien observations differ from mine in several other respects. He never found *kuhli* in heavily shaded places such as forests. All of the present sample were collected in forest. Pope, Mertens, and

other authors cited by Pope consider *kuhli* to be a high altitude form. Mertens (1934, p. 697), for instance, refers to it as a pronounced ("ausgesprochen") montane species. The present material came from elevations below 150 meters.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (23). Sandakan District, Sapagaya Forest Reserve (4).

Other North Bornean localities are Mounts Kina Balu, Kalawat, and Kappa, all on the west side of the colony (van Kampen, 1923).

***Rana microdisca palavanensis* Boulenger**

Rana palavanensis Boulenger, 1894, Ann. Mag. Nat. Hist., (6), 14: 85—Palawan.

Rana microdisca palavanensis Inger, 1954, Fieldiana, Zool., 33: 299, fig. 53, B.

One adult female with pigmented eggs and measuring 41.5 mm., snout to vent, was found on the floor of primary forest.

Notes on larvae.—Larvae tentatively identified as this species were collected in two small rain puddles on the forest floor. One pool was 10 cm. in diameter and 15 cm. deep, the other 20 cm. by 2 cm. In most respects these tadpoles agree with the descriptions of "*palavanensis*" (= *microdisca*, subspecies unknown) larvae given by Smith (1927) and of *microdisca microdisca* larvae given by Dunn (1928), Mertens (1930), and Schijfsma (1932), the outstanding difference being that the papillae are interrupted at the center of the lower lip in the present series.

Adults of *microdisca palavanensis* are forest floor inhabitants (Inger, 1954) and might be expected to oviposit in temporary rain pools scattered throughout the forest. It is unlikely that a stream- or pond-dwelling ranid would use this type of breeding site. It is possible that *Rana signata*, another forest floor species, may be the adult of the larvae. However, the general agreement with tadpoles of *microdisca* plus the fact that calling males of *signata* were found only on the banks of streams, reduce the possibility that the larvae belong to the latter species.

If the identification is correct, the habitat is widely divergent from that of larval *microdisca dammermani*, which Mertens (1930) found only in flowing water. Yet this difference is not surprising as it agrees with the difference in the habitats of the adults. Adult *dammermani* occur in the immediate vicinity of water—streams, ditches, and flooded rice fields (Mertens, 1930).

Body oval, depressed, obtusely pointed at snout; nostril slightly nearer eye than tip of snout; eyes supero-lateral; spiracle sinistral, high on side, above line between eye and vent, nearer anus than tip of snout; vent dextral, tube opening at edge of ventral fin.

Mouth ventral, subterminal; papillae in single row at sides of upper lip and along entire border of lower lip except for narrow gap opposite center; beaks edged with black, edge of upper beak a broad arc; upper lip with an outer continuous tooth-row and a divided inner row; the halves of inner row about one-third length of outer; lower lip with two outer continuous tooth-rows and a narrowly divided inner row; innermost row slightly longer than middle row, the outermost row one-third length of innermost. Tail tapering to point; upper fin low at root of tail, rising in middle third, beyond which it equals or exceeds depth of muscle; ventral fin parallel to edge of muscle, half width of upper fin; tail approximately 1.7 times length of body.

In specimens with well-developed hind limbs, tips of toes swollen; third and fifth toes webbed to distal subarticular tubercle, fourth to center subarticular tubercle.

Color (in alcohol) brown above; dark bar below eye and along canthus; colorless below; muscle and upper fin of tail with irregular dark spots; ventral fin with dark spots in terminal third.

Labial tooth-row counts were I:1-1/1-1:II (nine specimens) and I:1-1/2-2:I (one specimen). The papillae were not interrupted along the lower lip in only one specimen out of ten. The ratio of tail length to body length varied from 1.48 to 1.88 (mean, 1.71); the ratio of tail depth to length ran from 0.21 to 0.24 (mean, 0.22). Total lengths in ten specimens, ranging in hind limb development between limb bud stage and the appearance of metatarsal tubercles, varied from 20 to 23 mm.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (1 adult, 10 larvae). Sandakan District, Sapagaya Forest Reserve (5 larvae).

This species has been reported from Sandakan (Boulenger, 1920) and Kina Balu (van Kampen, 1923).

***Rana erythraea* Schlegel**

Hyla erythraea Schlegel, 1837, *Abbild. Amph.*, p. 27, pl. 9, fig. 3—Java.

Rana erythraea Boulenger, 1882, *Cat. Batr. Sal. Brit. Mus.*, p. 65, fig.

A female with pigmented ova and measuring 74.2 mm., snout to vent, was caught on the bank of a stream in the Kretam camp clearing.

Locality.—Kinabatangan District, near mouth of Kretam Kechil River (1).

Panjut is the only other record for North Borneo (van Kampen, 1923).

***Rana nicobariensis nicobariensis* Stoliczka**

Hylarana nicobariensis Stoliczka, 1870, Jour. Asiatic Soc. Bengal, 39: 150, pl. 9, fig. 2—Nicobar Islands.

Rana nicobariensis Boulenger, 1885, Ann. Mag. Nat. Hist., (5), 16: 389.

Rana nicobariensis nicobariensis Inger, 1954, Fieldiana, Zool., 33: 331.

In nine adult males with nuptial pads, humeral glands, and vocal sacs, snout-vent varies from 37.2 to 40.4 mm. (mean, 39.11 ± 0.75).

This species is very common in the roadside ditches of Sandakan. At the Kretam camp it was observed only in the brush along a small stream where the latter passed through the center of the large camp clearing. Adults were not heard or seen at the edge of the clearing or along the forest streams.

Both in Sandakan and at the Kretam camp *nicobariensis* called at all hours of the day and night. Its harsh, clacking sound resembles that of the American cricket frog, *Acris gryllus*.

Notes on larvae.—Eleven tadpoles were collected from a pool of standing water near the edge of the Kretam camp clearing. These differ in some body proportions, e.g., the relative distances of the spiracle from eye and vent, from the description of van Kampen (1923). Van Kampen states that the papillae of the lower lip are arranged in three rows. The crowding and consequent staggering of the papillae rather than a regular arrangement are responsible for the appearance of rows (see figure in Schijfsma, 1932).

A single tooth-row on the upper lip is unusual among East Indian ranid larvae; the combination of that character with papillae longer than the lower lip is diagnostic of *nicobariensis*.

Color (in alcohol) grayish brown above, colorless and transparent below; a dark streak running back from each side of snout, joining in frontal region, and continuing as faint band to occipital region; usually a dark stripe from eye to tip of snout; a black bar below eye and one between eye and spiracle; fins and muscle of tail marbled with black.

Tooth-row counts are I/1-1:I in one specimen and I/1-1:II in nine. The outermost row of the lower lip is one-fourth to one-third the length of the middle row. The ratio of tail length to body varies from 1.50 to 1.82 (mean, 1.73). Total lengths range from 20 mm. in a specimen without hind limb buds to 29-30 mm. in specimens with subarticular tubercles developed on the foot.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (7 adults, 11 larvae). Sandakan District, Mile 8, Sandakan (2 adults).

Previously reported North Bornean localities are Bongon (van Kampen, 1923) and Kiau on the slope of Kina Balu (Smith, 1931).

Rana signata signata Günther

Polypedates signatus Günther, 1872, Proc. Zool. Soc. London, 1872: 600, pl. 40, fig. C—Matang, Sarawak.

Rana signata Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 71.

Rana signata signata Inger, 1954, Fieldiana, Zool., 33: 312, fig. 58, B.

Ten males, all with nuptial pads, humeral glands, and vocal sacs, vary from 35.7 to 46.5 mm. snout to vent (mean, 41.5 ± 1.4 mm.). One female with pigmented ova measures 67.5 mm.

Color (in life) of sides, back, head, and posterior surface of thighs a network of black and light brownish yellow, the proportion and distribution of the two colors varying; strip from tip of snout over canthus, edge of upper eyelid, along dorso-lateral line to vent deep orange or brownish yellow; dorso-lateral stripe intersected in several places by black from back; dorsal surfaces of limbs deep orange or brownish yellow with black crossbars; ventral surfaces of body and limbs dark or light shades of gray; throat and belly spotted with yellow; tympanum dark brown, uniform or with yellow spot.

Males collected in the Kretam area were calling from within 5 cm. of the water's surface on the bank of a forest stream. The call is a weak trill or chirp. One specimen momentarily escaped while being held over the water. Instead of diving, this specimen swam at the surface and climbed on to the bank. *Rana signata* appears to be a forest floor species. The reduced webbing and behavior such as described above are in accord with the presumed non-aquatic habits.

All specimens were collected at night.

Localities.—Kinabatangan District, Gaja River (4). Sandakan District, Sapagaya Forest Reserve (1), Mile 8, Sandakan (6).

Mount Kina Balu is the only other North Bornean locality recorded (van Kampen, 1923).

Rana chalconota Schlegel

Hyla chalconotus (part) Schlegel, 1837, Abbild. Amph., p. 23—Java.

Rana chalconota Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 66.

Though Boulenger (1920) placed his own species *labialis* in the synonymy of *chalconota*, van Kampen (1923) disagreed and maintained *labialis* as a separate species. The disk of the second finger in *chalconota* is said by van Kampen to be "elliptic" and smaller than that of the third finger, whereas in *labialis* the second disk is "large" and "nearly circular." A second distinction noted by van Kampen, the "usually . . . broader and more distinct dorsolateral fold" of *chalconota*, is too vague to be of value. Bornean specimens at hand belonging to this group have a circular disk on the second finger, but the disk is smaller than that of the third finger. Thus they seem to be intermediate between the two conditions described by van Kampen.

But the identification of *labialis* with *chalconota* obscures a difference between the two type series.¹ The nuptial pad of *labialis* reaches the articulation of the two phalanges on the median side of the first finger. In males of *chalconota* the pad does not extend beyond the articulation of metacarpal and basal phalanx. The same difference exists between two samples of "*chalconota*" in the Raffles Museum: two males from Mount Ophir, Malay Peninsula, resemble the types of *labialis*, whereas males from Siberut Island agree with *chalconota*. The Bornean series is like *chalconota* in this respect.

Males in the original series of *labialis* do not have humeral glands. These structures are also absent in males from Siberut and Mount Ophir but are present in my Bornean specimens. Information concerning the types of *chalconota* is not clear on this point.

Provisionally the present series is identified as *chalconota*. Direct comparison of the types of *chalconota* and *labialis* is still to be desired.

Eighteen adult males with vocal sacs, nuptial pads, and humeral glands measure 32.9–40.3 mm., snout to vent. Seven females, all but one with pigmented ova, vary from 47.6 to 56.6 mm. One

¹ Information on the types was very generously supplied by Dr. M. Boeseman, Rijksmuseum, Leiden (*chalconota*), and Miss A. G. C. Grandison, British Museum (*labialis*).

female (51.8 mm.) had 447 pigmented ova in the right ovary. First, second, and third toes webbed to disks on outer sides, fifth toe to disk on inner side, fourth toe to distal subarticular tubercle; outer metatarsal tubercle round, present in all; posterior part of belly granular.

Color (in life) green, yellow, or pale yellowish brown above; cream-colored below; upper lip white; posterior and ventral surfaces of thighs red; limbs with or without dorsal crossbars.

Only three specimens were caught in primary forest; these were in low vegetation along a stream bank. The others were collected in secondary growth or in clearings. Fifteen were found at the edges of small pools.

The call, which is a drawn-out squawk usually followed by a few sharp staccato notes, was heard only at night.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (14). Sandakan District, Mile 5, Sandakan (1), Sapagaya Forest Reserve (10).

Also known from Kina Balu (Smith, 1931).

Rhacophorus leucomystax linki Taylor

Hyla leucomystax Boie in Gravenhorst, 1829, Del. Mus. Zool. Vrat., Fasc. 1, p. 26—Java.

Rhacophorus leucomystax Boulenger, 1889, Proc. Zool. Soc. London, 1889: 29.

Polypedates linki Taylor, 1922, Phil. Jour. Sci., 21: 276, pl. 3, fig. 2—Jolo, Jolo Island.

Rhacophorus leucomystax linki Inger, 1954, Fieldiana, Zool., 33: 383.

The populations of *leucomystax* from the area between Labuk Bay and Dewhurst Bay in northeastern Borneo agree with the subspecies *linki* (range: Palawan, Calamian Islands, and Sulu Islands) in the usual absence of vocal sacs in males and in the degree of ossification of the skin on the head. In these characters *linki* differs from *leucomystax* of Kina Balu (Inger, 1954).

Color (in life) cinnamon brown to pale yellow brown above, usually with dark brown markings; dorsal marking consisting of small spots and interorbital bar or, less often, longitudinal stripes; ventral coloration cream or white, immaculate or with brown mottling on throat. In alcohol dorsal surfaces dark brown or gray.

Twenty of this series were spotted on the back, eleven were striped (three with four stripes, the others with two), and sixteen were without stripes or spots.

Twenty-three specimens have no outer metatarsal tubercles, six have an outer tubercle on one foot, and eighteen have the tubercle on both feet. Two individuals lacked vomerine teeth.

Thirty-seven adult males with nuptial pads vary in snout-vent length from 42.6 to 57.4 mm. The mean of twenty-four chosen at random is 50.94 ± 0.64 mm. Only three males have vocal sacs. The ten females vary from 68.5 to 84.6 mm., with a mean of 75.03 ± 1.34 mm.

This species was found at night on the ground and in low vegetation (usually within two meters of the ground) along the edges of the Kretam camp clearing. Small aggregations occurred around every "well" in the area. Several individuals were caught in houses in the center of the clearing. This species, abundant in Sandakan, is one of the commonest frogs associated with human habitations in Malaysia.

The call consists of a harsh roll—similar to the sound caused by stroking an inflated rubber balloon with the fingers—followed by a sharp "chuck-chuck-chuck." The latter may be emitted alone. Usually calling did not begin until after dark, although one individual was heard at 5:45 P.M.

Notes on larvae.—Advanced larvae were reared through metamorphosis. Identification is based upon comparison of these individuals with adults. As agreement with published descriptions (Flower, 1896; van Kampen, 1923) is close, only color notes and variation of labial tooth-rows are given here.

The labial tooth-row counts vary according to the general stage of development as found by Gosner and Black (1954) in *Scaphiopus holbrooki*. Counts made on larvae from a nest mentioned below show the following frequency of upper labial teeth:

Age in days after hatching	Total length (mm.)	Upper labial tooth-rows				
		I	I:2-2	I:3-3	I:3-4	I:4-4
3	13.0	2	..	..	..	..
5	13.0-13.5	..	2	..	..	..
11	13.0-17.5	..	2	9	..	1
16	15.5-19.0	..	..	1	2	1
28	21.0-26.0	..	..	2	1	6

None of the above larvae had reached the hind limb bud stage (stage I of Taylor and Kollros, 1946). Beyond that stage a dental formula with less than I:4-4 on the upper lip must be rare in *leuco-*

mystax linki. Of ten larvae between stages VIII and XVIII (total lengths 36–50 mm.) nine have I:4–4 on the upper lip and one has I:5–5.

The dental formula of the lower lip shows less variation. The two youngest larvae in the tabulation above have two continuous rows. All other specimens have an inner, narrowly interrupted row and two outer continuous rows, except for two large larvae (total length 47 mm., stages XIV and XVII) that have three continuous rows on the lower lip.

By stage XVIII (hind limb fully developed) the labial teeth begin to degenerate. One larva in this stage had weak teeth and another (not included in the preceding paragraphs) had lost the labial teeth completely. Apparently after a particular level of development is reached the labial teeth are not replaced as they wear out.

Useful comparison with dental formulae given in the literature is difficult because previous authors have not considered stage of development as a source of variation. Pope (1931) figures a tadpole from Hainan with a dental formula of I:3–3/III but does not comment on variation. For larvae from western China Liu (1950) gives the following: I:3–3/1–1:II (23), I:4–4/1–1:II (2), and I:3–4/1–1:II (1). Apparently the usual formula of tadpoles from Bangkok, Thailand, is I:4–4/1–1:II (Flower, 1899), whereas larvae from Sumatra have only four rows (presumably I:3–3) of teeth in the anterior lip (van Kampen, 1907). Thus the fully developed arrangement in the Bornean series is that of Flower's Bangkok material.

Color (in life) dark green above speckled with black and yellow; young individuals white below; ventral surface of head in older larvae mottled with black; tail of young larvae with a double row of dark spots on dorsal surface of muscle near base; tails of older larvae reticulated with black in that area; fins with faint dusting of chromatophores except in larvae approaching metamorphosis; fins in this mature class with dark blotches; mature tadpoles with three to five dark crossbars on thighs, no longitudinal stripes on body.

The average ratio of tail length to body length in thirty-seven specimens in the Bornean series is 1.68 (range 1.20–3.13). The mean of tail depth to length is 0.350 (range 0.28–0.43) in seven specimens. These averages are 1.85 and 0.389 in larvae from western China (data from Liu, 1950).

A froth nest was collected on June 1, 1950. On the following day many larvae were free of the nest. At that time the gills were

external; suckers were present; the mouth was not open; chromatophores were distributed over the dorsal surface of the yolk mass and as a streak along the dorsal edge of the tail muscle; total length was 8 mm. During the next twenty-four hours the operculum was formed; the mouth was open; labial tooth-rows and papillae were feebly indicated, but the former lacked horn; suckers were still present; total length was 10–11 mm. In the following day black horny sheaths of beaks and labial teeth appeared; suckers were no longer visible; total length was 13 mm. By the twenty-ninth day total length varied from 21–26 mm.; hind limb buds were not evident.

Individuals alive after twenty-nine days were not as strong swimmers as freshly collected specimens of corresponding stages, although both groups were fed prawn and dead tadpoles. Probably the growth rate of the specimens reared in the laboratory is not comparable to that of wild individuals. However, the developmental rate in the early stages should correspond to that in nature since the larvae are then living on yolk.

Specimens collected at various stages have the following lengths:

Taylor and Kollros stage	Level of development	Total length (mm.)
VIII	foot paddle	40.0
IX	foot paddle	36.0
XI-XIV	web developing	36.0–43.0
XVIII	subarticular tubercles	46.0–50.0
XXI	fore limbs erupted	66.0
XXIII	small stub of tail left	16.0–18.0 (snout-vent)

Liu (1950) notes that he never found larvae of *leucomystax* in running water or in large ponds in China. My observations agree with his. Tadpoles were collected only in small pools and swampy ground at the edge of camp clearing. A froth nest was taken from dead branches of a small tree overhanging a "well" (fig. 88).

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (27 adults, 50 larvae). Labuk District, Beluran (6). Sandakan District, Mile 8, Sandakan (4); Sapagaya Forest Reserve (10).

The species has been reported from many localities in Sarawak and southwestern Borneo (van Kampen, 1923). The only previously recorded North Bornean localities are the Tuaran River on the west coast (van Kampen, 1923) and Kina Balu (Smith, 1931).



FIG. 88. Egg-mass (in white triangle) of *Rhacophorus leucomystax* above small pool at edge of large clearing.

Rhacophorus otilophus Boulenger. Figure 89.

Rhacophorus otilophus Boulenger, 1893, Proc. Zool. Soc. London, 1893: 527, pl. 44—Bongon, North Borneo.

Wolf (1936) suggests that *otilophus* may be conspecific with *leucomystax*. Since the two species are sympatric over much of North Borneo without any indication of interbreeding, Wolf's suggestion must be rejected.

Ten adult males with vocal sacs and nuptial pads vary from 64.4 to 80.5 mm. snout to vent (mean, 73.68 ± 1.46 mm.). Three adult females vary from 83.2 to 96.5 mm. (mean, 89.2 mm.).

Color (in life) bright lemon yellow above with many black longitudinal lines; thighs with 7–10 (rarely as few as 5) black cross-bars; ventral coloration cream or white; in some specimens throat



FIG. 89. Adult *Rhacophorus otitophus*.

suffused with brown. In alcohol dorsal coloration pale brown with dark lines.

Adults were observed low in vegetation (up to 3 meters high) surrounding the "wells" and swampy ground at the edge of the Kretam camp clearing (fig. 86). Like *leucomystax*, this species occurs in the towns of northeastern Borneo.

The call is similar to those of *leucomystax* and *pardalis*, consisting of a rolling "rumph-rumph" followed by a sharp "chuck-chuck."

Notes on larvae.—Numerous larvae of this species were collected and some were reared through metamorphosis. The following notes may be added to Boulenger's description (1893):

Body subspherical; snout broadly rounded; nostril twice as far from eye as from tip of snout; spiracle in line with mouth and ventral edge of tail muscle.

Mouth ventral, subterminal; papillae at lateral corner of upper lip and along entire margin of lower lip with exception of gap opposite center; beaks strong, serrated, black; upper beak a concave arc with pronounced convexity in center; upper lip usually with an outer uninterrupted tooth-row and three or four divided rows; the lower lip usually with three subequal, continuous tooth-rows.

Tail deepest proximal to center; upper fin beginning anterior to end of body and rising in high arc, equal to or slightly wider than muscle at deepest part of tail; lower fin a little narrower than upper. Digits of older tadpoles with disks; fourth toe webbed to center subarticular tubercle; other toes webbed to distal subarticular tubercles or slightly beyond; two large infra-anal tubercles; a dermal projection at tibio-tarsal joint.

Color of body (in life) yellowish-green above, white below; tail transparent with golden flecks on upper fin; larvae with well-developed hind limbs becoming more yellowish, with black longitudinal lines on back, thighs with five to seven narrow black bars, and dark infra-anal area; larvae with erupted fore limbs grayish yellow above, vertebral area with three narrow black longitudinal lines bounded on each side by a wider black line followed laterally by three narrow lines enclosed by a second wider black stripe.

The ratio of tail length to body length ranged from 1.22 to 1.88 (mean, 1.56) in twenty-one specimens. This approximates the values of 1.25 to 1.67 given by Boulenger (1893). The ratio of tail depth to tail length varied from 0.36 to 0.57 in nineteen individuals (mean, 0.461); Boulenger gives values of 0.33 to 0.43.

A froth nest of unknown age was brought into the field laboratory and placed in a metal container with 2 to 3 cm. of water. One or two days may have to be added to the ages of larvae described below. On the next day three embryos were free of the nest. Several more wiggled loose on the second day. Larvae of the second day had open mouths and external gills; suckers were present, but no labial teeth or beaks were evident; total length was 10 mm. On the fourth day the operculum was closed; suckers were still present; beaks and labial apparatus had not appeared; total length was 12 mm. The beaks, labial papillae, and suckers were present on the fifth day; total length varied from 12 to 14 mm. One or both of the suckers had disappeared by the seventh day; the beaks assumed their black color at this stage and some of the labial teeth were present; the first coil of the intestine was visible; total length was approximately 14 mm. On the eleventh day pieces of prawn were put into the container and were immediately fed upon. A specimen of this age measured 17 mm. By the twenty-ninth day none of the larvae had visible hind limb buds; total length of five varied from 21 to 23.5 mm. Although fed regularly, there is no reason to assume that growth of the laboratory-reared animals was normal. Temperature roughly approximated that of the normal habitat.

The labial tooth formula varies with the stage of development much as in *leucomystax linki*. The larvae from this nest showed the following frequency of upper labial teeth.

Age in days after hatching	Total length (mm.)	Upper labial tooth-rows					
		0	I	I:1-1	I:2-2	I:2-3 3-4	I:3-3 4-4
5	12.0-14.0	1	1	..	..	..	..
7	14.0	..	1	1	..	..	..
11	16.0-16.5	..	..	2	..	..	..
14	18.0	..	..	..	1	..	1
18	18.0-19.5	..	..	..	1	1	1
24	17.5-20.0	..	..	..	..	2	8
29	21.0-23.5	..	..	..	1	..	9

Several larvae, about 50 mm. long when captured, were reared through metamorphosis. From five days to one week after the appearance of hind limbs, the longitudinal stripes of the adult coloration became visible. About ten days elapsed between the development of the hind limb buds and eruption of the fore limbs; the tail was resorbed in three more days.

Lengths of larvae of various stages follow:

Taylor and Kollros stage	Level of development	Total length (mm.)	Dental formula
--	no hind limb buds	24.0-29.0	I:4-4/III (3)
IV	hind limb bud	50.0	I:4-4/1-1:II (1)
VIII	foot paddle	54.0	4-4/III (1)
XVIII	subarticular tubercles	55.0-57.0	4-4/III (1), I:4-4/III (1), 6-5/III (1)
XX	one forelimb erupted	53.0	teeth absent

Larvae of *otilophus* were found in great abundance in the small pools dotting the edges of the Kretam camp (fig. 86). The tadpoles were very active at night; a constant stream of individuals rose to the surface and dove back into the muddy depths. Larvae fed voraciously in the laboratory on dead tadpoles and prawns. The single egg-mass (fig. 90) identified was attached to low herbs at the side of a pool.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (11 adults, 62 larvae). Labuk District, Beluran (1). Sandakan District, Sandakan (1), Mile 5, Sandakan (1).



FIG. 90. Close-up of egg-mass of *Rhacophorus otitophus*.

Bongon is the only previously reported North Bornean locality (Boulenger, 1893).

***Rhacophorus pardalis pardalis* Günther**

Rhacophorus pardalis Günther, 1858, Cat. Batr. Sal. Brit. Mus., p. 83, pl. 6, fig. D—Philippines.

Rhacophorus pardalis pulchellus Wolf, 1936, Bull. Raffles Mus., no. 12, p. 207.

It has been suggested (Inger, 1954) that the Sumatran and Bornean populations of *pardalis* should not be maintained as a subspecies distinct from the Philippine form. The present series from Borneo cannot be separated from the typical form and agrees very

closely with Wolf's description of *p. pardalis* even in the characters said by Wolf to distinguish *pulchellus* from *pardalis*.

Color (in alcohol) brown above with or without dark cruciform markings; ventral surfaces whitish, immaculate, a few specimens with small black spots; sides with black spots; limbs with crossbars; web orange, usually with small black spots.

Color in life is extremely variable. In one male the ground color of the dorsal surfaces was pale tan; the cruciform pattern of the back, the interorbital bar, and the limb crossbars were darker brown. Anterior and posterior surfaces of the thighs were orange as were the dorsal surfaces of the digits. All ventral surfaces except the web were lemon yellow. The throat was immaculate, the belly spotted with orange. The sides were yellow spotted with brown. The web was orange red. A second male was dark brown above with scattered white spots. The dorsal surfaces of several specimens were mixtures of tan, black, blue, yellow, and orange irregularly distributed, the tan and yellow predominating.

Ten adult males, with vocal sacs and nuptial pads, vary from 40.5 to 44.0 mm., snout to vent (mean, 42.38 ± 0.45 mm.). Two females, both containing enlarged ova, measure 60.0 and 61.5 mm.

Adults of *pardalis* were observed at night in low trees and bushes overhanging a forest stream and in the vegetation surrounding the small pools at the edges of the Kretam camp clearing. One pair was seen in amplexus in the low herbs around one of these pools. The call is similar to those of *R. leucomystax* and *otilophus*. Usually it consists of a rolling sound followed by a sharp "chack-chack" repeated several times. The rolling sound may be omitted.

Most adults observed were perched on small branches or leaves. One female was seen to run up a small tree. The tree trunk was approximately 3 cm. in diameter. The frog placed the hands and feet on one side of the trunk and, with its body held away from the tree, proceeded up the trunk rapidly by alternately moving right hand and left foot as one unit and left hand and right foot as another. Specimens brought into the field laboratory were put on the lower end of a thin stick and gently prodded. All five individuals so treated climbed up the stick rapidly with the same hand-over-hand and foot-over-foot motion. This peculiar locomotion was recorded on motion picture film. Not one of these captive *pardalis* stimulated under these circumstances made an attempt to jump. Five *leucomystax* and two *otilophus* in the same situation jumped repeatedly and made no attempt to climb. A third *otilophus*, with one paralyzed

hind limb, made hand-over-hand movements but was unable to pull itself up; this specimen made no attempt to jump, probably because of its injured leg.

Individuals of these three species were held in a standing observer's hand and prodded. During the ensuing jump the body of *pardalis* was held as though slung among four parachutes, with the hands and feet above the plane of the body during the "flight." Both *leucomystax* and *otilophus* held the hands and feet in the plane of the body while in the air. This difference between *pardalis* and the other species is probably attributable to the greater extent of the web and presence of additional dermal flaps on the appendages of *pardalis*. The area of hand and foot was determined for one specimen of each sex of these three species. The results follow.

Species	Sex	Snout-vent (mm.)	Area (mm. square)		Total area ¹ snout-vent
			Hand	Foot	
<i>R. pardalis</i>	♂	43.4	54	130	8.5
	♀	60.0	106	253	12.0
<i>R. leucomystax</i>	♂	48.4	15	70	3.5
	♀	72.3	26	186	5.9
<i>R. otilophus</i>	♂	75.2	18	125	3.8
	♀	83.2	26	154	4.3

¹ Total area = twice combined area of hand and foot.

Notes on larvae.—Oviposition did not take place while the copulating pair noted above were under observation. However, the following morning a froth nest was found at the site and presumed to be that of the pair. Advanced larvae, obviously belonging to the same species as those hatching from the nest, agree with adult *pardalis* in having the toes and outer finger webbed to the disks.

Larvae of this species have not been described.

Body (fig. 91) flattened above, length one and one-half times width and depth; snout broadly rounded; nostril twice as far from eye as from tip of snout; eyes supero-lateral; spiracle sinistral, low on side, in line with mouth and ventral edge of tail muscle; spiracle midway between snout and vent or slightly nearer vent; anus dextral, opening of tube not reaching edge of ventral fin.

Mouth (fig. 91) ventral, subterminal; papillae in two rows at lateral corners of upper lip and in three or four uninterrupted rows around border of lower lip; beaks weak, narrowly edged with black; upper beak concave, without central convexity; upper lip with two

continuous tooth-rows and three or four divided rows; lower lip usually with three subequal, continuous tooth-rows, rarely inner row narrowly interrupted.

Tail pointed; deepest at mid-point; ratio of depth to length 0.21–0.31 (mean of five specimens 0.266); upper fin beginning high at root

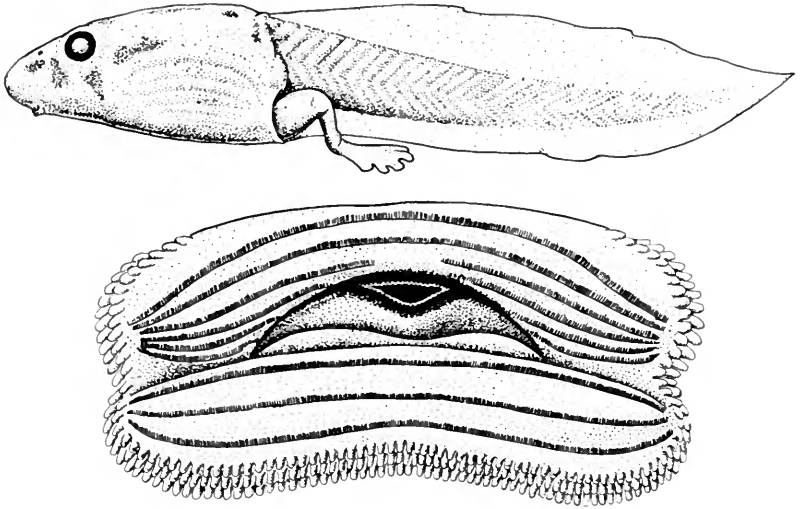


FIG. 91. Tadpole of *Rhacophorus pardalis pardalis*. Above, lateral view; $\times 2.7$. Below, oral view; $\times 18$.

of tail and rising gradually to center of tail, equal to or slightly deeper than tail muscle; lower fin subparallel to muscle, narrower than muscle; ratio of tail length to body length 1.75–2.60 (mean of eighteen specimens 2.18).

Digits of mature tadpoles with disks; all toes webbed to disks; web between third and fourth fingers just failing to reach disk of fourth; web between second and third fingers reaching disk of second; web between first and second fingers reaching subarticular tubercles.

Color (in life) pale olive green above; a black interorbital bar; a longitudinal black bar on canthus; round black spot below and slightly before eye; a vertical black bar below and behind eye; black Y running back behind eyes; body transparent and unmarked below; tail and fin unmarked.

The labial tooth-rows showed the following variation: II:3–3/III (12 specimens), II:4–4/III (3), II:4–4/1–1:II (1).

When the egg-mass mentioned above was three days old, it was brought into the field laboratory. The following day one larva was free of the nest. By the seventh day six more had wriggled loose. At this time the mouth was open, the beaks edged with black, and the papillae evident; the lower lip had three rows of teeth, but these lacked horny sheaths; no teeth were visible on the upper lip; suckers were no longer present; total lengths of two larvae were 11.5 and 12.5 mm. The labial teeth were equipped with horn by the twelfth day, at which time the dental formula was II:3-3/III in three larvae measuring 16.5-17.0 mm. These larvae were not reared beyond the twenty-first day; none had visible hind limb buds and total lengths varied from 18.0-20.0 mm.; at this stage the dental formula was II:3-3/III (9 larvae) or II:4-4/III (1).

A tadpole with toes differentiated but with the web in an early stage (stage XI of Taylor and Kollros) measures 33.0 mm.; one with the web in an intermediate stage of development (stage XIII) 38.0 mm.; a third with fully developed web (stage XIV) 39.0 mm. The labial tooth formula of the first of these is II:4-4/1-1:II, of the other two II:4-4/III.

Larvae of *pardalis* were obtained only in pools at the edge of the Kretam camp clearing—as was also true of *leucomystax* and *otilophus*. Both of these last two species have heavy subspherical bodies and deep tails, characters associated with tadpoles of the pool or pond habitat (Mertens, 1934; Liu, 1950). The only bodies of water around which adults of *leucomystax* and *otilophus* were evident were small pools. The tadpole of *pardalis* has a flatter body and a less deep tail (ratio of tail depth to length 0.266 in *pardalis* as compared to 0.460 in *otilophus* and 0.350 in *leucomystax*). It is thus less specialized in the direction of pool or pond habitation. Although no larvae of *pardalis* were observed in flowing water, that habitat may be utilized by *pardalis*, as both male and female adults were collected in vegetation overhanging a hill stream.

Larvae of all three species of *Rhacophorus* were found living together. Ecological distinction between these tadpoles, other than that suggested in the preceding paragraph, can be made. With respect to their feeding behavior in the field laboratory, the three species fall into a linear sequence. As soon as meat—usually dead tadpoles or bits of prawn—was placed in a container of *otilophus*, it was attacked at once by many larvae. When similar food was put in a container of *leucomystax*, varying intervals elapsed before it was fed upon, although it was eaten. In the case of *pardalis* meat was usually ignored. It seems reasonable to assume that these differences

—at least that between *pardalis* and the other two—in behavior would carry over into the natural habitat and that, therefore, *pardalis* probably does not compete with the others for food. On the contrary, *pardalis* might under certain circumstances—as in the case of weak individuals—be preyed upon by *otilophus* and *leucomystax*. The beaks of the three species vary in association with the feeding behavior, those of *otilophus* being strongest and those of *pardalis* weakest. The difference between *otilophus* and *leucomystax* in this regard is not as great as that between *leucomystax* and *pardalis*.

The following key will aid in identifying the three species of *Rhacophorus* tadpoles.

Papillae continuous around border of lower lip; a black bar between the eyes, one in front of each eye, and two black spots below each eye. *pardalis*.

Papillae interrupted at center of lower lip; no black markings on head.

Usually innermost tooth-row of lower lip narrowly interrupted; advanced larvae with three to five dark crossbars on thighs. *leucomystax*.

Usually innermost tooth-row of lower lip continuous; advanced larvae with five to seven dark crossbars on thighs. *otilophus*.

Locality.—Kinabatangan District, near mouth of Kretam Kechil River (12 adults, 35 larvae).

Smith (1931) has reported *pardalis* from Kina Balu.

***Rhacophorus appendiculatus appendiculatus* Günther**

Polypedates appendiculatus Günther, 1858, Cat. Batr. Sal. Brit. Mus., p. 79
—Philippine Islands.

Rhacophorus appendiculatus appendiculatus Wolf, 1936, Bull. Raffles Mus., no. 12, p. 161.

Seventeen males with vocal sacs and nuptial pads vary from 29.6 to 34.1 mm., snout to vent (mean, 31.79 ± 0.26 mm.).

Locality.—Sandakan District, Mile 8, Sandakan (17).

Mocquard (1890) reported *appendiculatus* from “North Borneo.”

***Philautus pictus* Peters**

Ixalus pictus Peters, 1871, Monatsber. Akad. Wiss. Berlin, 1871: 580.

Philautus pictus van Kampen, 1923, Amph. Indo-Aust. Arch., p. 269.

Three adult males with nuptial pads, 31.6–32.4 mm. snout to vent, and one female, 34.0 mm., were found in a water-filled tree hole in a small clearing of the primary forest.

Color (in life) dark chocolate brown to cinnamon above, whitish spots scattered irregularly over back, rows of light spots on edge of

upper eyelid and on canthus, longitudinal light spot on shoulder; row of small light spots on posterior outer edge of arm, one transverse row of spots across upper arm and one across lower arm; disks of two inner fingers white dorsally, those of two outer fingers brown with a white spot at each corner; white spots on legs, some forming transverse rows; disks of two inner toes white dorsally, that of third toe mostly white but with a small central brown triangle, those of two outer toes with white at corners only; iris bicolored, the upper half the same whitish color as the body spots, the lower half chocolate brown; ventral surfaces yellow or cream-colored, immaculate.

Localities.—Kinabatangan District, near mouth of Kretam Kechil River (4). Previously known in North Borneo only from Kina Balu at an elevation of 1000 meters or higher (Smith, 1931).

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