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## A New Species of Toad (*Bufo*) Indigenous to Southern Ceylon

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The small toad *Bufo fergusonii*, described by Boulenger in 1892, from Trivandrum, Travancore, has since been reported from other localities in peninsular India, as well as in Ceylon (Kirtisinghe, 1957). On May 9, 1965, Mr. Vicky Atukorale gave the senior author two preserved toads that he had obtained a few days earlier at Yala, near the southernmost tip of Ceylon. Mr. Atukorale had identified the toads with some doubt as *Bufo fergusonii*. Two days later Mr. Atukorale accompanied us on a trip from Colombo northward to Puttalam on the west coast of Ceylon, where we recorded the mating calls of several species of Anura. Shortly after midnight, on May 12, while we were recording a chorus consisting largely of microhylids, rhacophorids, and ranids in a shallow roadside pool 10 miles north of Puttalam, we heard a short trill that was not readily identified. Owing to the dense vegetation in as well as around the pool, it was difficult to trace the call to its source. When it was located it proved to be a small, rugose toad later identified as *Bufo fergusonii*.

Within the ensuing hour four specimens were obtained that we later compared with those taken at Yala. The toads were similar in size, but we noted differences, particularly in the shape of the parotoid gland. Through the kindness of Miss Alice G. C. Grandison, who lent us the holotype of *Bufo fergusonii* and other specimens in the British Museum

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(Natural History), we were able to make more extensive comparisons. Our investigation revealed that toads resembling those taken near Puttalam are restricted to peninsular India and northern Ceylon, whereas toads like those from Yala are known only from areas near the coast in southeastern and southern Ceylon. We are therefore describing the species represented by these populations, with which we associate the name of our friend Mr. Vicky Atukorale.

### ***Bufo atukoralei*, new species**

**HOLOTYPE:** No. 74290, an adult male in the American Museum of Natural History, taken near the Butturuwa Circuit Bungalow at Yala, Southern Province, Ceylon, early in May, 1965, by Vicky Atukorale.

**DIAGNOSIS:** A small toad similar to *Bufo fergusonii* in size and habitus, but differing from this species in possessing elongated rather than round parotoid glands (figs. 1 and 2). The ratio of the length to the width of the gland in adults and subadults varies from 2.0 to 2.6 in *B. atukoralei*, whereas the ratio for *B. fergusonii* ranges from 0.7 to 1.3 (fig. 5). The shape of the parotoid is correlated with less conspicuous characters; *B. fergusonii* is a more rugose species that attains larger dimensions. Furthermore, the measurements of toads of both sexes in the samples examined reveal that females tend to be larger than males in *B. fergusonii*, as they are in most species of *Bufo*. In contrast, the mean for the snout-to-vent lengths of the males of *B. atukoralei* slightly exceeds that for females.

**DESCRIPTION OF THE HOLOTYPE:** The specimen is an adult male with a snout-to-vent length of 27.5 mm. and a head width of 9.4 mm. The head length, measured from the posterior margin of the tympanum to the end of the snout, is 7.8 mm. The distance from the anterior border of the eye to the end of the snout is 3.2 mm. The head length comprises 29 per cent of the distance from the snout to the vent. Viewed from above the snout terminates in a blunt point; in profile the convexly rounded snout projects above the lower jaw. The interorbital distance is less than one-third of the diameter of the head. The tympanum is round and moderately distinct, and its diameter (1.4 mm.) is half of that of the eye, measured horizontally. The canthus rostralis is distinct, and the canthal ridges extend from the supraorbital crests almost to the end of the snout, where they terminate above and slightly beyond the nostrils, the inner edges of which are scarcely 1.6 mm. apart. The parietal and postorbital crests are approximately as well developed as the supraorbital crests. The parietal ridge is confluent with the anterior end of the parotoid gland, which is irregular in shape (as shown in fig. 2), and nearly twice as long as the distance between the anterior margin of the eye and the

end of the snout. The parotoid glands are 5.5 mm. in length, and each has a maximum width of 2.8 mm.

The fingers are moderately long, the first, second, and fourth being approximately equal in length, whereas the third is nearly twice as long. The subarticular tubercles are moderately well developed, but rounded rather than sharply convex. The tips of the toes are similar to those on the fingers; the third toe is slightly larger than the fifth, and the fourth is much the longest. The three distal phalanges of the fourth toe are free, but the webbing extends to the base of the distal phalanx on the other toes. The inner metatarsal tubercle is more nearly round and slightly shorter than the oval-shaped outer metatarsal tubercle. Spiny tubercles are more pronounced on the inner edge of the tarsals. The length of the tibia is 0.33 of the snout-vent length.

The skin is covered with wartlike tubercles that are less pronounced on the ventral surface than on the dorsum, where they vary in size, particularly at the middle of the body. Under magnification it may be seen that each tubercle is actually a clump of smaller tubercles, the largest of which projects above the others near the center of each group. On the dorsum the central tubercle is cornified and spinelike, whereas on the ventral side the clumps are less elevated, and the central tubercle is neither spinelike nor cornified. Anteriorly there are fewer tubercles in each clump, and on the dorsal surface they are more widely spaced, as they are on the interorbital surface and the eyelids (figs. 1 and 2). Tubercles are present on the sides of the head, except in the loreal concavities. Tubercles with the spinelike cornification are irregularly distributed on the snout, and along the upper lip to the angle of the mouth, with a few at the lower anterior margin of the tympanum. Enlarged tubercles behind and below the level of the tympanum are whitish in color, without the cornification. Similar whitish tubercles are present on the fold of skin that extends from the anterior surface of the femur. The spiny tubercles on the upper surfaces of the limbs are slightly smaller than those on the adjacent portions of the body.

The color of the preserved specimen is grayish brown, with faintly discernible markings. On the head a pale bar extends from the interorbital area onto the anterior portion of the eyelids. There are traces of irregular darker blotches bordering a faint vertebral stripe that widens to form a much lighter, broader streak between the parotoid glands. The light streak is the most conspicuous marking, though vestiges of bars or blotches are discernible on the limbs. The sides of the head are light gray, and a pale gray area extends from the tympanum backward and somewhat downward and onto the forearm. The under surfaces are dingy

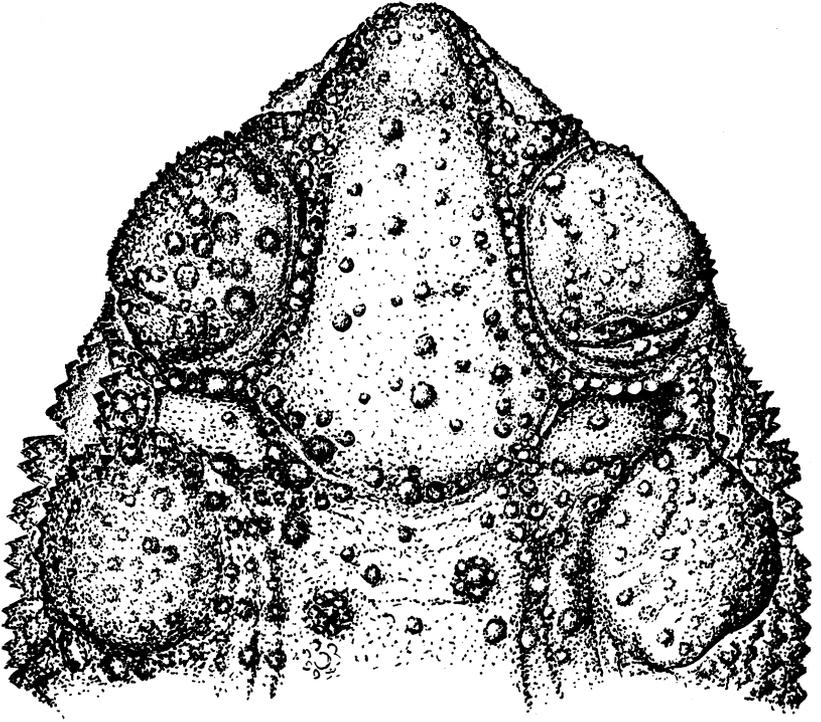


FIG. 1. *Bufo fergusonii*, showing the shape and position of the parotoid glands and other structures on the dorsal surface of the head and anterior portion of the trunk of an adult male (A.M.N.H. No. 74725), obtained 10 miles north of Puttalam, Northwestern Province, Ceylon.  $\times 10$ .

white, mottled with darker spots along the median line of the belly; the spots are larger and more pronounced anteriorly, with a darker area that extends along the posterior portion of the gular sac and onto the pectoral region.

**PARATYPES:** All specimens examined are from localities on the coast of Ceylon. Those designated as paratypes include A.M.N.H. Nos. 75298–75301, from Hikkaduwa, A.M.N.H. Nos. 75296, 75297, from Galle, A.M.N.H. No. 74290, from Yala (type locality), B.M.(N.H.) Nos. 1910.3.16.39–1910.3.16.41, from Hambantota, all in the Southern Province, and B.M. (N.H.) Nos. 1908.72.2.16–1908.72.2.23, from Batticaloa, in the Eastern Province

The paratypes include two individuals from Hambantota, and five from Batticaloa that are possibly immature. They vary from 17.0 to 22.3

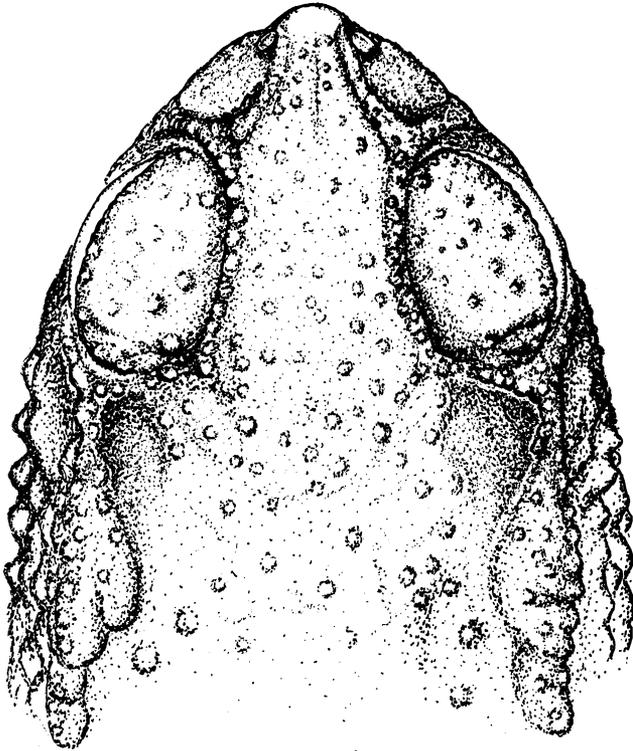


FIG. 2. *Bufo atukoralei*, dorsal surface of the head and anterior portion of the trunk of the holotype, showing the shape and position of the parotoid glands and other structures. Adult male (A.M.N.H. No. 74290), from Yala, Southern Province, Ceylon.  $\times 10$ .

mm. in snout-vent length, though two females from Batticaloa, respectively 26.5 and 26.7 mm. in snout-vent length, had ovulated and hence are definitely sexually mature. Two males, 22.3 and 23.0 mm. in length in the same series, are probably mature, for males from Hikkaduwa that ranged in length from 21.8 to 24.2 mm. were calling when captured on December 28, 1965. One from Hambantota has snout-vent dimensions of 27.0 mm.; one from the type locality is 26.7 mm. in length, the same size as the larger of the two from Galle that were participating in a breeding chorus on December 26, 1965. Nuptial pads are not discernible on any of these specimens, and apparently they do not occur on either species.

Specimens preserved more than half a century ago, though faded and

yellowish in color, still retain vestiges of the pattern observed in the type. The bar that extends across the head and the eyelids, and the pale vertebral blotch, are evident on adults as well as on immature individuals. The parotoid glands are invariably elongated, but they vary somewhat in size and shape, even on opposite sides of the same individual. The length of the parotoid is at least twice its greatest diameter; the ratio of the length to the width varies from 2.1 in females from Hambantota to 2.6 in specimens from Batticaloa (the ratio for the holotype is 2.0, but it is 2.4 on a paratype from the type locality). The ratio of the head width to snout-vent length varies from 0.34 to 0.43, but means for toads of both sexes are 0.37.

COMPARISONS: In addition to the holotype of *Bufo fergusonii*, No. 92.10.5.18, a female from Trivandrum, Kerala ("Travancore"), in the collection of the British Museum (Natural History), we have examined others from the same collection, including one additional specimen from India, No. 1904.4.23.1, a male from Madras, and No. 96.12.15.1, a female from Kalawewa, North Central Province, Ceylon. Two adult males and an immature male, taken 10 miles north of Puttalam, in the Northwestern Province are now Nos. 74274-74276 in the collection of the American Museum of Natural History. The holotype and the male from Madras, respectively 33.7 and 34.7 mm. in snout-vent length, are the largest specimens examined, though Kirtisinghe (1957) has given 46.0 mm. as the maximum size. Perhaps exceptionally large females attain such dimensions in India. P. H. D. H. De Silva (1955b) has given measurements for nine females and one male from Mullaittivu, Northern Province. The male had a snout-vent length of 26.5 mm., which closely approximates the length of males that were calling when found near Puttalam. Adult males of *Bufo fergusonii* range in size from 26.5 to 34.7 mm., whereas the males of *Bufo atukoralei* vary from 21.4 to 27.5 mm. There is an even greater discrepancy in the sizes attained by members of the other sex, for the snout-vent length of the largest females of *B. atukoralei* is less than 27.0 mm., in contrast to the females of *B. fergusonii* that we examined, and the measurements given by De Silva (*supra cit.*) indicate a range of 32.5 to 39.0 mm. in the series from Mullaittivu.

The evidence available, therefore, indicates that the maximum snout-vent length of *B. atukoralei* is scarcely 70 per cent of that attained by *B. fergusonii*. Probably females of the larger species are not sexually mature until they exceed the maximum size attained by females of *B. atukoralei*, but this assumption remains to be verified. Ratios reveal minor variations in proportions, but the most significant differences between the species are those associated with the size and shape of the parotoid gland. Dif-

ferences between species in the snout-vent length of adult toads are not necessarily correlated with differences in body shape, or limb length, as shown by studies of the three species in the *Bufo debilis* group of the United States and Mexico (Bogert, 1962). The proportions are nearly identical in the three North American toads, which differ in pattern, color rugosity, and size, as well as in characteristics of their mating call. The two small species in Ceylon have apparently diverged in somewhat similar fashion, though the most prominent feature that distinguishes the two species is the shape and size of the parotoid. In *B. fergusonii* the ratio of its length to its maximum width varies from 0.7 to 1.3, with a mean of 0.85, whereas the ratio for the elongated gland of *B. atukoralei* varies from 2.0 to 2.6, with a mean of 2.3 (fig. 5). Similar results are obtained if the length of the gland is compared with the snout-vent length of each species (fig. 6). The ratio of the parotoid length to the snout-vent length varies from 0.09 to 0.13, with a mean of 0.11 in *B. fergusonii*, and from 0.16 to 0.24 in *B. atukoralei*, for which the mean is 0.19. The differences are dichotomous, therefore, whether the length of the gland is compared with its width or the snout-vent length. As shown in figures 1 and 2, the spines below the parotoid project more conspicuously on *B. fergusonii* than on *B. atukoralei*, which lacks the clumps of cornified spines.

As may be seen in figure 3, on living individuals of *B. fergusonii* there are vestiges of bars on the limbs, as well as traces of two pairs of dark blotches on the dorsum, and somewhat paler areas in the nuchal region. On preserved specimens the pattern, particularly the white patch in the vertebral region, is more conspicuous in *B. atukoralei*, although similarities are evident. The greater rugosity of the skin of *B. fergusonii* may tend to obscure the pattern, which is perhaps more evident on immature individuals than on adults. The female holotype of *B. fergusonii* is faded, but, as shown in the plate that accompanied the original description (Boulenger, 1892), it had faint traces of markings. The individual depicted by Kirtisinghe (1957) has indistinct bars on the limbs, and a light spot between the parotoids. Also the toad depicted has pale areas flanking the midline posteriorly where black blotches are present on those from near Puttalam.

Apparently the toads of some demes or local populations are much more brightly colored than others. The four specimens of *B. fergusonii* taken north of Puttalam were much alike, with relatively drab colors and little contrast between light and dark areas. The coloration differs little from that shown in the black-and-white photograph reproduced as figure 3. After the specimen had been fixed in formalin and transferred



FIG. 3. Adult male *Bufo fergusonii*, with the dorsal pattern characteristic of living individuals, taken 10 miles north of Puttalam, Northwestern Province, Ceylon. Snout-to-vent length of preserved specimen (A.M.N.H. No. 74274) is 27.8 mm.

to ethyl alcohol, little change in color could be detected. Specimens from Mullaittivu, presumably freshly preserved, were described by De Silva (1955b) as having parotoids that "vary from bright yellow to rusty brown. A distinct yellowish patch is present on each side of head above fore-arm. Arms and legs are striped dark brown. The male is smaller and slender with a dark reddish band from below the base of the paratoid to the groin on each side which, in the females is bright yellow. Throat, chest and belly bright yellow with blackish markings in the male while in the females the colour of these parts varies from pale yellow to white, without the blackish markings."

The venter is dingy white and immaculate on the larger males of *B. fergusonii* taken near Puttalam, but a few black spots are present on the belly of a small male. Dark spots are more often present on males of *B. atukoralei*, particularly on those from the southern extremity of the island. The venter is most heavily pigmented on males taken at Hikkaduwa by



FIG. 4. Adult male of *Bufo atukoralei*, dorsolateral view of paratype photographed shortly after it was captured near Galle, Southern Province, Ceylon. Snout-to-vent length of preserved specimen (A.M.N.H. No. 75296) is 26.7 mm.

the junior author, and the specimens were somewhat smaller and more rugose than those obtained at Galle a few days earlier. The pattern was well defined on those from Galle, one of which is illustrated in figure 4. On the live toad the band across the head from one eyelid to the other was somewhat obscured by yellowish brown mottling. The lateral stripe extending from the tympanum to the groin was olive-brown, and the sharply defined bars on the hind limb were dark brown. The conspicuous pustules bordering the lateral brown stripe were yellowish white. The pale area between the parotoid glands, though present on the preserved specimen, consisted of four pale spots marking the corners of a more or less square light area, the posterior corner of which separated two brown triangular blotches on a light gray background mottled with

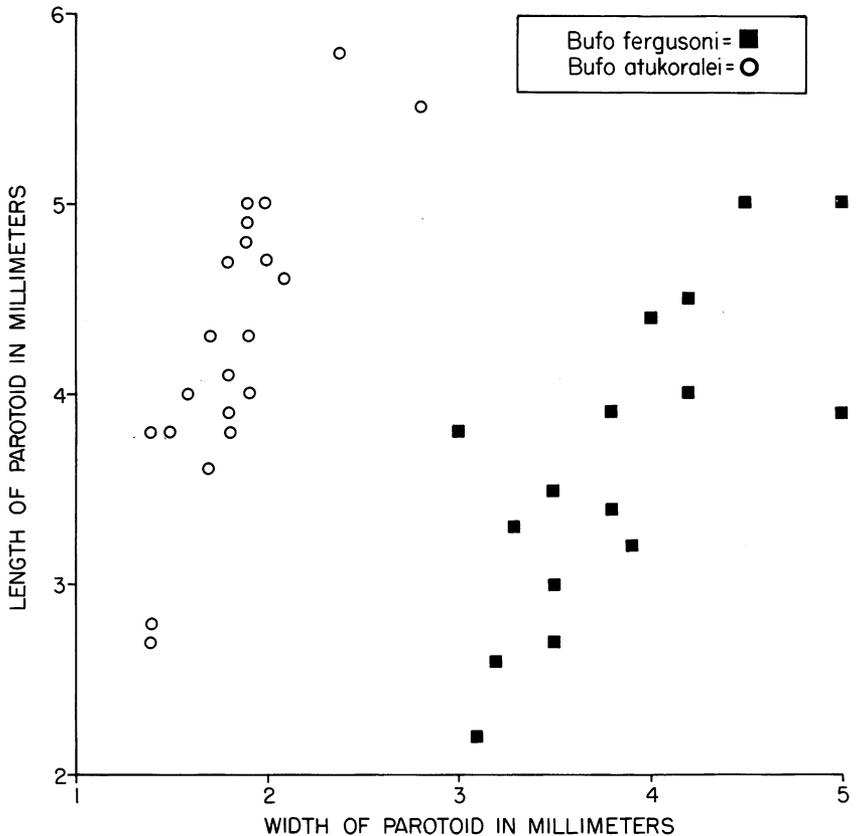


FIG. 5. Relationship of length to width of parotoid glands in *Bufo fergusonii* and *Bufo atukoralei*. Both glands on each individual were not invariably the same. When they differed, dimensions for each side were plotted separately.

yellowish pigment. The paired blotches toward the rear of the dorsum meet on the vertebral line to form a light brown crescentic stripe that extends almost from groin to groin. When the hind limbs were drawn up while the toad was at rest, the crescentic stripe was confluent with the darker bars on the femur and the tibia. When preserved, however, the pattern and colorations of this individual were much the same as those seen on specimens from Yala, or the vestiges of the pattern retained on faded specimens from Batticaloa and Hambantota.

DISTRIBUTIONS: The specimens we have examined indicate that *Bufo atukoralei* is restricted to a narrow belt along the coast of Ceylon, from Batticaloa in the Eastern Province southward around the south end of

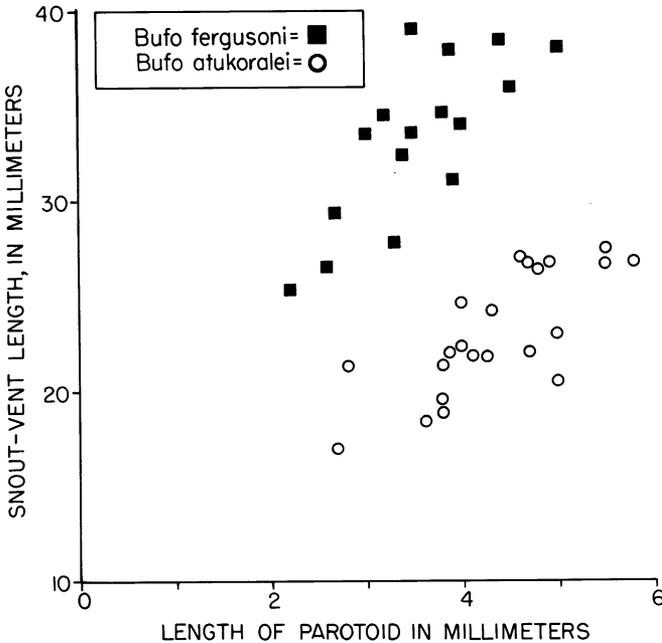


FIG. 6. Relationship of snout-to-vent length to length of parotoid glands in *Bufo fergusonii* and *Bufo atukoralei*. When gland on right differed in length from that on the left, each was plotted separately. Note that maximum snout-to-vent lengths of the toads representing *Bufo atukoralei* closely approximate minimum lengths of those in the sample of *Bufo fergusonii*.

the island and thence northward on the west coast almost to Kalutara in the Western Province.

*Bufo fergusonii* inhabits coastal localities in India and Ceylon, as well as small islands, and it may occur at elevations below 300 meters inland. In addition to the specimens we have examined, namely, the holotype from Trivandrum, the specimens from Madras, those from 10 miles north of Puttalam, and the individual from Kalawewa, the species has been reported by Rao (1915) from the outlying districts of Mysore, Mysore; southern Malabar, and from Nungambakam (a suburb of Madras?), in the state of Madras. In Ceylon *B. fergusonii* has been reported by De Silva (1955a, 1957) from three localities in the Northern Province, Anativu Island off the coast of Jaffna, Tunukkai, and Mullaittivu. Both species were represented in the series examined by De Silva (1955b), but the measurements he gave for the parotoid glands indicate that specimens from Mullaittivu are referable to *fergusoni*. The specimens from Ham-

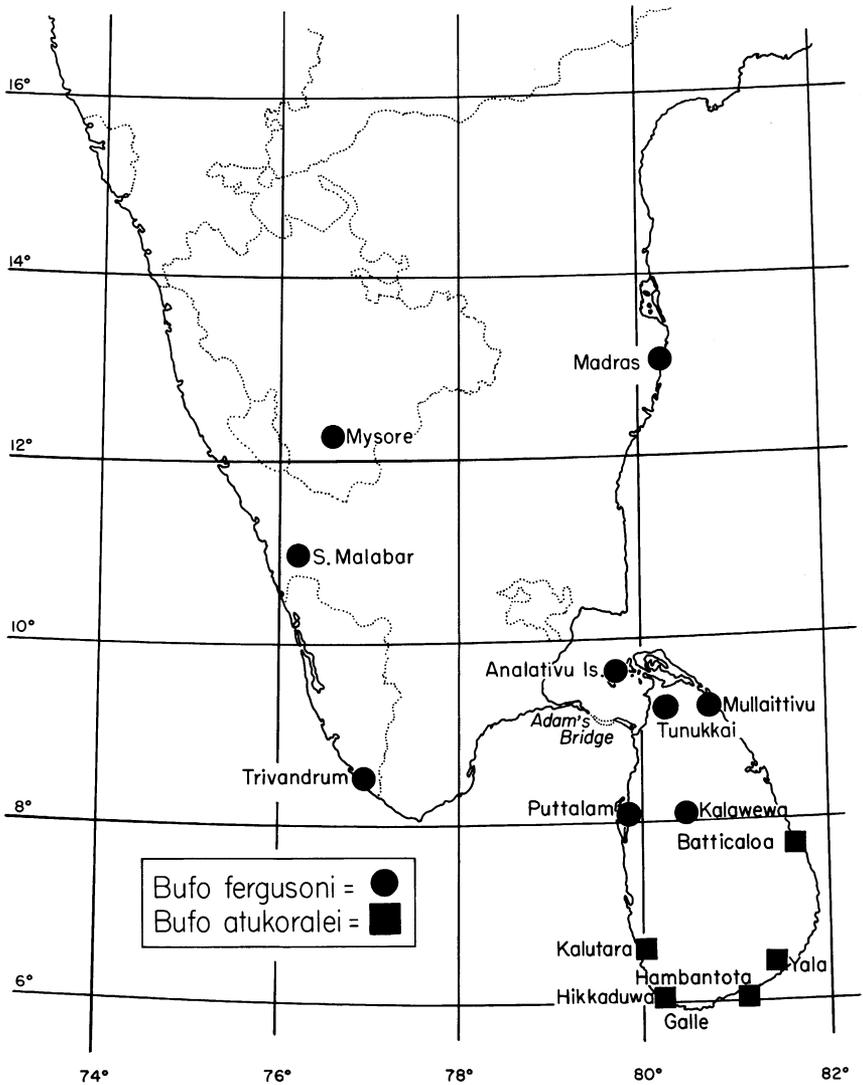


FIG. 7. Locality records for *Bufo fergusonii* in peninsular India and Ceylon, and for *Bufo atukoralei* in southern Ceylon.

bantota and Batticaloa in the British Museum that De Silva referred to *B. fergusonii* are those now designated as paratypes of *B. atukoralei*.

In Ceylon, therefore, the few records of *B. fergusonii* (see map, fig. 7) suggest that it is restricted to the lowlands, from latitude 8° N. north-

ward. The elevated portion of the island lies to the south. The mountains rise somewhat abruptly from the surrounding plains and reach elevations slightly above 2500 meters at the middle of the island, near latitude 7° N. The coastal plain, delimited by the 30-meter contour, is narrowest along the southeastern coast, but it extends nearly 50 kilometers inland in some areas on the southwestern and northeastern coasts. All specimens of *B. atukoralei* have been taken on the coastal plain, and it is uncertain whether *B. fergusonii* actually occurs as far inland as Kalawewa. The species was first reported from Ceylon by Méhely (1897), who had received two specimens supposedly taken at Kalawewa. One of these is now in the British Museum, and there is no question concerning its identity. Many specimens received by museums half a century ago were not documented with precision, however, and until other specimens of this small toad are taken so far from the coastal plain, the record for Kalawewa should be regarded with suspicion. Tunukkai, where De Silva (1955a) reported the species, is roughly 20 kilometers from the coast, but almost at the edge of the coastal plain.

#### HABITS AND HABITAT

The paratypes of *Bufo atukoralei* from Galle were found during a heavy downpour in a fairly acid paddy field nearly 16 kilometers inland. They were calling from a pile of debris near the middle of a stream. Those from Hikkaduwa, which are somewhat smaller, darker, and more rugose, were found in a pool of brackish water within 50 meters of the sea. These dwarf toads do not assemble at spawning sites in large numbers. Breeding aggregations tend to be small, and the males in any assemblage may be scattered or somewhat concentrated, depending on the cover available. Their presence is readily detected by their mating calls, but, unless calls can be traced, the toads are difficult to find, for they seldom venture into the open. Such habits, coupled with their small size and the difficulties entailed in finding them, readily account for their scarcity in collections. It seems probable, moreover, that collectors mistake these dwarf toads for juveniles of the larger, more abundant species of *Bufo*.

Once the collector has become familiar with the mating call of *Bufo atukoralei*, its presence is easily detected in many areas where the species would otherwise be overlooked. After he obtained a representative series of the species at Hikkaduwa on the evening of December 29, 1965, the junior author heard these dwarf toads at several localities along the coast. The species appeared to be prolific and rather continuously distributed along the coast from Galle northward almost to Kalutara. Specimens were obtained near the southern border of the Southwestern Province,

8 kilometers south of Kalutara, but no toads of the species were either heard or found north of this point. Those obtained at Galle and Hikkaduwa were often seen crawling or climbing, but they never leaped. They readily ate termites while being observed in the terrarium where they were kept for several weeks.

The shallow pond where we obtained specimens of *Bufo fergusoni* and recorded their mating calls 10 miles north of Puttalam on May 12, 1965, was situated near a large slab of concrete that apparently had once

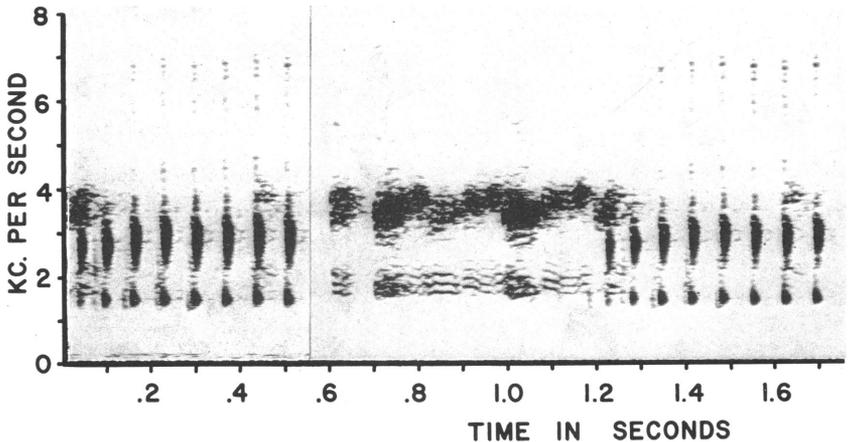


FIG. 8. Sound spectrogram of mating call of *Bufo fergusoni* recorded 10 miles north of Puttalam on May 12, 1965, at air temperatures of 25.6° C. Spectrogram encompasses two calls issued by *B. fergusoni* at an interval exceeding that shown on time scale. Several calls of *Rana limnocharis* precede the second call on the spectrogram.

served as the floor of a hut. The small toads were restricted to the vicinity of this slab of concrete, and we suspect that most of them had emerged from sanctuaries beneath it. Any more or less impervious object on the surface that tends to conserve moisture in the sandy alluvial soil characteristic of the area would be advantageous to small, terrestrial amphibians that burrow beneath the surface to escape desiccation during periods of drought. Fewer than 10 toads were calling at this site, but breeding activity may have reached its peak in the area four or five days earlier. Stations south of Puttalam reported precipitation exceeding 350 mm. for the two-day period of May 7 and 8, when a storm brought heavy rains to all portions of the southwest coast.

The toads obtained near the concrete slab were placed on a narrow ledge along the foundation of the house while they were being photo-

graphed the morning following their capture. They attempted to climb the plaster-covered wall on the inner side of the ledge, but displayed no inclination to leap from the ledge to the ground. Rao (1915) has reported that *Bufo fergusoni* in India "burrows with great ease in loose earth and feeds almost exclusively on termites." Rao added, "It does not touch black ants, small beetles and earthworms which form the staple food of bigger toads like *Bufo melanostictus*." Perhaps the ants and the beetles had obnoxious qualities in the region where Rao observed the behavior of these toads. The stomach contents of one toad taken near Puttalam consisted largely of ants, although the metallic blue elytra of two small beetles were also present. The stomach of another contained termites, a few ants, and portions of other insects not readily identified.

Rao's statement that *Bufo fergusoni* "does not utter the plaintive metallic cry of the Indian Toad [*Bufo melanostictus*]" is somewhat ambiguous, but probably he did not intend to imply that the smaller toad was voiceless. We obtained recordings of *Bufo fergusoni* near Puttalam, but unfortunately we have not yet recorded the call of *Bufo atukoralei*. Spectrograms of the mating call of *B. fergusoni* (fig. 8) reveal that its call consists of a short trill, 0.5 second in duration when air temperatures were 25.6° C. Each trill consists of eight uniformly spaced pulsations, of which the first two are somewhat weaker in volume than those that follow. Individual males issued the short trill at irregular intervals. The dominant frequency is approximately 3000 cycles per second.

#### LEVEL OF DIVERGENCE

Neither of these small toads has been reported from a wide area on the southwestern coast of Ceylon, although the fauna in the vicinity of Colombo has been intensively studied by naturalists residing in the area. As noted above, the junior author has recently found *Bufo atukoralei* some 50 kilometers south of Colombo, near Kalutara. Kalutara and Colombo are within the wet zone where there are no "dry months" and the annual rainfall exceeds 1995 mm. The nearest record for *Bufo fergusoni* is nearly 100 kilometers north of Colombo, at Puttalam. This is within the Dry Zone, which was defined by Cooray (1948) as having an effective rainfall for no more than 10 months of the year, and less than 1995 mm. annually. Three of the localities where *B. atukoralei* has been taken (Batticaloa, Yala, and Hambantota) are within the area mapped as Dry Zone, but Galle and Hikkaduwa are in the Wet Zone, as defined by Cooray.

Although *B. fergusoni* has been reported only from the Dry Zone, there are no records of the species south of Mullaittivu on the northeast coast.

Probably the species occurs farther south, but it remains to be ascertained where it is replaced by *B. atukoralei*, currently unknown north of Batticaloa. The nearest records for the two species are separated by a distance of nearly 200 kilometers. The coastal plain is not interrupted between Mullaittivu and Batticaloa, and no marked change in ecological conditions is apparent in the intervening area. It seems probable that the ranges of both species will be extended, but it is conjectural whether annectant populations will be discovered. If distributions prove to be more or less continuous, there may be a gradual transition from one population to the next. Conceivably but improbably, field studies will reveal populations comprised of toads with parotoid glands intermediate in shape. Toads with round parotoids may be abruptly replaced geographically by smaller toads with elongate parotoids, and their distributions may be mutually exclusive. Or field investigations may show that the species occur sympatrically in a narrow zone where there is some overlap in distributions. Under such conditions any of several isolating mechanisms may discourage interbreeding, but hybridization commonly occurs among toads in zones of sympatry when the difference in size is no greater than it is between *B. fergusoni* and *B. atukoralei*.

Until the requisite investigations are carried out, uncertainties remain. The information now available suggests that *Bufo atukoralei* has reached the species level in its degree of divergence. The toads are sufficiently alike, however, to leave little doubt that they share the same ancestor. Nevertheless, it is relatively certain that at some stage during their evolution interbreeding was limited, if not curtailed. Otherwise two relatively homogeneous assemblages of toads would not have become so well differentiated. It is pertinent to note that the populations in peninsular India are somewhat larger but otherwise almost identical with those in northern Ceylon, despite the effective barrier that precludes any gene exchange between toads in the two areas.

Ceylon is separated from the mainland by nearly 40 kilometers of open sea at Palk Strait, to the west of Analativu Island, where *Bufo fergusoni* has been reported by De Silva (1957). Roughly 50 kilometers to the southwest of Analativu there is an almost continuous chain of islands known as Adam's Bridge which links Mannar Island on the coast of Ceylon with Pamban Island that juts out from the mainland. Under present conditions the gaps in Adam's Bridge are too great to afford an amphibian a means of dispersal, though *Bufo fergusoni* perhaps survives on some of these islands, as it does on Analativu. Jaffna Peninsula and the adjacent islands undoubtedly comprised part of the land bridge that sporadically connected Ceylon with the mainland.

Several species of vertebrates are endemic to Ceylon, but many others, including *Bufo fergusonii*, have apparently gained access to the island so recently that they are scarcely distinguishable morphologically from populations on the mainland. The differentiation of *Bufo atukoralei* is readily explained, however, if it be assumed that the ancestors of the two species reached Ceylon before it became an island. Geologists consider Ceylon to be part of the vast Dekkan Plateau of southern India, which is probably one of the oldest land masses extant. Deraniyagala (1949) believed that Ceylon was connected with India until sometime during Miocene times. The progenitors of many of the species now endemic in Ceylon presumably began to diverge from those on the mainland at that time. The duration of the period of isolation has not been ascertained, but in some instances the nearest relatives of Ceylonese populations had disappeared on the mainland before the island first became re-connected with the mainland at some time during the Pleistocene. As Deraniyagala noted, vertebrates migrated in both directions whenever there was a connection.

If the ancestors of the small toads had gained access to the peninsula prior to Miocene times, the progenitors of *B. atukoralei* were perhaps well established and widely distributed before they were cut off from those on the mainland. Divergence initiated during the Miocene may have continued for several million years before Ceylon was again temporarily connected with the mainland. Meanwhile, if the toads on the mainland had become adapted to seasonal fluctuations in rainfall, they were perhaps better suited to conditions on the northern portion of the erstwhile peninsula than the progenitors of *Bufo atukoralei* that had occupied the area while it was isolated from the mainland. If so, *Bufo fergusonii* may have supplanted the populations at the north end of the peninsula, whereas to the south populations on the coastal plains on each side of the mountains continued to survive and become the progenitors of *Bufo atukoralei*. The smaller toad obviously tolerates conditions in the Wet Zone, though it may be less well adapted than *B. fergusonii* to withstand drought. As a result the distributions of the two species have remained mutually exclusive on the island.

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