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A New Species of Frog (Genus Rana, Subgenus Paa) from Northern Pakistan (Amphibia, Anura)

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ABSTRACT—A new species of *Rana* (*Paa*) from the Hazara Division, northern Pakistan, is described. The relationships of this species within the subgenus *Paa* are discussed, and the occurrence of two other species of this subgenus in Pakistan is outlined.

* * *

In view of the important works recently devoted to the study of the Amphibians of Pakistan (Minton, 1966; Mertens, 1969; Khan, 1976), it is surprising that a new species should be discovered in the northern part of this country. The new species was found in the Hazara Division, which has its peculiar topography, vegetation and waterways and differs very markedly from the surrounding areas. We therefore propose to give this new form the name

Rana (Paa) hazarensis sp. nov.

Holotype.—MNHN 1978.3056, adult male, collected near Datta, northern Pakistan (Manshera District, Hazara Division, 34°15'N 73°15'E, elevation about 1200 m) (Fig. 1), on 15 June 1978, by M. S. Khan.

Paratypes.—MNHN 1978.3057-3064, 4 adult males and 4 adult females, and BMNH 1978.795, MHNG 1597.19, SMF 69579, FMNH 207872, AMNH 102457, USNM 210132, 6 adult females, same collection data as the holotype; MNHN 1978.3065, an adult female, from the same locality, collected on 6 August 1972 by M. S. Khan.

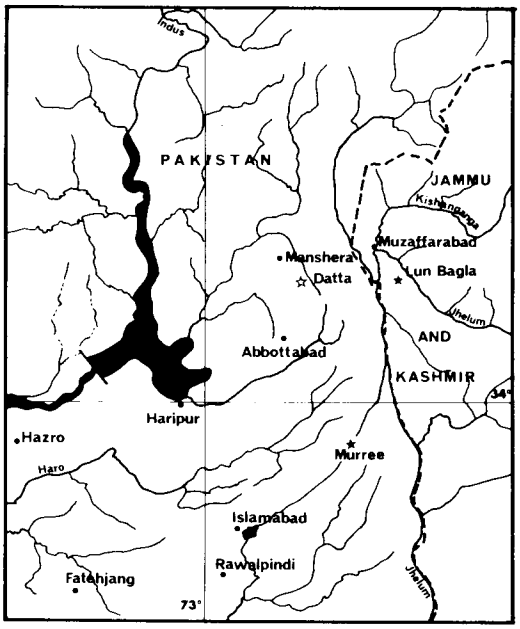

FIGURE 1. Map of northern Pakistan and neighboring areas, showing the type-locality of *Rana (Paa) hazarensis* sp. nov. (Datta), the type-locality of *Rana (Paa) vicina* Stoliczka (Murree) and another locality where this latter species was found (Lun Bagla).

DESCRIPTION OF THE HOLOTYPE
Figures 2 to 6

(In order to facilitate comparisons, the same plan has been used for this description as for previous descriptions of related species (Dubois, 1976, 1977a).)

Adult male (snout-vent length: 55.7 mm).

Head longer (20.8 mm) than wide (19.8 mm). Snout rounded, slightly projecting beyond the mouth, much longer (9.0 mm) than horizontal diameter of eye (6.0 mm). Canthus rostralis rounded, loreal region strongly concave. Distance between nostrils (5.3 mm) greater than width of upper eyelid (4.2 mm), itself greater than interorbital width (3.7 mm). Nostril as close to tip of snout as to eye (4.3

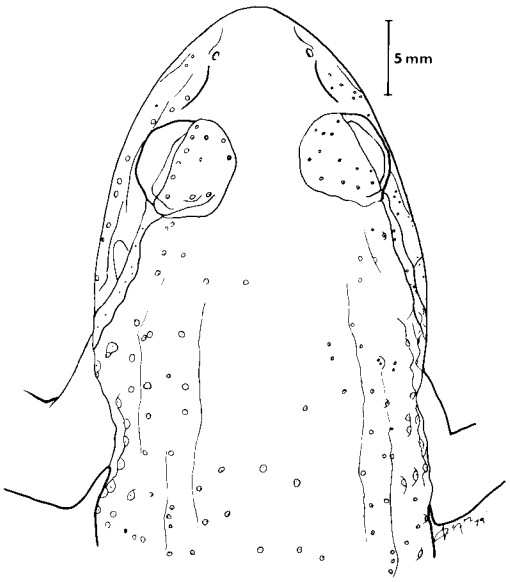

FIGURE 2. Dorsal view of the anterior part of the body.

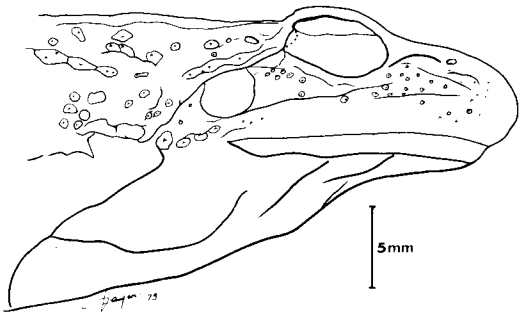

FIGURE 3. Lateral view of the head.

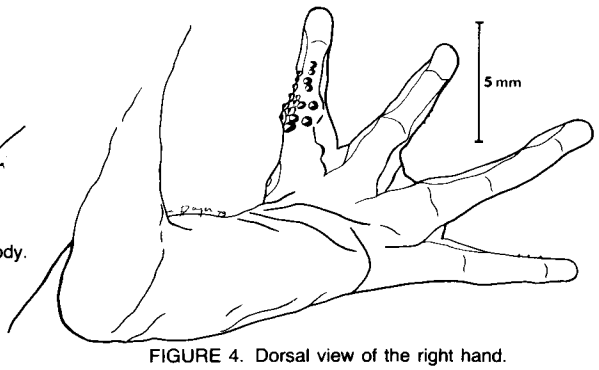

FIGURE 4. Dorsal view of the right hand.

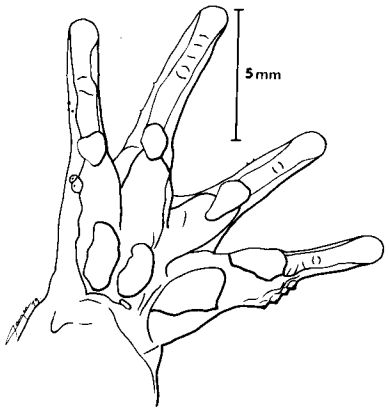

FIGURE 5. Ventral view of the right hand.

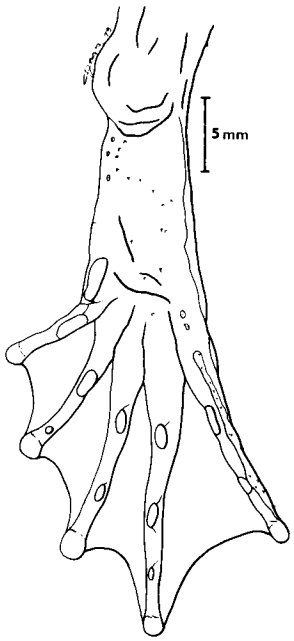

FIGURE 6. Ventral view of the right foot.

FIGURE 2 to 6. *Rana (Paa) hazarensis* sp. now., holotype.

mm), slightly oval with a small fleshy expansion of hind part. Tympanum more or less rounded, greatest (vertical) diameter (3.4 mm) greater than distance to eye (2.9 mm). Presence of a small vestige of pineal ocellus. Vomerine teeth in two short series of 4 and 3 teeth, almost perpendicular to axis of body, closer to each other than to choanae, longer than distance between them. Maxillary teeth well developed. Tongue wide, granular, notched behind. Supra-tympanic folds present, although not very prominent, from eye to behind jaws' commissure.

Fingers slender, third longer than fourth, fourth slightly longer than first, first slightly longer than second. A distinct groove present on upper surface of fingers at junction between penultimate and last phalanx. Tips of fingers rounded, flattened on upper surface, very slightly swollen on lower

surface. Dermal borders present along the internal and external sides of all fingers, larger at their base, connecting between fingers (like a small web). Proximal subarticular tubercles of fingers prominent, longer than wide, particularly long on first finger (Table 1); no distal tubercle. Internal metacarpal tubercle prominent, longer (3.5 mm) than wide (2.1 mm); two palmar tubercles, moderately prominent, longer than wide.

TABLE 1. *Rana (Paa) hazarensis* sp. nov., holotype. Measurements of the right hand (in millimeters).

		Finger			
		I	II	III	IV
Width of the finger tip		1.1	1.2	1.2	1.2
Proximal subarticular tubercle	Length	2.3	1.9	1.4	1.3
	Width	1.2	1.1	1.0	0.9

Hind limbs moderately long, rather strong. Tibiotarsal articulation to nostril; heels overlapping very slightly when limbs folded at right angles to body. Leg less than three times as long (27.8 mm) as wide (9.8 mm), a little longer than thigh (27.4 mm), much longer than distance from base of internal metatarsal tubercle to tip of fourth toe (25.5 mm). Toes rather long, fourth longer (13.9 mm) than one third of distance from base of tarsus to tip of fourth toe (36.7 mm). Tips of toes swollen, wider than subarticular tubercles of toes (Table 2), devoid of any groove between the upper and lower surfaces. External metatarsals separated by web. Webbing complete, reaching tips of all toes and not incurved between them. A dermal fringe along first toe, from tip to metatarsal tubercle; another one along fifth toe, from its tip to about middle of its metatarsal. Subarticular tubercles of toes very prominent, longer than wide (Table 2). Internal metatarsal tubercle prominent, three times longer (3.5 mm) than wide (1.2 mm), length roughly equal to that of metatarsal of first toe (3.4 mm), less than half length of first toe (7.5 mm). No external metatarsal tubercle. No tarsal fold.

TABLE 2. *Rana (Paa) hazarensis* sp. nov., holotype. Measurements of the right foot (in millimeters).

		Toe				
		I	II	III	IV	V
Width of the swollen toe tip		1.3	1.5	1.5	1.5	1.5
Proximal subarticular tubercle	Length	2.2	2.1	1.8	1.4	1.8
	Width	0.9	0.8	0.8	0.7	0.7
Second subarticular tubercle	Length	—	—	1.1	1.7	1.1
	Width	—	—	0.5	0.9	0.8
Third subarticular tubercle	Length	—	—	—	0.7	—
	Width	—	—	—	0.6	—

Skin of upper and lateral parts of body and of limbs covered with numerous small warts showing small horny spinules at their tip; such spinules also present on upper and lateral parts of head, rare on median anterior third of back; latter smoother than rest of body. No latero-dorsal folds, but some warts in a line at the place of such folds, especially in anterior part of back. Skin of lower parts of body, head and limbs smooth.

Upper parts greyish superimposed with a network of darker color (dark olive green in life). A clear grey transverse band on back of head, joining posterior borders of eyelids. Lateral edge of supratympanic fold and canthus rostralis dark. Upper parts of hind limbs with dark crossbars; hinder parts of thighs with a network of small blackish spots. Lower parts of body and limbs whitish; throat mottled with grey. Webbing of feet greyish.

Male secondary sex characters.—Fore limbs distinctly enlarged ventrally. Small blackish horny nuptial spines on internal metacarpal tubercle and on first finger of both hands (Table 4). An opening of internal vocal sac on both sides of mouth floor, rather posteriorly.

SEX DIMORPHISM

Measurements of the 5 adult males and 11 adult females of the type-series indicate the existence of only one significant difference in the body proportions of both sexes (Table 3): females have a proportionally wider head than males. The data seem also to indicate that females are of a greater mean size than males, that the tibia and the head are proportionally longer in females than in males, and that, although in both sexes the head is always longer than wide, the ratio head width/head length is lower in males than in females; these differences are of a lesser magnitude

TABLE 3. Variation and sex dimorphism in the body proportions of *Rana (Paa) hazarensis* sp. nov., based on the measurements of 5 adult males and 11 adult females.

Sex	Range	Mean	Standard deviation	V[1]	RE[2]	Median	U[3]	P
			Snout-vent length (in millimeters)					
♂	47.4–60.5	52.7	4.98	9.45	1.28	52.4	15	> 0.10
♀	48.5–65.5	57.2	5.76	10.07	1.35	56.0		
			Head width (in thousandths of snout-vent length)					
♂	331–368	349	13.5	3.88	1.11	354	7	0.02*
♀	359–377	366	5.4	1.49	1.05	366		
			Head length (in thousandths of snout-vent length)					
♂	361–387	373	8.5	2.27	1.07	373	16	> 0.10
♀	364–396	380	9.1	2.39	1.09	379		
			Ratio head width/head length (in thousandths)					
♂	882–955	934	27.4	2.94	1.08	951	10	> 0.05
♀	923–990	963	18.0	1.87	1.07	963		
			Tibia length (in thousandths of snout-vent length)					
♂	466–499	484	12.0	2.48	1.07	489	12	0.10
♀	471–529	501	15.2	3.03	1.12	506		

[1]V = variation coefficient = 100 σ/m.
[2]RE = "ratio of extremes" = maximum value observed/minimum value observed (Dubois, 1976:36).
[3]Comparisons of males and females by mean of the Mann-Whitney U test (Siegel, 1956).
*Difference significant (two-tailed test).

TABLE 4. Number of nuptial spines on the hands of four adult males of *Rana (Paa) hazarensis* sp. nov.

Specimen number	Snout-vent length (mm)	Hand	Number of spines: Metacarpal tubercle	Number of spines: First finger
MNHN 1978.3057	60.5	Left	2	26
		Right	3	27
MNHN 1978.3056	55.7	Left	2	23
		Right	2	21
MNHN 1978.3058	52.4	Left	2	23
		Right	2	22
MNHN 1978.3059	47.4	Left	1	19
		Right	1	23

than the first one noted above, and do not appear statistically significant on the base of the small numbers of specimens available, but greater series might well prove these differences, or some of them, also to be real.

The five adult males examined exhibit bilateral openings of vocal sacs on the sides of the mouth floor. One of them (MNHN 1978.3060, snout-vent length 47.6 mm) is devoid of nuptial spines on the hands, while the other four do possess such spines: the number of spines is 1 to 3 on the metacarpal tubercle and 19 to 27 on the first finger (Table 4). No spines are present on the other fingers, nor on the fore arms, nor on the breast. Smaller spinules, similar to those of the upper parts of the body, are sometimes present on the external side of some fingers and also on the palm of the hand, but such spinules can also be found in females. In breeding males, the fore limb is distinctly swollen ventrally.

VARIATION

The type-series is very homogeneous. A slight variation may however be observed in the extent of webbing (in some specimens the web is very slightly incurved between the tips of the toes). The distribution and abundance of warts and spines on the upper parts of the body is also subjected to a little variation; in all specimens the skin of the anterior part of the back is smoother than on the rest of the back. In all specimens of both sexes the throat is mottled with dark spots. In most specimens a greyish longitudinal band with indistinct limits is present on the flanks, starting from above the insertion of the arm and extending down to the hind leg or near it.

For the estimation of the amount of variability in the body proportions, the same two indexes were used as in a previous work on the central himalayan species of the subgenus *Paa* (Dubois, 1976): the variation coefficient V and the "ratio of extremes" RE. In both sexes these two indexes have a rather low value (Tables 3 and 5). Among the eight central himalayan species studied (Dubois, 1976: 213), only two, *Rana blanfordii* and *Rana ercepeae,* show mean values of these

indexes as low as or lower than in *Rana hazarensis*. The low variability of this species may however be in part an artifact due to the fact that the specimens examined all do come from a single population, which was not the case for the central himalayan species studied.

INTERNAL CHARACTERS

The female MNHN 1978.3063 has been summarily dissected: the nasal bones are of a rather large size, but well separated from each other and from the frontoparietals; the scapular girdle is typical firmisternial, with an entire omosternum, as observed in other species of *Paa* (Dubois, 1975).

The right testicle of the male MNHN 1978.3060 is white, granular and of a large size, also typical of the subgenus *Paa* (Dubois, 1975).

Most of the females collected in August 1978 were in full breeding condition. The right ovary of the female MNHN 1978.3064 (snout-vent length 59.7 mm) was removed; it contained 353 ripe eggs of a general cream-whitish color, except for a small blackish area at the animal pole. If we assume that the number of eggs is roughly the same in both ovaries (see Dubois, 1975), the total number of ripe eggs of this female appears to be about 700. The diameter of the vitellus of ten eggs is 1.83 to 2.08 mm (mean 1.98 mm).

TABLE 5. Variability in the body proportions of *Rana (Paa) hazarensis* sp. nov., based on the five biometrical criteria and the values of Table 3.

Index of variability	Sex	Range	Mean
V	♂	2.27– 9.45	4.20
	♀	1.49–10.07	3.77
	♂ + ♀	1.49–10.07	3.99
RE	♂	1.07– 1.28	1.12
	♀	1.05– 1.35	1.14
	♂ + ♀	1.05– 1.35	1.13

TADPOLES

Five tadpoles (MNHN 1978.3066-3070) were collected with the adults near Datta on 15 June 1978. Different developmental stages from 25 to 42 of Gosner's (1960) table are represented in this small collection. The detail of the stages, tooth-rows formulae, and principal measurements of these tadpoles are given in Table 6.

TABLE 6. Principal characteristics of five tadpoles of *Rana (Paa) hazarensis* sp. nov. (staging according to Gosner, 1960).

Stage	Tooth-rows formula	Total length (mm)	Body length (mm)	Depth of caudal muscle (mm)	Total depth of tail (mm)
25	1:5+5/1+1:2	38.4	13.7	3.5	7.0
36	1:6+6/1+1:2	65.3	21.4	7.2	12.2
40	1:7+7/1+1:2	74.0	24.4	7.7	13.8
40	1:7+7/1+1:2	75.2	25.0	7.5	14.1
42	1:7+7/1+1:2	76.8	25.3	7.5	13.8

These tadpoles are characterized by a very large size, among the largest in the subgenus *Paa* (see Dubois, 1976). Their general coloration is clear, with small dark spots mainly on the tail and also, less abundant, on the back. Their caudal muscle is well developed, much more than the tail fin.

The oral disk is large, bordered, except on the major part of the upper lip, with a row of small papillae, which is doubled interiorly by a second irregular row on the lower lip. Quite numerous papillae (roughly 10 to 20) are present at the lips commissure. The beak is bordered with very small teeth; its anterior part is blackish, and incurved in its middle; its posterior part is blackish in its anterior half only, whitish behind. The number of rows of horny labial teeth on the upper lip is very high for the subgenus (6 to 8).

Rana minica and *Rana sikimensis* are the only two other known species of *Paa* of the *Rana liebigii* supergroup the tadpoles of which may exhibit as high a number of tooth-rows on the upper lip as 8, and also present more than a few papillae at the lips commissure (see Dubois, 1976). The tadpole of *Rana hazarensis* may be distinguished from those of these two species mainly by its much greater size, the greater development of its caudal muscle and its clearer coloration.

ECOLOGICAL NOTES

The new species was discovered in small torrents running in deep gorges in the region of Datta, which lies 11 miles from Abbottabad and 4 miles from Manshera, 2.5 miles off the main road towards East, in the plain of Rsh (Fig. 1). Apart from the new species, the amphibian fauna of this region consists of *Bufo stomaticus, Bufo melanostictus* (rare), *Microhyla ornata, Rana (Euphlyctis) c. cyanophlyctis, Rana (Euphlyctis) t. tigerina* and *Rana (Tomopterna) breviceps.*

Rana (Paa) hazarensis was found in pools of clear water in the beds of deeply embanked torrents. These pools extend under large rocks so as to form spacious recesses, often about 1 to 1.5 meters wide and 1 meter deep; they contain water even during the dry season (May-June). Adults of the new species were found during the afternoon sitting on the shore of these pools; when disturbed, they would dive into the water and hide themselves under the stones lying on the bottom. Tadpoles were found swimming in the same pools as the adults. No pairing nor eggs were observed. On one occasion, the call of a male was heard: it was a low grunt uttered in short series; the male was sitting outside the pool, facing water. It is not known whether this was a mating call or not. Breeding in this species might start with the first rains of the summer, in June; among the specimens collected at mid-June, most of the females were full of ripe eggs and the males had nuptial spines on the hands. The advanced tadpoles which were present in the pools at the same date might possibly have developed from eggs deposited the preceding year.

In the deep pools where *Rana hazarensis* was collected, no other amphibian species was seen. *Bufo stomaticus, Rana cyanophlyctis* and *Rana breviceps* were found pairing in shallow pools along the torrent beds. A single specimen of *Rana hazarensis* was found in a large open pool where many *Rana cyanophlyctis* were in breeding activity, in a region where the torrent was not deeply embanked, but such an occurrence seems rather unusual for this species.

DISCUSSION

Even more than its discovery, the morphology of the new species is unexpected: it is quite different from all the other known species of *Paa*, and the relationships of the species are difficult to ascertain.

In lacking a tarsal fold, the new species agrees, within the subgenus *Paa,* with the species of the *Rana liebigii* supergroup (Dubois, 1976:24; 1977a:990). However it disagrees with all or most of them (see Dubois, 1976) in several other important features: first finger longer than the second (instead of being as long as or shorter than it); dermal fringe along fifth toe extending to the middle of the metatarsal (instead of stopping at the level of the first metatarsal tubercle); webbing complete (instead of being more or less incurved between the tips of the toes); hind legs much shorter than in all the other known species of the supergroup; hind legs apparently longer in females than in males (instead of being as long as or shorter than in them).

Rana hazarensis occupies therefore a quite isolated position among the species of *Paa* devoid of a tarsal fold. Within this group however, the species the most closely related to it seems to be *Rana minica* (see Dubois (1976) for a detailed description of this species); both species lack a latero-dorsal fold but have the upper parts of the body covered with warts and spinules; the general aspect and coloration of adults are similar; the tadpoles of both species are quite similar. The rather close relationship of these two species here suggested is supported by the biogeographical data, since both are present in the western Himalayas. While the distribution of *Rana hazarensis* outside its type-locality is presently unknown, *Rana minica* is known to be present at least from Himachal Pradesh to western Nepal (Dubois, 1976, 1979). It should however be stressed that, even if *Rana minica* is the closest living relative of *Rana hazarensis*, these two species exhibit strong differences: *R. hazarensis* is of a much greater size than *R. minica*; the relative proportions of the head are very different in both species (see Dubois, 1976); the tibia of *R. minica*, although among the shortest within the *R. liebigii* supergroup, is much longer than in *R. hazarensis*; *R. minica* has the most reduced webbing of all the supergroup, while *R. hazarensis* has the most complete; the male secondary sex characters of *R. hazarensis* seem to be less developed than those of *R. minica*.

Regarding this last point, it is still uncertain whether the males of *Rana hazarensis* found near Datta in June 1978 were in full breeding condition, but the fact that most of the females collected were full of ripe eggs supports this hypothesis. If this is true, then the male of *Rana hazarensis*, with nuptial spines only on the first finger and on the metacarpal tubercle, would exhibit a rather weak development of secondary sex characters as compared to most of the species of the subgenus *Paa*—although not as weak as in *Rana sikimensis* (see Dubois, 1976) or *Rana vicina* (see Dubois, 1979). *Rana hazarensis* is also characterized by rather unusual eggs for the subgenus: the eggs obtained by dissection of a mature female are distinctly smaller and more numerous than in nine other species of *Paa* previously studied in this respect (Dubois 1975:1104). The very important male secondary sex characters and the large size and low number of the eggs, which are the most noteworthy characteristics of the subgenus *Paa,* are both considered to be adaptive features related to breeding in swiftly running torrents (Dubois, 1975). Therefore the loss or reduction of these characteristics might well be an indication of a change in ecology, and possibly in breeding behavior, egg deposition site, etc. The present evidence is that *Rana hazarensis* is rather a species of clear water pools in the beds of torrents than a truly torrent species as other species of *Paa*. This point will have to be confirmed by further field studies, including the male mating call and its comparison with those of central himalayan species of *Paa* (Dubois, 1977b, 1977c), breeding behavior, etc.

The discovery of *Rana hazarensis* adds a third species of *Paa* to the amphibian fauna of Pakistan. The other two species are *Rana sternosignata* and *Rana vicina. Rana sternosignata,* often reported from Pakistan (Murray, 1885; Loveridge, 1959; Minton, 1962, 1966; Mertens, 1969; Khan, 1976), is a very peculiar species of the *Rana spinosa* supergroup, which seems to be quite closely related to *Rana phrynoides* from northern Indochina and southern China (Dubois, in preparation). As for *Rana vicina,* this species was described by Stoliczka (1872) on the basis of a single specimen from Murree, but never reported later, except for specimens wrongly identified (see Dubois, 1976). However, recent collection in Jammu and Kashmir and in Himachal Pradesh have shown it to be a valid species, closely related to *Rana liebigii* and widely distributed in the western Himalayas (Dubois, 1979). Apart from the type-specimen from Murree, a second specimen is known from northern Pakistan, namely a young frog (SMF 64483) from Lun Bagla, at the border between Pakistan and Azad Kashmir, which was reported by Mertens (1969) under the name *Rana pleskei* but was later shown to belong to the *Rana liebigii* group (Dubois, 1976:273). It is thus clear that *Rana vicina,* which was omitted by recent compilers of lists of the amphibians of Pakistan (Minton, 1966; Mertens, 1969; Khan, 1976), is part of the fauna of this country.

APPENDIX: MUSEUM ACRONYMS

AMNH = American Museum of Natural History, New York; BMNH = British Museum (Natural History), London; FMNH = Field Museum of Natural History, Chicago; MHNG = Muséum d'Histoire naturelle, Genève; MNHN = Muséum national d'Histoire naturelle, Paris; SMF = Senckenberg Museum, Frankfurt; USNM = National Museum of Natural History, Washington.

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