

Taxonomy and Biogeography of *Kaloula* Species of Eastern India

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ABSTRACT.— Four species of *Kaloula* have been reported from the Republic of India, and eastern India harbours all three recognized mainland species, namely, *K. assamensis*, *K. pulchra*, and *k. taprobanica*. This study reveals that the north-east Indian population of *Kaloula taprobanica* is a variant form of the nominal species. This variant and *K. assamensis* show overlap at their eastern and western limits of distribution, respectively. The distribution patterns indicate that Brahmaputra river acts as barrier to dispersal of *Kaloula* species in eastern India.

KEY WORDS: *Kaloula*, eastern India, distribution, barrier

INTRODUCTION

The genus *Kaloula* Gray, 1831 (Anura: Microhylidae) is pan Asian in distribution (range: Korea and northern China to the Lesser Sundas and the Philippines, Bangladesh, India, and Sri Lanka) and is represented by 15 nominal species (Das et al. 2004, Diesmos et al., 2002; Iskandar and Colijn, 2000; Dutta, 1997). The following characters considered diagnostic for the genus (see Parker, 1934; Inger, 1966): subarticular tubercles enlarged; and bony ridge along posterior border of each choana. Additional characters that are typical of the genus and frequently used to diagnose

Kaloula from other genera of microhylidae include: tongue oval, free posteriorly; tips of fingers expanded into truncate disks; toes webbed; finger I shorter than finger II; no spine-like dermal projections at heel or elbow; belly lacking brown network on yellow background; snout short; inner metatarsal tubercle shovel-shaped; clavicles absent; prevomers undivided; sternum large, cartilaginous; and a small, cartilaginous omosternum.

In India, four species of *Kaloula* have been reported (Chanda 2002, Das et al. 2004, Cherchi 1954). However, much confusion prevails regarding the distribution and status of *K. pulchra* and *K. taprobanica* (see Schleich and Kästle 2002). Although Parker (1934) considered these the latter as a subspecies of *K. pulchra*, which was later elevated to the status of species (Dutta and

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Manamendra-Arachchi 1996), in many of the earlier publications (Sarkar et al. 1992, Deuti and Bharati-Goswami 1995, Chanda 2002, Kanamadi et al. 2002), these two taxa have been referred under the nomen *Kaloula pulchra*, with a distribution from Sri Lanka to

south-east Asia. In this paper, we have examined populations of all three east Indian *Kaloula* species to evaluate the status and distribution of species occurring in this region.

TABLE 1. Measurement ratio of different morphological parameters of *Kaloula* species

Species	SVL	HL:SVL	HL:HW	SL:HL	SL:SVL	EN:NS	EN:SL	EN:HL	ED:HL	ED:SL
<i>K. taprobanica</i> (ZSIC A3867)	55.48	0.33	0.78	0.29	0.097	1.46	0.65	0.19	0.31	1.06
<i>K. taprobanica</i> (ZSIC A7976)	40.1	0.29	0.81	0.33	0.096	2.79	0.87	0.29	0.28	0.84
<i>K. taprobanica</i> (ZSIC A5599)	58.85	0.29	0.87	0.33	0.094	1.82	0.66	0.21	0.3	0.93
<i>K. taprobanica</i> (ZSIC A7975)	44.28	0.22	0.6	0.6	0.13	1.83	0.65	0.39	0.45	0.75
<i>K. taprobanica</i> (AVCM A0902)	51.7	0.23	0.94	0.49	0.11	1.47	0.56	0.28	0.42	0.85
<i>K. taprobanica</i> (AVCM A0903)	49.5	0.22	0.71	0.57	0.13	2.13	0.5	0.28	0.45	0.8
<i>K. taprobanica</i> (AVCM A0904)	56.5	0.22	0.73	0.48	0.11	1.47	0.61	0.3	0.45	0.93
<i>K. taprobanica</i> (AVCM A0905)	49.25	0.22	0.69	0.44	0.09	2.03	0.66	0.29	0.39	0.88
<i>K. taprobanica</i> (AVCM A0906)	53.2	0.2	0.65	0.44	0.1	1.57	0.57	0.28	0.5	0.98
<i>K. taprobanica</i> (AVCM A0907)	51.6	0.21	0.78	0.252	0.11	1.77	0.61	0.32	0.34	0.65
<i>K. taprobanica</i> (AVCM A0909)	40.3	0.22	0.75	0.61	0.14	1.71	0.59	0.36	0.45	0.8
<i>K. taprobanica</i> (AVCM A0910)	48.45	0.21	0.61	0.46	0.09	1.76	0.74	0.34	0.47	1.02
<i>K. taprobanica</i> (AVCM A0911)	45.5	0.2	0.68	0.51	0.1	2.13	0.71	0.36	0.42	0.82
<i>K. taprobanica</i> (AVCM A0912)	44.8	0.23	0.71	0.43	0.1	1.72	0.63	0.24	0.34	0.8
<i>K. taprobanica</i> (AVCM A0913)	46.75	0.24	0.74	0.44	0.1	1.68	0.66	0.29	0.41	0.94
<i>K. taprobanica</i> (AVCM A0914)	43.45	0.26	0.82	0.48	0.11	1.68	0.7	0.28	0.39	0.97
<i>K. taprobanica</i> (Katemiaghat)	52.58	0.23	0.66	0.66	0.15	4.28	0.79	0.53	0.49	0.73
<i>K. aff. taprobanica</i> (AVCM A0566)	35.5	0.21	0.61	0.5	0.11	1.6	0.59	0.3	0.58	1.16
<i>K. aff. taprobanica</i> (AVCM A0567)	34.5	0.23	0.73	0.45	0.1	1.6	0.69	0.31	0.55	1.21
<i>K. pulchra</i> (AVCM A0705)	61.85	0.2	0.65	0.61	0.12	1.52	0.52	0.32	0.56	0.91
<i>K. pulchra</i> (AVCM A0707)	73	0.22	0.65	0.48	0.11	1.04	0.49	0.23	0.45	0.93
<i>K. pulchra</i> (AVCM A0706)	65.25	0.24	0.68	0.46	0.11	1.11	0.49	0.22	0.46	1.01
<i>K. assamensis</i> (AVCM A0491)	42	0.23	0.79	0.58	0.13	1.4	0.57	0.33	0.51	0.86
<i>K. assamensis</i> (AVCM A0372)	43.05	0.23	0.69	0.57	0.13	1.35	0.56	0.32	0.43	0.76
<i>K. assamensis</i> (AVCM A0672)	52.2	0.2	0.68	0.45	0.09	1.74	0.56	0.25	0.54	1.2

TABLE 1. Continues

Species	ED:SVL	ED:EN	INS:IOS	HAND:FLL	IMC:HAND	LEG:SVL	TBL:SVL	T4:TBL	IMT:TBL	IMT:T4	IMT:OMT	TBL:TBW
<i>K. taprobatica</i> (ZSIC A3867)	0.1	1.64	0.45	0.51	0.16	1.13	0.23	1.51	0.29	0.19	2.27	1.1
<i>K. taprobatica</i> (ZSIC A7976)	0.08	0.97	0.65	0.51	0.16	1.09	0.34	1.12	0.22	0.2	2.3	3.08
<i>K. taprobatica</i> (ZSIC A5599)	0.09	1.41	0.6	0.61	0.16	1.14	0.33	1.14	0.16	0.14	1.88	2.55
<i>K. taprobatica</i> (ZSIC A7975)	0.1	1.16	0.58	0.41	0.16	1.18	0.35	1.22	0.19	0.15	1.78	2.62
<i>K. taprobatica</i> AVCM (A0902)	0.1	1.52	0.49	0.49	0.21	1.2	0.33	0.91	0.18	0.19	2.14	2.61
<i>K. taprobatica</i> AVCM (A0903)	0.1	1.61	0.7	0.5	0.2	1.08	0.31	1.19	0.23	0.19	1.78	2.83
<i>K. taprobatica</i> AVCM (A0904)	0.1	1.52	0.64	0.52	0.17	1.03	0.31	1.15	0.18	0.16	1.63	2.44
<i>K. taprobatica</i> AVCM (A0905)	0.08	1.34	0.72	0.63	0.16	1.06	0.29	1.24	0.17	0.13	1.6	2.3
<i>K. taprobatica</i> AVCM (A0906)	0.1	1.8	0.65	0.5	0.19	1.1	0.31	1.3	0.2	0.17	1.67	2.2
<i>K. taprobatica</i> AVCM (A0907)	0.07	1.06	0.74	0.56	0.19	0.99	0.28	1.36	0.22	0.16	2.21	2.6
<i>K. taprobatica</i> AVCM (A0909)	0.1	1.25	0.68	0.48	0.19	0.97	0.3	1.3	0.21	0.16	1.65	2.26
<i>K. taprobatica</i> AVCM (A0910)	0.1	1.39	0.71	0.7	0.17	1.01	0.3	1.27	0.2	0.16	1.93	2.72
<i>K. taprobatica</i> AVCM (A0911)	0.1	1.15	0.58	0.45	0.17	1.01	0.28	1.28	0.18	0.14	1.7	2.15
<i>K. taprobatica</i> AVCM (A0912)	0.08	1.27	0.68	0.71	0.19	1.01	0.28	1.33	0.24	0.18	2	2.48
<i>K. taprobatica</i> AVCM (A0913)	0.1	1.42	0.73	0.55	0.13	1.11	0.31	1.29	0.18	0.14	1.89	2.8
<i>K. taprobatica</i> AVCM (A0914)	0.1	1.38	0.71	0.45	0.13	1.17	0.32	1.27	0.21	0.16	2.07	2.87
<i>K. taprobatica</i> (Katemiaghut)	0.11	0.92	0.64	0.53	0.23	0.99	0.37	1.1	0.19	0.17	1.7	2.82
<i>K. aff. taprobatica</i> (AVCM A0566)	0.12	1.96	0.63	0.53	0.17	1.09	0.25	1.59	0.25	0.16	1.67	1.89
<i>K. aff. taprobatica</i> (AVCM A0567)	0.12	1.76	0.73	0.62	0.1	1.07	0.26	1.54	0.24	0.16	1.69	2.04
<i>K. pulchra</i> (AVCM A0705)	0.11	1.76	0.63	0.49	0.18	1.29	0.35	1.36	0.2	0.15	2.05	2.74
<i>K. pulchra</i> (AVCM A0707)	0.1	1.92	0.67	0.51	0.17	1.06	0.28	1.33	0.24	0.18	1.6	2.09
<i>K. pulchra</i> (AVCM A0706)	0.11	2.04	0.69	0.57	0.18	1.15	0.31	1.28	0.23	0.18	1.69	2.1
<i>K. assamensis</i> (AVCM A0491)	0.12	1.52	0.75	0.47	0.21	1.15	0.35	1.23	0.18	0.15	1.86	2.94
<i>K. assamensis</i> (AVCM A0372)	0.1	1.35	0.68	0.48	0.16	1.21	0.3	1.43	0.16	0.11	1.24	2.35
<i>K. assamensis</i> (AVCM A0672)	0.11	2.15	0.6	0.47	0.16	1.07	0.27	1.48	0.2	0.12	1.3	1.88

MATERIALS AND METHODS

We collected specimens of *Kaloula* from the states of Assam and Orissa in India, and materials were deposited in the Arya Vidyapeeth College Museum (AVCM). Voucher specimens were examined in the Zoological Survey of India, Kolkata (ZSIC), Zoological Survey of India, Eastern Regional Station, Shillong (ZSIS), Pachunga University College (PUC), Mizoram, and Mizoram University (MU) museum. Measurements for each specimen were taken with a dial vernier caliper to the nearest 0.01 mm. The following measurements were taken: Snout vent length (SVL: from tip of the snout to vent), Head length (HL: from the angle of the jaw to the tip of the snout), Head width (HW: width of the head at the level of the angle of the jaw), Eye to nostril distance (EN: distance between anterior point of the eye and the nostril), Nostril to snout distance (NS: distance from the nostril to the tip of the snout), Internarial space (INS: distance between the two nostrils), Interorbital space (IOS: minimum distance between the upper eyelids), Snout length (SL: from the anterior corner of the eye to the tip of the snout), Eye diameter (ED: Distance from posterior corner to the anterior corner of the eye), Forelimb length (FLL: distance from the posterior edge of the forelimbs at its insertion to the tip of the longest finger), Length of the Inner metacarpal tubercle (IMC: greatest length of the inner metacarpal tubercle), Leg length (LEG: distance from insertion to the tip of the longest toe of the hind limb), Tibia length (TBL: Distance between the surface of the knee to the surface of the heel, with both tibia and tarsus flexed), Tibia width (TBW: Greatest width of the tibia at any point of its length), Fourth toe length (T4: from base of fourth phalange to the tip), Inner metatarsal tubercle (IMT: greatest length of

the inner metatarsal tubercle), Outer metatarsal tubercle (OMT: greatest length of the outer metatarsal tubercle). The webbing formula used here follows Savage and Heyer (1997). Further, collection details of the specimens studied were noted to project the distribution of each species. Principle Component Analysis was done with 16 component variables using BioDiversity Professional version 2.

RESULTS

The present study reveals the presence of three species of *Kaloula*, *K. assamensis*, *K. pulchra*, and *K. taprobanica* in northeast India. Measurements of these species are provided in Table 1.

Kaloula assamensis (Fig. 1) is a medium size frog (SVL 52.20 mm). Snout about half of the head length; upper eyelid width smaller than snout length and inter-orbital space; eye diameter smaller than snout length; tympanum hidden, a strong tympanic fold. Fingers free, tips dilated, sub articular tubercles prominent, relative finger length $F_3 > F_4 > F_2 > F_1$. Toes webbed, tips slightly rounded, relative toe length $T_4 > T_3 > T_5 > T_2 > T_1$, toe web formula $I_{1\frac{1}{2}-2} II_{1\frac{1}{2}-2\frac{1}{2}} III_{1\frac{1}{2}-2} IV_{2-1\frac{1}{2}} V$. Supernumerary tubercles present at the base of each digit of the manus; an inner pointed metatarsal tubercle and a smaller round outer metatarsal tubercle; inner metatarsal tubercle longer than the first toe.

Colour.— Dorsally dark brown with a dark edged yellow vertebral stripe, commencing from snout tip and ending near the vent; a dark bordered broad orange brown stripe on either lateral side, extending from the post ocular region to the inguinal region. A light pericloacal ring present. Venter light yellowish orange.

Locality and habitat.— *Kaloula assamensis* has been reported in the original description of Das et al. (2004) to be collected from- agricultural (*Brassica* sp.) fields, beneath herbaceous moist vegetations in Majbat (26° 45' N, 92° 20' E); from a herbaceous plant ca. 0.3 m above substrate at 1830 hrs in Nameri National Park (26° 56' N, 92° 52' E); blades of grass (*Saccharum* sp.) at 1 m above substrate in

Orang National Park (26° 30' N, 92° 15' E); a fern within a waterlogged area, while sitting at a height of ca. 0.6 m above substrate, at 1920 hrs in Pakhui National Park (26° 55' N, 92° 51' E). One individual was also recorded from Sirajuli (26° 41' N, 92° 11' E), beneath herbaceous vegetation. This species was found only during the months of June and July.



FIGURE 1. *Kaloula assamensis* (AVCM A0049)

Kaloula pulchra (Fig. 2) is a large microhylid frog (SVL 73.00 mm). Snout approximately 50% of the head length and slightly longer than the eye diameter; upper eyelid width almost equal to the internarial space but smaller than the interorbital space; eye smaller than the snout. Tympanum hidden, a weak tympanic fold. Fingers free, tips truncated; relative finger length $F_3 > F_4 > F_2 > F_1$. Toe tips round, relative toe length $T_4 > T_3 > T_5 > T_2 > T_1$; Toe web formula $I_1 - I_{1\frac{1}{2}-2} III_{1\frac{1}{2}-3} IV_{3-1} V$. A strong shovel shaped inner metatarsal tubercle and a small round

outer metatarsal tubercle; inner metatarsal tubercle much smaller than the first toe. Tibiotarsal articulation reaches the shoulder.

Colour.— Dorsum dark brown; a yellowish orange dorsolateral band on either side, extending from the back of the eye to the groin, which is bright yellow in sub adults and whitish in juveniles. Venter yellowish white, however, individuals from Meghalaya State with brownish venter has also been reported (S. Mahony pers com.). Dorsal skin rough, ventral granular.

Locality records and habitat.— In Southern Assam district of Cachar *K. pulchra* is recorded from Barkhola (24° 55' N, 92° 44' E), Bihara (24° 57' N, 92° 39' E), Naraincherra (24° 58' N, 92° 44' E), Marucherra (24° 58' N, 92° 46' E), Chotorampur (24° 57' N, 92° 46' E). From Karimganj district this species was recorded from Dohali, Badsahi Tilla, Patharia, Tilbhum, Longai RF. In Mizoram State, we recorded the species from Shimmui (23° 43' N, 92° 44' E), LED picnic spot and ITI waterfall (23° 43' N, 92° 44' E) areas, all

around Aizwal city. Pawar and Birand (2001) recorded the species from primary and secondary forested habitats of Dampa Tiger Reserve (23° 20'-23° 04' N, 92° 15'-92° 30' E), Nengpui Wildlife Sanctuary (22° 21'-22° 30' N, 92° 45'-92° 50' E) and Palak Lake (22° 14' N, 92° 53' E). In Tripura State, the sole locality for the species is Jampui Hills (Vanghmun Village, 23° 58' N, 92° 16' E) where it was encountered near a forest trail (S. Mahony, pers comm.)



FIGURE 2. *Kaloula pulchra* (AVCM A0707)

The habitat of *K. pulchra* was recorded to be water logged paddy fields, swampy areas at degraded evergreen forest edges, in ponds with extensive aquatic vegetation, and around human habitation. During April-June, calling aggregations of *Kaloula pulchra* were recorded from swampy or temporary waterlogged areas in and around human habitations as well as from forest edges. This species was often encountered in herbaceous vegetations and also on tree trunk between

0.3–1 m above ground level. Individuals were also recorded from tree holes at a height of ca. 2.5 m. One individual was seen at 3 m height while climbing a tree during a heavy shower.

Males of *K. pulchra* start calling from April, during both day and night hours. No calling activities were recorded after June though individuals (both males and females) were encountered in the habitat.

Kaloula taprobanica is a moderate size frog (SVL 59.4 mm). Snout short about 30% of the head length, slightly longer than the eye diameter; nostril closer to the snout tip; interorbital space larger than the upper eye lid; tympanum hidden, a weak tympanic fold. Fingers free, with truncated discs that are about two times as wide as the penultimate phalange; relative finger length $F_3 > F_4 > F_2 > F_1$. Toes with truncated tips, toe web $I_{1-1} II_{1/2-2} III_{1/2-3} IV_{3-1} V$; relative toe length $T_4 > T_3 > T_5 > T_2 > T_1$. A strong compressed shovel shaped inner metatarsal tubercle and an oval small outer metatarsal tubercle; inner metatarsal tubercle much smaller than the first toe. Tibiotarsal articulation reaching to the level of the armpit.

Colour.— Dark median area flanked by yellowish red dorsolateral bands; an interorbital bar of the same colour. The median area fenestrated by large irregular shaped markings of yellow-red colour. Both bands and markings bordered by dark colour. Venter pale yellow spotted with dark brown or black.

Locality record and habitat.— Two individuals (Figs. 1, 2) were collected from Santinagar (26° 25' N, 90° 16' E) of Kokrajhar district, Assam during the present study. One individual was recorded from a garden adjacent to human habitations and another from a marshy area between railway tract and highway between 19 hrs to 19.30 hrs (IST) on the same day. Besides specimens from different localities of Orissa [Vitarkanika (AVCM A0902- A0907), Thakurmunda (AVCM A0908, A0910, A0912 – A0914), Balangir (AVCM A0909) and Konarak (AVCM A0910)], Karnataka [Lukunda (ZSIC A5599)], West Bengal [Howrah (ZSIC A7975 & A7976)] and Madhya Pradesh [Jabalpur (ZSIC A3867)] were also studied.

DISCUSSION

In Orissa, *K. taprobanica* was commonly encountered in dry deciduous forest, inhabiting tree holes between 1-4 m above ground. This species was also encountered in a tree hole in mangrove swamp at Bhitarkanika Wildlife Sanctuary. In the dry deciduous forest of Behrempur district, Orissa, one individual was encountered inside a *Ficus* tree hole (at 1.5 m height) near a hill stream. In Central Orissa, this species was recorded from near human habitation where juveniles were recorded during January at Bhitarkanika. In Puri district, *K. taprobanica* was recorded from a *Casuarina* forest perching on a *Ficus* tree at 1 m height. According to Schleich and Kästle (2002), *K. taprobanica* was a semi arboreal frog and were recorded up to 6 m above ground level. In West Bengal, Sarkar et al. (1992) also recorded the species from 1.5 m above ground.

The specimens collected from Santinagar area of Kokrajhar district (AVCM A0566 & A0567) have small body size (SVL 35.5 mm). Snout about 50% of the head length, distinctly smaller than the eye diameter. Finger tips dilated, toe tips round. Toe web formula $I_{1/2-2} II_{2-3} III_{2-4} IV_{4-2} V$. Dorsal colour similar to the typical form, however, marking colour may be bright orange (AVCM A0567) or dull yellow (AVCM A0566) (Figs. 3, 4). The venter mottled with dark brown. PCA reveals that *Kaloula assamensis*, *K. taprobanica* and *K. pulchra* are three distinct populations (Fig. 6) and the specimens from Kokrajhar is probably a sub-population of *K. taprobanica*. Due to similarity in colour pattern we have placed provisionally these two collections affiliated to *Kaloula taprobanica*. Parker (1934) observed that the general characters of *K. taprobanica*, particularly digital disc size, proportion of

the toes and interdigital webbing, are similar to *K. baleata*; the colour pattern appeared to offer reliable diagnostic character.



FIGURE 3. *Kaloula taprobanica* (AVCM A0567)



FIGURE 4. *Kaloula taprobanica* (AVCM A0566)

Based on the present study a key to the species of *Kaloula* of Assam has been developed as follows:

- i. Inner metatarsal tubercle larger than first toe.....iii
- ii. Inner metatarsal tubercle smaller than first toe.....iv
- iii. Medium size, snout about half of the head length, strong tympanic fold, toe web $I_{1\frac{1}{2}-2}II_{1\frac{1}{2}-2\frac{1}{2}}III_{1\frac{1}{2}-2}IV_{2-1\frac{1}{2}}V$. a dark edged yellow vertebral stripe.....*K. assamensis*
- iv. Large size, snout about half of the head length, weak tympanic fold, toe web $I_{1\frac{1}{2}-2}II_{1\frac{1}{2}-2\frac{1}{2}}III_{1\frac{1}{2}-2}IV_{2-1\frac{1}{2}}V$. Dorsum dark brown, without any markings; a yellowish orange dorsolateral band on either side.....*K. pulchra*

Medium size, snout about one third of the head length, distinct tympanic fold; toe web $I_{1\frac{1}{2}-2}II_{1\frac{1}{2}-2\frac{1}{2}}III_{1\frac{1}{2}-2}IV_{2-1\frac{1}{2}}V$. Dorsum dark brown median area fenestrated by large irregular shaped markings of yellow-red colour; broken yellowish red dosolateral band on either side.....*K. taprobanica*

Kaloula assamensis has been reported from four localities in the state of Assam and one each in the state of Arunachal Pradesh and West Bengal (Das et al., 2004, Talukdar et al., 2007 and Paul et al., 2007). We recorded the species from Nameri National Park, 26° 56' N, 92° 52' E; ca. 140 m a.s.l.). The global distribution of the species seems to be restricted to the north bank of the Brahmaputra from 92° 52' N 89° 25' E.

K. pulchra is widespread in south-east Asia and in north-east India, reported from Meghalaya (Horoo et al., 2002), Tripura

(Sarkar et al., 2002, S. Mahony *pers. com.*), Mizoram (Sailo et al., 2005) and Assam (Dey and Gupta 2000). In the present study it was further reported from Barail range, Southern Assam and Mizoram. The Meghalaya Plateau and Mizoram appears to form the western limits to its distribution in India (Fig. 2). The distribution of *K. pulchra*, reported in various literatures (Sekar, 1991, Nayak et al., 1993), from southern India to Bengal and also to western India probably refer to another species of the genus (*K. taprobanica*). The eastern most limit of distribution of the species reported so far is 90° 38' E. A single specimen (collected, photographed, examined and released) from Katerinaghat (28° 20.243' N, 81° 07.855' E; 128 m asl) showed colouration similar to *K. assamensis* (Fig. 5), morphometrical similarity to *K. taprobanica* but with different web formula ($I_{\frac{1}{2}-1}II_{\frac{1}{2}-2}III_{2-2}IV_{2\frac{1}{2}-\frac{1}{2}}V$). Due to paucity of sample, we could not ascertain its status and suggest further study of this population.

Kaloula taprobanica is endemic to Sri Lanka through Penisular India up to the north-eastern part of Indian subcontinent (West Bengal and Bangladesh) (Kirtisinghe, 1957, Biju, 2001, Schleich and Kästle, 2002, Daniels, 2004). Dutta (1997) reported the presence of this species from north of Tinsukia, however, repeated surveys in the areas failed to reveal the presence of the species. We consider the distribution of *K. taprobanica* as reported by Dutta (1997) as doubtful and requires further examination of the specimen and locality mentioned. Annandale (1917) recorded that the specimens from Calcutta (Kolkata) had bright red markings on their backs instead of dull yellowish seen in Malayan populations of *K. pulchra*. Parker (1934) reported an intermediate form between *Kaloula pulchra*

and *Kaloula taprobanica* from Calcutta, in which the webbing of the toes is similar to the typical form (*K. pulchra*) but the colour pattern is that of the Ceylon (Sri Lanka) species (*K. taprobanica*). Similar observations were also made by Romer (1949) who also opined that since the geographic range of both *K. pulchra* and *K. taprobanica* extends to Bengal [present day West Bengal (India) and Bangladesh],

intermediate forms in Bengal are not to be unexpected. However, the range of occurrence of such a form may be interesting in understanding biogeography. In the present study specimens from Howrah (near Kolkata) (ZSIC A7975-76) do not show any marked variation from the typical *K. taprobanica*.



FIGURE 5. *Kaloula* species of Katerinaghat, Uttar Pradesh, India (not collected)

Dutta and Manamendra-Arachchi (1996) opined that *Kaloula taprobanica* from Sri Lanka is similar to the populations that occur in southern and north-eastern India and differs from those of south-east Asia in dorsal markings and size. Probably the authors referred to either the intermediate form affiliated to *K. taprobanica*, as suggested in this communication, or to *K.*

assamensis for the north-eastern Indian population of *K. taprobanica*. *K. pulchra* is definitely the south-east Asian form referred by the authors (mention type locality). This species has wide distribution in central and southern northeast India.

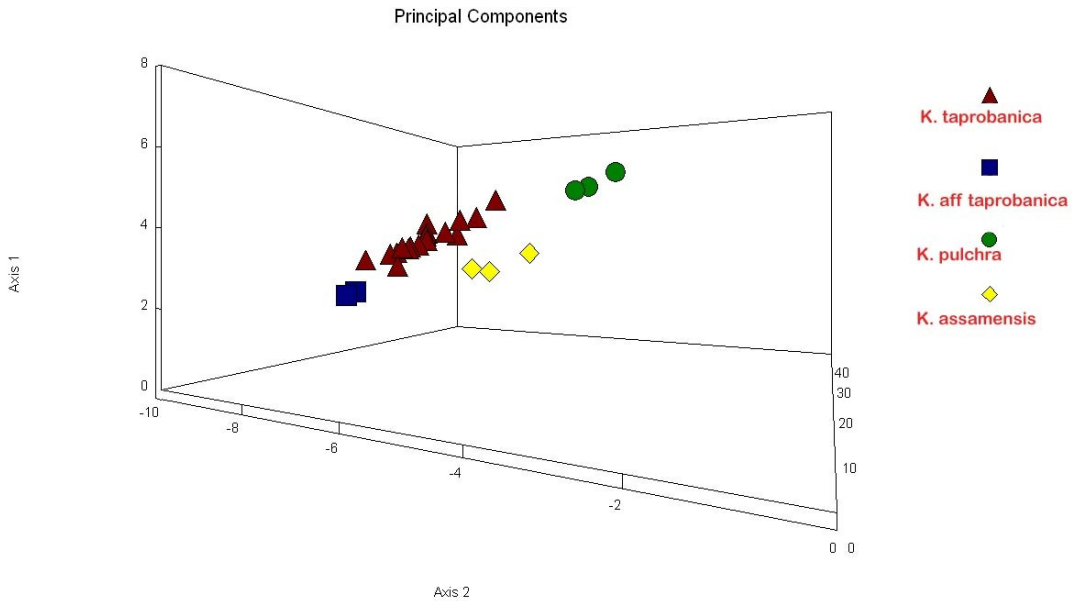


FIGURE 6. Principal Component Analysis of *Kaloula* species

The present study suggests that $90^{\circ} 25'$ E longitude is the eastern limit of distribution of *K. taprobanica*; and *K. taprobanica* and *K. assamensis* overlap each other at their eastern and western limits of distribution respectively. *K. assamensis* is so far known to be restricted to the localities north of river Brahmaputra and the localities are close to Indo-Bhutan Border, thus this species may occur in low elevation areas of Bhutan. Reza and Mahony (2007) reported *Kaloula taprobanica* from Madhupur National Park, Mymensingh District (Bangladesh, $24^{\circ} 41'$ N, $90^{\circ} 08'$ E). This locality, together with that of western Assam (Kokrajhar district) is characterized by the dominance of sal forest (*Shorea robusta*). Further, *Kaloula pulchra* has been reported from Lawachara National Park, north-eastern Bangladesh ($24^{\circ} 19'$ N, $91^{\circ} 47'$ E, A.H.M. Ali Reza

pers. comm.) which, on the other hand, is an evergreen forest patch adjacent to southern Assam and Mizoram's lowland tropical evergreen forest. Thus, it appears that *K. pulchra* is a wet zone species distributed on the south bank of the Brahmaputra River. *K. taprobanica* is on the other hand distributed on north bank of the river Brahmaputra (Fig. 7). For *K. taprobanica* the Brahmaputra River in India and its old course in Bangladesh, is presumably a barrier to its distribution. A subspecies of *Kaloula baleata*, *K. baleata ghoshi* had been reported from Andaman Island which differs from the typical form in the webbing pattern and length of the rear limbs (Cherchi 1954). This species is kept outside the purview of the present study due to non availability of specimens for study.

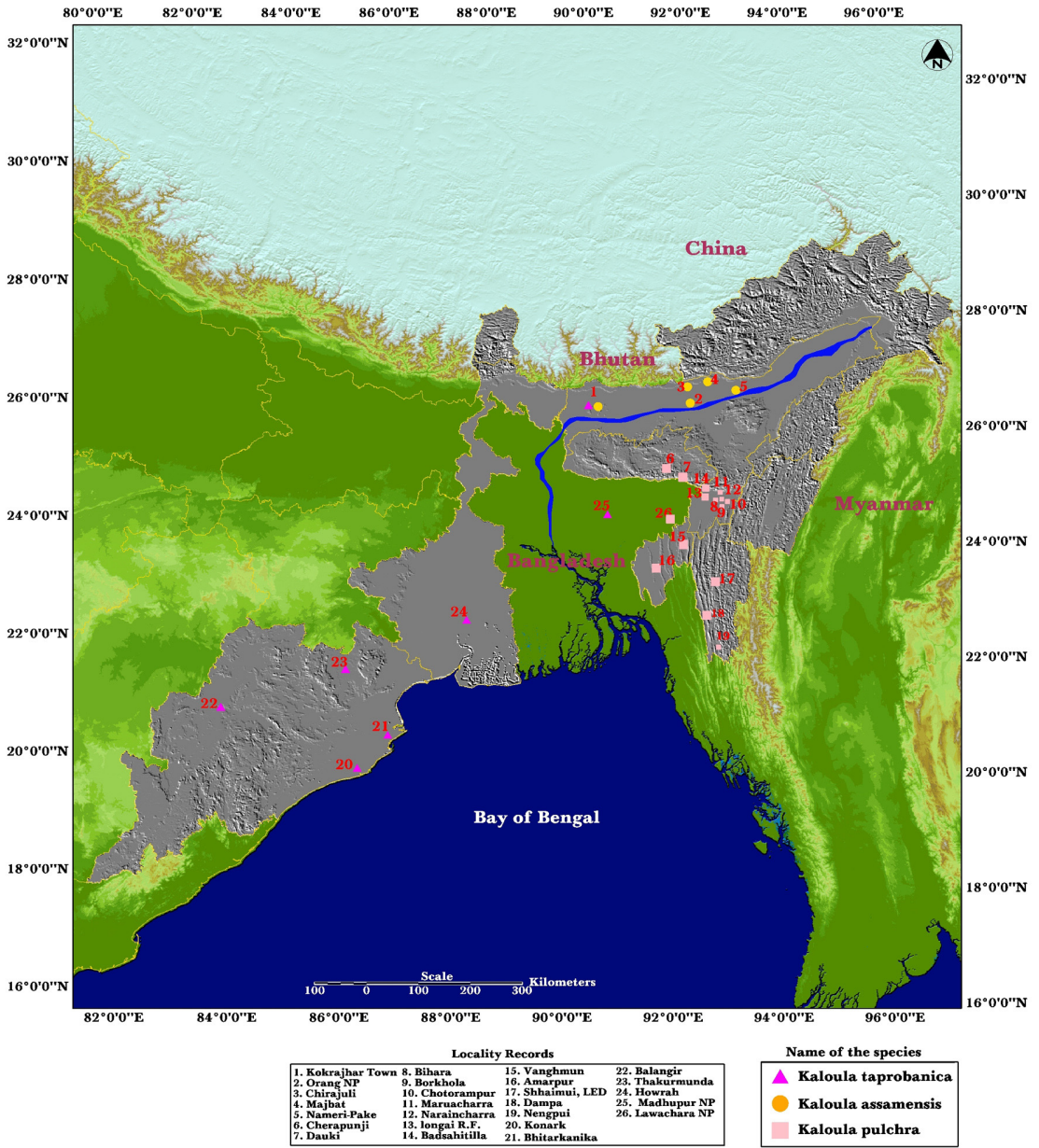


FIGURE 7. The locality recorded for three species of the genus *Kaloula*.

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