Validity of the nomen *Polypedates himalayensis* (Annadale, 1912)

Abstract

The present study confirms the species status of *Polypedates himalayensis* and suggests its removal from the synonymy of *Polypedates leucomystax* and *Polypedates maculatus*. Further the study proposes the occurrence of two distinct species group within *Polypedates*, namely *leucomystax* (represented by *P. teraiensis*), and an intermediate between *leucomystax* and *maculatus* (represented by *P. himalayensis* and *P. megacephalus*), in northeast India and suggests the nomen *Polypedates teraiensis* for the northeast Indian population of *Polypedates leucomystax* species complex.

Introduction

The extant amphibian genus *Polypedates* of the family Rhacophoridae (Anura) is known to contain twenty four species of which seven species are so far recorded from the northeast India (Annandale, 1912; Chanda 1994, Roy et al. 1998, Ahmed and Dutta 2000, Ao et al. 2003, Mathew and Sen 2010).

Annandale (1912) described a new subspecies, *Rhacophorus maculatus himalayensis* from Abor hill expedition (type locality of Kobo, alt. 400 ft. asl) near Pasighat and East bank of Siang (Dihang) river (alt. 1100 ft. asl) East Siang district, Arunachal Pradesh, India which was later elevated to the species status (*Polypedates himalayensis*) [see Chanda et al. 2000]. Ahl, 1931 considered *Rhacophorus* (*Rhacophorus*) *himalayanus* as valid nomen for the subspecies *Rhacophorus maculatus himalayensis* described by Annandale, 1912. Gorham (1974) treated the taxon as synonymous with *Polypedates leucomystax* (Gravenhorst, 1829). Dubois (1986) considered *Polypedates himalayensis* valid, but his designation of MNHN 1983.1170, from "Rakshe, 2000-2070 m, East-Nepal" as the neotype was set aside with the discovery of the syntypes by Chanda et al. (2000). Schleich and Kästle (2002) placed it in the synonymy of *P. leucomystax* and Frost (2017) maintained this nomen as synonym to both *Polypedates leucomystax* and *Polypedates maculatus*.

Since the original descriptions, the nomen *Polypedates himalayensis* has been treated in various ways and the status of this nomen is uncertain. We evaluate the status and validity of the nomen *Polypedates himalayensis*.

Polypedates teraiensis (lateral view)
Photo Credit: Abhijit Das

Materials and Methods

Specimens were collected from different localities Assam: [Joypore RF (27°11' - 27°20' N and 95°26' - 95°29' E), Podumoni-Borjan-Bherjan WLS (27°23' - 27°28' N and 95°29' - 95°36' E), Nambor-Garampani WLS (26°23' - 26°25' N and 93°51' - 93°55' E), NP (26°55' - 27°03' N and 92°40' - 93°06' E), Garbhanga Reserve Forest (26°07' - 26°09' N and 92°33' - 91°55' E), and Mizoram: Tamdil (92°39' - 92°57' E and 23°43' - 23°58'). Further collections were also made from Orissa: [Bhubaneswar (20°16' N & 85°51' E) and Baripada (21°56' N & 86°44' E)].

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The collections were deposited in the Museum of Arya Vidyapeeth College (AVCM) and catalogued.

Types and Voucher specimens of *Polypedates* species of different museums AVCM, ZSIC and ZSIS) and personal collections (ID, SKD, MFA & BC) were also examined.

The specimens were measured using a Mitutoyo Dial Calipers (±0.01 mm accuracy) to record morphometric parameters for adult and larva. Abbreviations of the parameters along with their full forms, as follows;

Adult : SVL - (Snout to vent length) from tip of snout to vent; HL - (Head length), from angle of jaw to the tip of the snout; ED - (Eye diameter), from anterior corner to posterior corner for the eye; SL - (Snout length), from anterior corner of eye to the snout tip; EN - (Eye to nostril distance), from the anterior corner of eye to center of nostril; UE - (Upper eye lid), vertically between both edges; IAE - (Inter space anterior eye), space between the anterior corner of eye; IPE - (Inter space posterior eye), space between posterior corner of eye; Pupil - Vertical/horizontal orientation of pupil; NS - (Nostril to snout distance), from the center of nostril to the tip of the snout; TE - (Tympanum to eye distance), from posterior corner of eye to anterior edge of the tympanum; HWAJ - (Head width at jaw), distance between the two lateral angles of jaw; HWPE - (Head width posterior to eye), distance between the two lateral sides at posterior corner of eye; HWAE - (Head width anterior to eye), distance between the two lateral sides at anterior corner of eye; HWN - (Head width at nostril), distance between the two lateral side at nostril; VR - (Vomerine ridge), position, orientation, size; IVR - (Inter-vomerine ridge), space between the closest edge of both vomerine; IOS - (Inter orbital space), minimum distance between the two eyes from the base of the eyelid dorsally; INS - (Inter-narial space), distance between two nostrils at center of each nares; HTYD - (Horizontal tympanic diameter), maximum distance from the anterior to the posterior corner of the tympanum; VTYD - (Vertical tympanum diameter), maximum distance from the dorsal to the ventral corner of the tympanum; HDN - (Head depth at nostril), from dorsal surface of the nasal bone to the ventral surface of the maxilla; HDE - (Head depth anterior to eye), from dorsal surface touching anterior corner of eye to the ventral surface of the maxilla; HDAJ - (Head depth at angle of jaw), from dorsal surface of the cranium directly above angle of the jaw to the ventral surface of the maxilla; MN - (Mandible nostril), from mandible at jaw angle to centre of nostril; MAE - (Mandible anterior eye), from mandible at jaw angle to anterior corner of eye; MPE - (Mandible posterior eye), from mandible at jaw angle to posterior corner of eye; Snout - Shape from dorsal view; FLL - (Fore limb length), from arm-pit to tip of 3rd finger; Fore-arm - From posterior end of

Polypedates himalayensis shows distinct variation in body size between male and female
Photo Credit: Indraneil Das

Radio-ulna to tip of 3rd finger; Hand L - From base of first finger to tip of 3rd finger; IMC/PT - (Inner meta-carpel/ palmar tubercle), presence/absence, from base to tip of the tubercle; MMC - (Middle meta-carpel tubercle), presence/absence, from base to tip of the tubercle; OMC - (Outer meta-carpel tubercle), presence/absence, from base to tip of the tubercle; NP - (Nuptial pad), from base to tip of the pad; F1, F2, F3, F4 - From base to tip of the 1st, 2nd, 3rd, 4th finger; F1D, F2D, F3D, F4D - (Disc diameter of the 1st, 2nd, 3rd, 4th finger), from the tip of the last phalange to the tip of the disc; HLL - (Hind limb length), from anus to tip of 4th toe; TBL - (Tibia length), from knee to tibio-tarsal articulation; TBW - (Tibia width), maximum width of tibia; Ft L - (Foot length), from base to tip of the 4th toe; IMT - (Inner meta-tarsal tubercle), presence/absence, from base to tip of the tubercle; OMT - (Outer meta-tarsal tubercle), presence/absence, from base to tip of the tubercle; SAT -(Sub-articular tubercle), presence/absence,SNT- (Supernumerary tubercle), presence/absence, TTA - Tibio tarsus articulation; T1, T2, T3, T4, T5 - Toe length. (From base to tip of the 1st, 2nd, 3rd, 4th & 5th toe); T1D, T2D, T3D, T4D, T5D - (Disc diameter of the 1st, 2nd, 3rd, 4th & 5th toe), from the tip of the last phalange to the tip of the disc; Toe web formula has been portrayed following Savage & Heyer (1997).

Tadpole: The eggs laid in foam nest in the specially designed enclosures were allowed to develop naturally and the larval stages were collected for taxonomic characterization. Grosjean (2005) pointed out that a development climax for most characters is reached by the tadpoles from 32 - 40 Gosner (1960) stages and as we observed that this climax is reached at Gosner stage 36 in *Polypedates himalayensis*, we selected larval stage 36 in the present study. The following larval parameters were measured.

SVL- (snout vent length), from tip of snout to vent tube; BL- (Body length), from tip of snout to body-tail junction; BW- (Body width), maximum width of the body; BH- (Body height), maximum height of the body; HL- (Head length), distance from tip of snout to posterior margin of eye; HD- (Head depth), maximum height of head; ODL- Oral disc length; ODW- Oral disc width; EN- (Eye to nostril distance), distance between anterior point of eye and middle nostril; NS- (Nostril to snout distance), distance between anterior point of nostril to tip of the snout; INS- (Inter-narial space), distance between nostrils; IOS- (Inter-orbital space), minimum distance between the eyes; ED- (Eye diameter), distance between anterior corner of eye to the posterior corner of the eye; SPL- Spiracle length; TL- (Tail length), from the body-tail junction to the tip of the tail; TMW- (Tail maximum width), maximum thickness of the tail at mid-tail position; MTH- (Maximum tail height), greatest distance between dorsal and ventral fin margin; BS - Beak serration; LTRF - (Labial tooth row formula), number and status representation of the larval Keratodont. The keratodonts proximal to the upper beak were termed as 'A' and counted starting from the outer fringe of oral armature, while those distal to the lower beak were termed as 'P' and counted starting from near lower beak.

Foam nest constructed on ground by *Polypedates himalayensis*

The advertisement calls were recorded using an analogue device, Sony DSC micro cassette recorder coupled with a unidirectional microphone, Ahuja XLR 1000. Calls were digitalized into WAV formats after filtering the disturbances using Computer software "Goldwave 5.55" and "Audacity 1.2.6". The filtered calls were run in the "Sound Ruler, Gnomovision version 69" software to record various acoustic parameters following Roy (1993) and Matsui (1994).

Polypedates leucomystax
Female, AMNH 68169 from Abuyog, Philippines.
Photo Credit: Abhijit Das

Abbreviation used

RF = Reserve Forest, WLS = Wild life sanctuary, NP = National park, AVCM = Museum of Arya Vidyapeeth College, ZSIC = Zoological Society of India, Kolkata, ZSIS = Zoological Survey of India, Eastern Regional Station, Shillong, ID = Indraneil Das, SKD= Sushil Kumar Dutta, MFA= Md. Firoz Ahmed, BC = Basundhara Chetri

Results and discussion

The *Polypedates himalayensis* is described from the syntype specimen and also from the collections made during the present study

Adult

Original description of Annandale (1912): "A well-developed parietal-squamosal arch; dorsal surface of skull smooth; skin of dorsal surface of head free". Distributed in Eastern Himalayas, Assam, Western China.

Description from syntype (ZSIC 16944) (Table I) [ZSIC 16969 has been mutilated and could not be measured].

A moderate size species. Head slightly longer than broad, dorsally flat to slightly concave and triangular; head length more than three times the head depth at nostril, about 1/3rd of the snout-vent length. The cephalic skin free from the nasal and the fronto-parietal. Canthus rostralis oblique; loreal slightly concave. Snout obtusely pointed and project beyond the lower lip, little less than half of the head length, about 18% of the snout-vent length. Nostril closer to the snout than eye; eye-nostril (EN) more than 63% of the snout length, about 1/3rd of the head length. Eye large, its diameter about 40% of the head length, more than 3/4th of the snout length, about 15% of the body length, more than the distance from eye to nostril.

Nostril oval without flap laterally. Internarial space smaller than the inter-orbital space; interorbital space slightly convex, greater than upper eye lid. A symphysial knob on mid lower jaw. Tympanum roughly rounded, smaller than eye, separated from eyes by a space of about a quarter of the tympanum size.

Hand with inner metacarpal tubercle, middle metacarpal tubercle and outer metacarpal tubercle. Fingers long, tips with well-developed circular discs and provided with terminal knuckle, circum-marginal groove and basal groove. The relative finger length - F3 >F4 >F2 >F1; sub articular tubercles small, not well developed; super numerary tubercles present. Rudimentary web between the 1st- 2nd and, 2nd - 3rd fingers.

Tibia long, more than half of the body length, about six times of its width. An elongated inner metatarsal tubercle (IMT); outer metatarsal tubercle absent. Tip of toes

dilated into disc, disc with terminal knuckle, basal groove and circum-marginal groove. Tibio tarsal articulation reach eye. Relative toe length - T4>T5>T3>T2>T1; Toe webbing - I1-1II0-2III1/2-2IV11/2-1/2V.

Secondary Sexual Characters (male): nuptial pad on 1st and 2nd fingers, elongated paired internal vocal sacs at the base of jaw angle.

Description based on collections from NE India (Table I): A medium sized. Head length almost equal to its width, slightly convex dorsally; head length more than three times head depth at nostril, about 1/3rd of the snout-vent length. Skin of head free from the nasal and the fronto-parietal bones. Canthus rostralis rounded; loreal almost vertical and concave. Snout obtusely pointed, more than half of the head, about 1/5th of the body length. Nostril closer to the snout than eye, eye-nostril space more than 61% of the snout length and about 1/3rd of the head length. Eye moderate, about 35% of the head length, its diameter lesser than 3/4th of the snout length, slightly greater than the distance from eye to nostril. Nostril oval without flap laterally. Inter narial space smaller than the interorbital space. Pineal body absent. Symphysial knob on mid lower jaw present. Tympanum rounded, smaller than eye, about 60% of the eye diameter, separated from the eye by a distance lesser than horizontal tympanic diameter.

Fore limbs are moderately long, more than 1½ of the hand length. Hand provided with inner metacarpal tubercle, middle metacarpal tubercle and outer metacarpal tubercle. Inner metacarpal tubercle about 1/5th of the hand length. Fingers long, tips of fingers with well-developed circular discs having terminal knuckle, circumferential groove and basal groove. The relative finger length - F3 >F4 >F2 >F1; relative finger disc size - F3D>F4D>F2D>F1D. Subarticular tubercle prominent. Fingers with rudimentary web at the base of the 1st - 2nd and, 2nd - 3rd fingers. super numerary tubercles present.

Hind limb long, tibia long, 30% of the leg length, about half of the body length, about four to five times more than its width. Inner metatarsal tubercle elongated and about 10% of the foot length; outer metatarsal tubercle absent. The tip of toes dilated into disc having terminal knuckle, basal groove and circumferential groove. Tibio tarsal articulation reach the eyes. Relative toe length - T4>T5>T3>T2>T1; relative toe disc size - T4D>T5D>T3D>T2D>T1D; Toe webbing- I1½-1II½-2III½-2IV1½ -½V. Vomerine ridge narrow, elongated, positioned between choanae, angular to the body axis. Choanae oval.

Dorsum and upper flank golden-brown to coffee-brown with scattered black spots, occasionally with blackish unpatterened blotches; two dorso-lateral broken but distinct lines from inter orbital position to groin present. Upper lip brownish bordered with a faint white line; lower lip brown. Circular tympanum flesh pink to translucent dark tan. Limbs and digits with oblique cross bars; inner and outer thigh reticulated with dark brown stripes forming white oval to polygonal blotches. Dorsal surface mostly smooth with strong granulation around vent; ventral strongly granulated; ventrally lower lips, tibia and tarsus smooth. A dorso-lateral sharp supra tympanic fold extend from posterior eye to armpit present. A dark brown streak extend just beneath the supra-tympanic fold from posterior tympanum to mid-flank, occasionally up to the groin. Belly creamy white, throat, thigh and chest white with brown speckles; Ventral thigh light reddish. Toe web uniformly brown.

Sexual characters: Male- internal vocal sac at base of mouth, nuptial pad at the base of 1st and 2nd fingers.

Female: distinctly larger than the male.

Ecological notes: This species was observed only during April to June, which is also the breeding period. This was found to inhabit damp ground covered by undergrowths or leaf litter in the open areas of forests, without crown canopy but surrounded by trees. Calling males were always traced below leaf-litter or undergrowths or sometimes fallen logs. Calls started with low pitched single interval clucks and ending with fast repetition of clucks that occasionally lasted for 60 to 90 seconds. Eggs were observed to lay in foam nest constructed under leaf litter or ground vegetation.

Tadpole

Original description of Annandale (1912)

Head and body moderately flat above, ovoid, rounded in front, convex on ventral surface.

Mouth nearly terminal, comparatively small, lips relatively narrow, both directed forward; upper lip smooth except at the corners, which bears numerous rounded papillae; lower lip with a fringe interrupted in the middle, and consisting of similar papillae about three deep;

LTRF I:3+3/I+I:2 or I:3+3/3; beak in two parts; the upper beak not hooked, the lower crescentric; both parts massive, both serrated.

Eyes and nostril- Eyes lateral directed outwards; nostril nearer tip of snout than eye.

Glands- A large gland in front of and slightly below each eye. Spiracle sinistral, pointing backwards and little upwards, flap like, large. Anus dextral. Tail long and slender, twice as long as head and body, sharply pointed; its outline not strongly sinuous; fin membranes deep through out its length.

Colouration - Mottled with dark brown on dorsal surface and sides; fin membranes minutely spotted; ventral surface white.

Description based on collections from NE India (Table III)

Larva moderate [mean total length (TL):30.692 mm]. Snout-vent length constituting 1/3 rd of total length; head large; Body oval and elongated in dorsal view; ovoid in lateral view; widest at the middle of the intestinal coil, body width more than half of Snout-vent length; body height marginally less than width. Snout rounded in dorsal view and maximum width immediately behind eyes. Eyes moderate size, larger than the space between nostril and snout. Positioned more dorsally than dorso-laterally and directed laterally. Inter orbital space about 3/4th of body width. Nares elliptical, small with a mid-dorsal bifid skin projection; positioned more dorsally than dorsolaterally; directed antero-laterally; the internarial almost half of interorbital space.

Table I: Relative measurements of *Polypedates himalayensis* comb nov., *Polypedates leucomystax* (Borneo) and *Polypedates teraiensis* (NE India)

Variable	*Polypedates himalayensis*			*Polypedates leucomystax* (Borneo)	*Polypedates teraiensis* (NE India)	
	Syntype ZSIC 16944	Male (24) Mean + SD	Female (21) Mean + SD	Male (2)	Male (23) Mean + SD	Female (22) Mean + SD
SVL	31.84	44.948+ 3.32	60.357+3.07	47.17+1.23	53.79+ 2.26	70.687+7.35
HL:SVL	0.366	0.3228+0.003	0.300+0.002	0.320+0.014	0.322+0.009	0.300+0.012
HL:HW	1.074	1.0213+0.008	0.92561+0.031	1.105+0.007	1.009+0.006	1.009+0.027
SL:HL	0.494	0.53894+0.015	0.53244+0.029	0.505+0.035	0.532+0.021	0.517+0.010
SL:SVL	0.181	0.17489+0.004	0.19321+0.039	0.165+0.007	0.171+0.003	0.157+0.005
EN:HL	0.314	0.336+0.007	0.337+0.008	0.335+0.021	0.359+0.012	0.354+0.015
EN:NS	2.10	1.908+0.048	1.664+0.051	1.785+0.007	2.089+0.066	2.511+0.071
EN:SL	0.636	0.6167+0.004	0.6371+0.052	0.665+0.007	0.617+ .025	0.637+0.027
ED:SVL	0.145	0.1159 +0.003	0.10833+0.008	0.115+0.007	0.107+0.002	0.099+0.006
ED:SL	0.801	0.658+0.022	0.66183+0.028	0.710+0.099	0.619+0.016	0.656+0.029
ED:EN	1.259	1.0664+0.034	1.046+0.644	1.060+0.141	0.921+0.028	0.931+0.055
ED:HL	0.396	0.35933+0.012	0.3522+0.022	0.355+0.021	0.333+0.005	0.329+0.163
INS:IOS	0.838	0.785+0.025	0.684+0.043	0.715+0.007	0.616+0.002	0.592+ 0.028
IOS:UE	1.36	1.2374+0.199	1.6066+0.117	1.350+0.155	1.630+0.129	1.615+0.247
HTYD:ED	0.638	0.5762+0.139	0.63817+0.034	0.615+0.021	0.726+0.008	0.673+0.039
TBL:SVL	0.579	0.52639+0.040	0.55306+0.04	0.490+0.001	0.515+0.023	0.521+0.021
TBL:TBW	5.984	5.3782+0.061	4.256+0.075	5.580+0.014	4.941+0.036	4.681+0.313
TE:HTYD	0.251	0.42578+0.012	0.4165+.013	0.345+0.064	0:348+0.013	0.431+ 0.052

...acle sinistral, slightly bulging laterally, ...t and narrow, opening at the middle ...d of body, directed postero-dorsally, at ...height of the middle of the lower part of ...caudal muscle; inner centripetal wall ...ed to the body wall and longer than the ...ternal centripetal wall; closer to end of ...dy than to snout, and opens as an oval ...t.

...il long. Tail musculature moderate ...progressively tapering, marginally falling ...ort of tail tip. Tail maximum width lesser than body width; tail height point of maximum height of tail located just before the proximal third) exceeded the body height; upper fin extending up to the posterior edge of head, both fins slightly convex; tip pointed.

Vent tube short, dextral, fused to the ventral fin, gradually tapering to narrow lateral opening; directed latero-ventrally, entirely attached to ventral fin but free from tail muscle.

Sub-dermal gland consisting of a pair of postorbital gland (semicircular aggregation)about one eye-length behind eye. Lateral line present on snout and dorsum, absent on tail.

Oral disc anteroventral, not emarginate and with marginal papillae row uniseriate ventrally and biseriate laterally; lips expanded into horizontal orientation; open mouth funnel almost as wide as body; lateral lip corners pointed, Papillae cylindrical with a rounded tip, increasing in length anteroposteriorly, of moderate size except the marginal papillae of the posterior part of the lower labium moderately long. No denticulate papillae, anterior labium not separate from posterior labium, marginal papillae of anterior labium confined to lateral corners, posterior labium with continuous row of marginal papillae.

Upper lip not as deep (anteroposteriorly) as lower, separated from snout by marginal groove.

Beaks thin, both keratinised and serrated along outer edges with many long, fine, pointed serrate, upper with median notch.

Upper jaw sheath "arc" shaped and narrower than the lower one, lower jaw sheath 'V'-shaped.

LTRF 1:3+3/3. A1 almost touching lateral papillae, A2 touching beak dorsally, A2, A3 & A4 progressively shortened; P1 and P2 almost equal while P3 shorter.

Foam nests of *Polypedates teraiensis*

In various literatures occurrence of *Polypedates leucomystax* has been reported from various parts of northeast India along with the presence of *Polypedates teraiensis*, the nomen which has been proposed for *P. leucomystax* for the population in Nepal, Bangladesh and India. In the present study, the validity of this complex was also investigated.

Original description of *Polypedates leucomystax* by Gravenhorst (1829): "Toes half webbed, abdomen and femur granulated below, rusty in colour above, margin of the upper jaw and lateral border of the anterior feet with white" [translated]

Description based on material examined during the present study

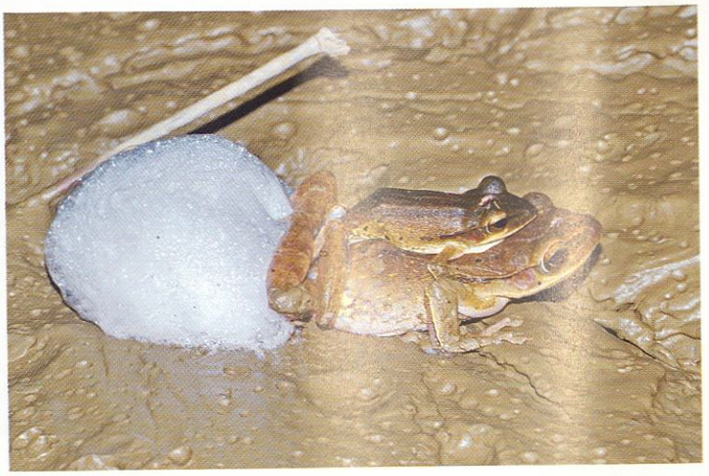
[1.a] Bornean population: - The present description is based on two male specimens from personal collection (ID). A medium sized frog, head longer little than broad, dorsally flat to slightly concave and triangular; head length more than four times the head depth at nostril, head length about 1/3rd of the snout-vent length. The species have much of the head skin co-ossified with the nasal and the fronto-parietal bones. Canthus rostralis oblique and loreal region slightly concave. Snout obtusely pointed, project beyond the lower lip more than half of the head length and lesserer than 17% of the snout-vent length. Nostril closer to the snout than eye, eye nostril distance little lesserer than two times the distance between nostril and snout, eye-

nostril distance more than 65% of the snout length and about 1/3rd of the head length. Eye diameter about 33% of the head length, 3/5th of the snout length, about 10% of the body length and slightly lesserer than the distance from eye to nostril.

Nostril oval without flap laterally. Internarial space less than the inter-orbital space, interorbital space slightly convex. Pineal occelus obscure. Symphysial knob on mid lower jaw. Tympanum round , smaller than eye, separated from eyes by a space of lesserer than half of the tympanum. Choanae oval. Vomerine ridge oblique, angular to the body axis, originating from the anterior corner of choanae and extends beyond the lower edge.

Fore limb more than 1½ of the hand length. Hand provided with inner metacarpal tubercle, middle metacarpal tubercle and outer metacarpal tubercle. Inner metacarpal tubercle less than 1/5th of the hand length. Fingers long, tips of fingers with well developed circular discs having terminal knuckle, circum-marginal groove and basal groove. The relative finger length - F3 >F4 >F2 >F1; relative finger disc size - F3D>F4D>F2D>F1D. SAT small and not well developed; Super numerary tubercles absent. Rudimentary web between the 1st – 2nd and, 2nd – 3rd fingers. Hind limb long, more than 11/2 times than snout-vent length. Tibia long, 30% of the leg length, about half of the snout vent length, 51/2 more than its width. An elongated inner metatarsal tubercle (IMT). Outer metatarsal tubercle absent. Tip of toes dilated into disc, disc with terminal knuckle, basal groove and circum-marginal groove. Tibio tarsal articulation reaches beyond anterior corner of eyes or at least midway between eye and nostril. Relative toe length - T4>T5>T3>T2>T1; relative toe disc size - T4D>T5D>T3D>T2D>T1D. Toes webbing - I1-1½II1-2III1-2IV2-1V.[Table I].

Dorsum grey to golden brown and with four distinct dark dorsal stripes, lateral two originate from posterior corner of eye while the middle two originate from snout, all four gradually disintegrate into brown spots towards the posterior proximities. Upper part of flank light brown while lower flank and groin reticulated with brownish streaks forming oval spots in between. Upper lip pale white and lower lip brownish. Fore limb, thigh, tibia and tarsus with coffee brown transverse bands with occasional specks of white on the thighs. Inner thigh marbled with oval brownish spots, outer thigh reticulated. Skin of snout, inter orbital space, lateral side of head, upper eyelids rough with rounded tubercles. Ventrally white; strong granulation on the ventral aspect of the throat, chest, belly and thigh, smooth on tibia and tarsus. A supra-tympanic fold extend dorso-laterally from posterior corner of eye to the armpit, ending abruptly and not converging to armpit.



Amplexus in *Polypedates teraiensis*

Sexual character (male): Nuptial pad on 1st and 2nd fingers, antero-posteriorly elongated paired internal vocal sacs at the base of jaw angle.

[1.b] NE Indian population: A relatively large species. Head little longer than broad, dorsally flat to slightly concave and triangular; head length more than four times the head depth at nostril, length of the head about 1/3rd of the snout-vent length. The species characterized by co-ossified skin on nasal and fronto-parietal. Canthus rostralis oblique and loreal region slightly concave. Snout obtusely pointed and projects beyond the lower lip, more than half of the head length and about 17% of the snout-vent length. Nostril much closer to the snout than eye, eye-nostril more than 61% of the snout length, about 1/3rd of the head length. Eye diameter about 33% of the head length and eye diameter 3/5th of the snout length, about 10% of the body length, slightly less than the distance from eye to nostril.

tril oval without lateral flap. Internarial e lesser than the inter-orbital space and rbital space slightly convex, greater upper eye lid.

al occelus obscure. Symphysial knob on lower jaw present. Tympanum round, aller than eye, separated from eyes by a ace of lesser than half of the tympanum. oanae oval. Vomerine ridge oblique, ngular to the body axis, originating from ue anterior corner of choanae, extend eyond the lower edge.

Fore limbs moderately long, more than 1½ of the hand length. Hand provided with inner metacarpal tubercle, middle metacarpal tubercle and outer metacarpal tubercle. Inner metacarpal tubercle less than 1/5th of the hand length. Fingers long, tips of fingers with well- developed circular discs having terminal knuckle, circum-marginal groove and basal groove. The relative finger length - F3 >F4 >F2 >F1; relative finger disc size - F3D>F4D>F2D>F1D. SAT small, not well developed; Super numerary tubercles absent.

Rudimentary web between the 1st – 2nd and, 2nd – 3rd fingers. Hind limb long, more than 11/2 times than snout-vent length. Tibia long, 30% of the leg length, about half of the snout vent length, more than 41/2 times its width. An elongated inner metatarsal tubercle (IMT), lesser than 10% of the foot length; outer metatarsal tubercle absent. Tip of toes dilated into disc, disc with terminal knuckle, basal groove and circum-marginal groove. Tibio tarsal articulation reach beyond anterior corner of eyes or at least midway between eye and nostril. Relative toe length - T4>T5>T3>T2>T1; relative toe disc size T4D>T5D>T3D>T2D>T1D. Toewebbing - I1-1½II1-2III1-2IV2-1V (Table I)

Mathew and Sen (2009) described two new species namely *Polypedates assamensis* and *Polypedates subansiriensis* from this region. However, both the species were described based on single specimen. Both the species have loose cephalic skin, head broader than long, pineal body as tiny spot and TTA reaching the nostril.

Polypedates leucomystax complex of NE India (PL NEI) was compared with the *Polypedates leucomystax* (Borneo) and found to differ from the later by having larger size longer snout, smaller eye. Further, in PL NEI the tibia was longer, the TTA reached the anterior corner of the eye vs to the snout tip in *P. leucomystax*. Dubois (1986) observed relatively small SVL in Borneo population (SVL >48.2 mm) of *P. leucomystax* than the population of Nepal terai (SVL = 51.5 – 82.8 mm) and also relatively long tibia (TBL:SVL = 0.469 – 0.607 in Borneo population and TBL:SVL = 0.461 – 0.532 in Nepal population) and proposed Nepal and NE India population as a distinct subspecies of *P. leucomystax* and provided the subspecies name as *P. leucomystax teraiensis;* the Bornean population was maintained by him as nominative subspecies, *P. leucomystax leucomystax*. However he described the population of Bangladesh, Manipur, Mayanmar as a transition state between these two but maintained the nomen *P. leucomystax teraiensis* for these populations. The present study supports the view of Dubois (1986).

Polypedates himalayensis differed from *Polypedates teraiensis* in having loose cephalic skin, smaller size, larger snout length, larger eye size, larger eye to nostril space, and longer hind limb; from *Polypedates maculatus* in having smaller size, larger eye diameter and longer tibia; from *Polypedates taeniatus* by showing smaller size, larger eye, longer tibia and smaller eye nostril space; from *Polypedates megacephalus* in having shorter tibia; from *Polepedates himalayensis* in having smaller size, smaller snout (length) and longer tibia; from *Polypedates subansiriensis* in having smaller size, broader head and larger eye

The larval characters of *Polypedates himalayensis* also exhibited difference from *Polypedates teraiensis*, and *P. megacephalus*. *Polypedates himalayensis* differed from *Polypedates teraiensis* tadpole in higher total length and SVL, lesser comparative inter orbital space, greater comparative inter narial space, lesser comparative tail muscle width; from Polypedates maculatus in having lesser body length and SVL, lesser comparative body width, greater comparative eye diameter, greater comparative inter orbital space, lesser comparative inter narial space, much smaller body width and body height, and from tadpole of *Polypedates megacephalus* in having

sinistral spiracle and LTRF I:3+3/I+I:2 or I:3+3/3

The acoustic analysis of *Polypedates* species (Table 3) is presented as below

Acoustic characters (Table III)

The call of *Polypedates himalayensis* found to include 6 to 7 notes of 5 to 18 pulses with a call duration of 4700 ms. The mean pulse peak was 3.654 ms (±1.276) and relative pulse peak noted was 0.799 Hz (± .074).The Pulse Dominant frequency was 0.252 Hz (± 0.103)and the fundamental frequency ranged from 1139 Hz to 2211 Hz (mean 1296 ± 370). The interval between subsequent pulses in 6 pulsed note was 2.99 ms and that of 7 pulsed note was 31.96 ms with a mean pulse interval of 10.23 ms (± 11.62).

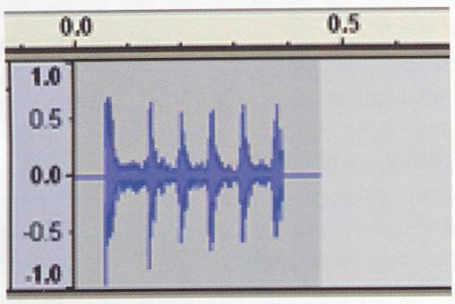


Figure 1a: WAV format of a single call of *Polypedates himalayensis*

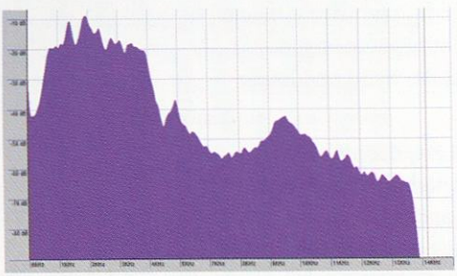


Figure 1b: Plot spectrum at 512 frequency bin of *Polypedates himalayensis*

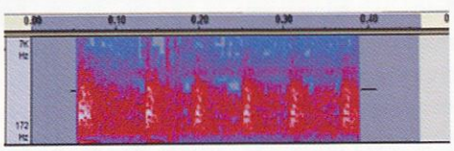


Figure 1c: Band spectrum of a single call of *Polypedates himalayensis*

The Bornean population of *Polypedates leucomystax* had a single note call which include 11 or 12 pulses with mean call duration of 1700 ms. The mean pulse peak was noted at 0.79 Hz (± 0.094) and relative pulse peak at 0.854 Hz (± .032). Pulse Dominant frequency was 0.202 Hz (± .024). The fundamental frequency started from 1148.4 Hz and reaches 1176 Hz (mean 1162±19.5). The interval between subsequent pulses in 11 pulsed note was 3.6 ms and that of 12 pulsed note was 3.9 ms with a mean pulse interval of 3.77ms (± 0.243)

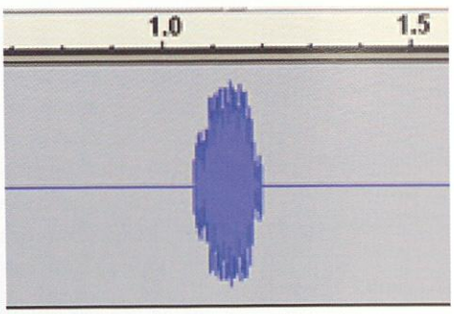
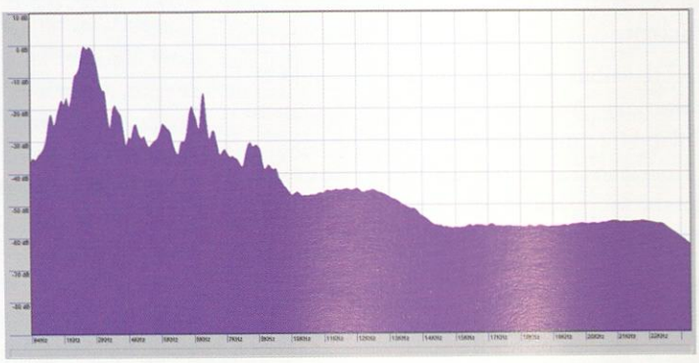


Figure 2a: WAV format of a single call of *Polypedates leucomystax*

Figure 2b: Plot spectrum at 512 frequency bin of *Polypedates leucomystax*



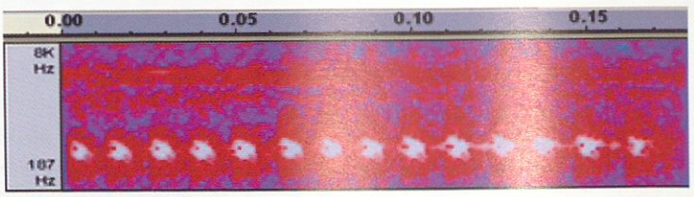


Figure 2c: Band spectrum of a single call of *Polypedates leucomystax*

The call *Polypedates teraiensis* of N E India was with a single note of 1 to 6 pulses with mean call duration of 1750 ms. The mean pulse peak was 0.234 ms (±0.082) and relative pulse peak recorded at 0.773 Hz (± 0.118). The Pulse Dominant frequency was 0.187 (± 0.270). The fundamental frequency started from 990.5 Hz and reaches 1205.9 Hz (mean 1051.1 ±66.9). The interval between subsequent pulses in 1 pulsed note was -1 ms and that of 6 pulsed note was

7.096 ms with a mean pulse interval of 1.321ms (± 2.458)

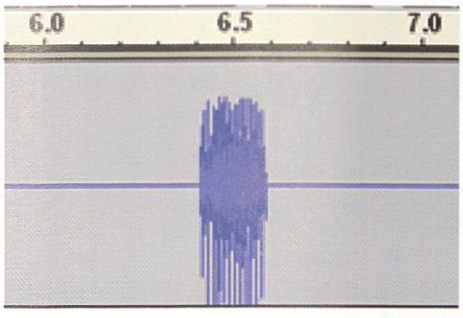


Figure 3a: WAV format of a single call of *Polypedates teraiensis*

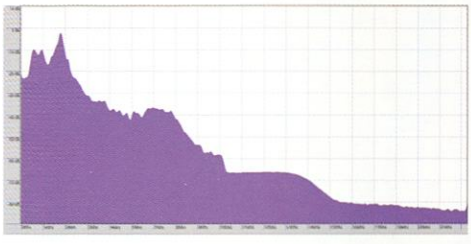


Figure 3b: Plot spectrum at 512 frequency bin of *Polypedates teraiensis*

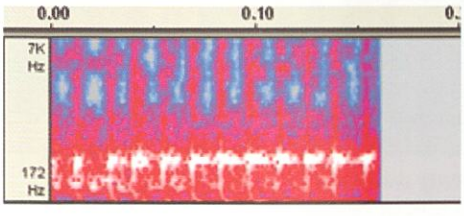


Figure 3c: Band spectrum of a single call of *Polypedates teraiensis*

Polypedates maculatus from Orissa was found to produce two types of calls type A and type B. Call type B was more frequently encountered with (Plate IV and V).

Call type A: Call type A was a multi note call consisting of 3 to 7 pulses with mean call duration of 114 ms. The pulse peak was 0.869 ms (±.070) and relative pulse peak was 0.788 Hz (± 0.021). The Pulse Dominant frequency was 0.336 Hz (± 0.120). The fundamental frequency started from 508.2 Hz and reached the crest of 703.4 Hz (mean 608.3 ± 76.1). The interval between subsequent pulses in 3 pulsed note was 8.46 ms and that of 7 pulsed note was 22.74 ms with a mean pulse interval of 14.61 ms (± 4.63).

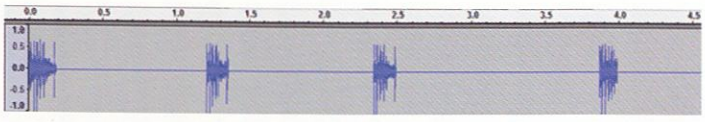


Figure 4a: WAV format of four consecutive calls of Type A

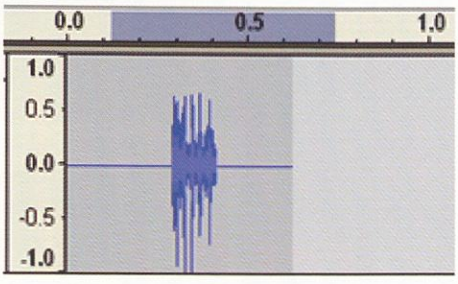


Figure 4b: WAV format of single call of type A

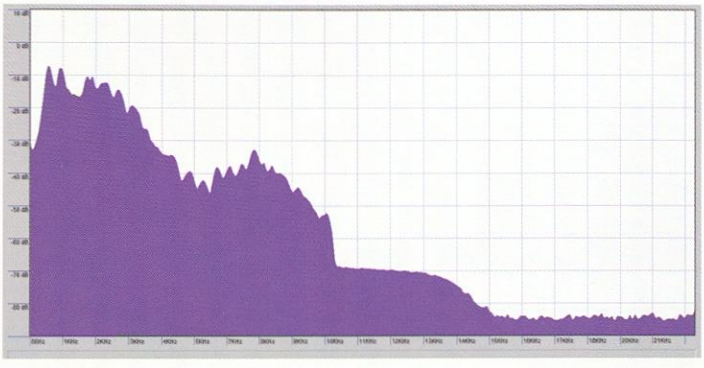


Figure 4c: Plot spectrum at 512 frequency bin of type A

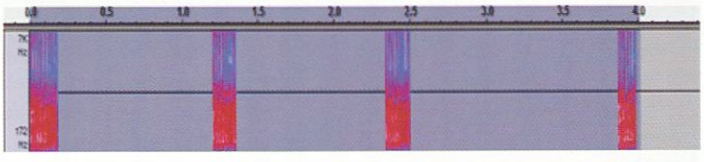


Figure 4c: Plot spectrum at 512 frequency bin of type A

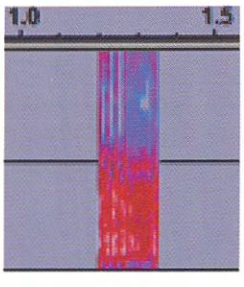


Figure 4e: spectrum of single call of type A

Call type B: This call was multi (9) note and consisted of 5 pulses each with mean call duration of 6500 ms. The mean pulse peak and relative pulse peak recorded were 0.557 Hz (± 557) and 0.82 Hz (±0.15) respectively. The Pulse Dominant frequency was 1780.08 Hz (±797.67). The

fundamental frequency started from 388 Hz and reached 1249 Hz (mean 663 ± 341). The interval between subsequent pulses range was between -1ms and 20.70 ms with mean interval of 14.33 ms (± 8.88).

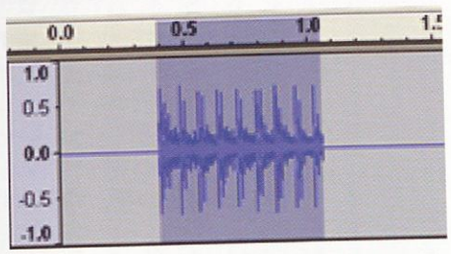


Figure 5a: WAV format of single call of Type B

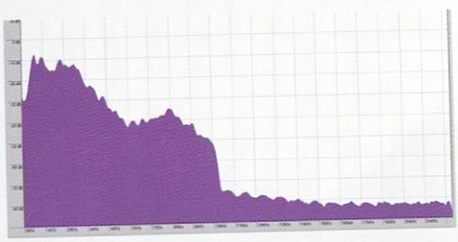


Figure 5b: Plot spectrum at 512 frequency bin of Type B

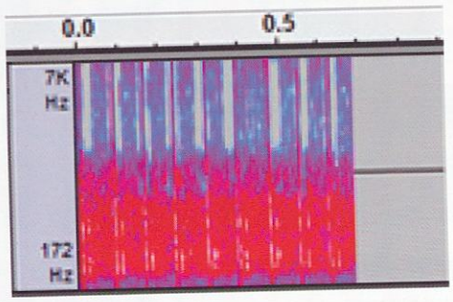


Figure 5c: Band spectrum of single call of Type B

The advertisement call analysis also suggested distinct status of *Polypedates himalayensis*. Further, it has been demonstrated that the Northeast population and Bornean population of *Polypedates leucomystax* represent two distinct populations.

The above discussion suggests a distinct specific status of *Polypedates himalayensis* and we suggest removal of nomen *Polypedates himalayensis* from the synonymy of *Polypedates leucomystax* and Polypedates maculatus.

Dubois (1986), considering the nature of cephalic skin, marking on the dorsum and presence of nuptial pad on fingers, suggested the assemblage of *Polypedates* into two species groups namely- *P. leucomystax* (*P. leucomystax, P. megacephalus* and *P. teraiensis*) and *P. maculatus* (*P. maculatus, P. himalayensis* and *P. zed*). In the present study all the species of both the groups were examined except for *P. zed* which was reported only from Nepal. *P. leucomystax* group has fused cephalic skin and nuptial pad on the first two fingers, besides longitudinal markings on the dorsum (Dubois 1986). In the present study besides these three features mentioned above, it was observed that the head gape size was higher in *P. leucomystax* group than that of the *P. maculatus* group and may consider as a key character that separates the members into two distinct groups.

P. himalayensis has loose cephalic skin like *P. maculatus* but contained nuptial pad on the first two fingers like *P. leucomystax*. Thus placement of this species in either of the Dubois's group became difficult and the present study suggests an intermediate group for this species. Further, *P. megacephalus*, which has been reported from Nagaland, (Ao et al. 2003) and Manipur (Ningombam and Bordoloi 2007) in northeast India, was resurrected from the synonomy of *Polypedates leucomystax* (Matsui et al 1986) and included under *P. leucomystax* group (Dubois, 1986). This species in the present study was also recorded from Sikkim. Due to the presence of non co-ossified cephalic skin but nuptial pad on both first and second fingers, this species also to be included under intermediate group.

Annandale (1912) reported *Polypedates maculatus* from Arunachal Pradesh and Roy et al. (1998) and Mathew and Sen (2010) from Meghalaya. We failed to find this species in either of the locations and could not trace any voucher specimens collected by any of the authors. Further, voucher specimens ZSIC A1684 (Collector- Pramod Goswami, in Oct 1943 from Nalabri) and ZSIC A1588 (Collector Kar Bahadur, 30.05.1960 from Cherrapunjee) have been misidentified and labeled as *P. maculatus* but in fact that are *P. himaylayensis*. Thus it appeared that the reports of *P. maculatus* from northeast India was erroneous and the present study suggests removal of the species from the faunal list of northeast India.

Acknowledgement

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Polypedates cf. *himalayensis* from north-east India

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Materials examined:

***Polypedates leucomystax*: ID MOS0041, ID MOS0090, Borneo**

***Polypedates teraiensis*:** 8575 (ZSIC), V/A/ERS/567 (ZSIS), V/A/ERS/ZSI/766 (ZSIS), V/A/ERS/428 (ZSIS), AVCM J-012, AVCM J-018, AVCM J-022, AVCM J-023, AVCM J-024, AVCM J-027 (Joypore, Assam), AVCM J-028, AVCM A-0032, AVCM J-033 (Podumoni), AVCM J-034 Podumoni,, AVCM J-035 (Amsang R.F), AVCM J-036(Amsang R.F), AVCM J-038, AVCM J-040, AVCM J-041, AVCM J-042, AVCM J-043, AVCM J-045, AVCM J-046, AVCM J-047, AVCM J-048, AVCM J-049, AVCM J-050 (Podumoni, Assam) AVCM J-054, AVCM A-0078 (Pakke, Arunachal Pradesh), AVCM A-0087(Pakke, Arunachal Pradesh), AVCM A-0088, AVCM A-0089(Pakke, Arunachal Pradesh), AVCM A-0141, AVCM A-0182 (Pakke, Arunachal Pradesh) AVCM A-0248(Pakke, Arunachal Pradesh), AVCM A-0255, AVCM A-0141(Nambor-Garampani WLS), AVCM HT 57, AVCM HT 58, AVCM HT 60 (Kolasib, Mizoram), MFA 10017, MFA 10294 (Cheerapunjee, Meghalaya).

***Polypedates himalayensis*:** ZSIC-16944, ZSIC-16969, ZSIC-17792 & ZSIC-16958 (Abor Hill); AVCM J-001, AVCMJ-002, AVCMJ-003, AVCMJ-004 AVCMJ-006, AVCMJ-007, AVCMJ-008, AVCMJ-009, AVCMJ-010, AVCMJ-013, AVCMJ-014, AVCMJ-015, AVCMJ-016, AVCMJ-017, AVCMJ-021, AVCMJ-025 (Joypore) RF, AVCMJ-019, AVCMJ-030, AVCMJ-029, AVCMJ-020 (Podumoni WLS), AVCMJ-026, AVCMJ-031, AVCMJ-032, AVCMJ-036, AVCMJ-037, AVCMA-315, AVCMA-318, AVCMA-320, AVCMJ-018 (Pakke, Arunachal Pradesh) AVCM-SP01, AVCM-SP02, AVCM-SP03, AVCM-SP53 (Meghalaya), AVCM-HT 0002, AVCM-HT 0013, AVCM-HT 51 (Mizoram), AVCM-NL02, AVCM-NL03 (Nagaland), ZSIC-15715, ZSIC-A1684, ZSIC-A3457, ZSIC-A4416, MFA10058, MFA10060, MFA10234 (Cherrapunjee)

Table II: Measurements of tadpole (Gosner stage 36) of *Polypedates himalayensis* (n=10)

Variable	Mean +SD	Range
TL	26.15+0.03	26.10 - 26.19
SVL	9.24+0.03	9.20 - 9.28
HL	7.07+0.01	7.05 - 7.09
Tail	20.40+0.05	20.32 - 20.47
BW	5.05+0.01	5.04 - 5.06
BH	5.04+0.05	4.96 - 5.10
TMW	2.34+0.08	2.23 - 2.46
EN	1.99+0.02	1.96 - 2.02
NS	1.17+0.04	1.10 - 1.22
INS	1.61+0.17	1.42 - 1.89
IOS	3.81+0.02	3.79 - 3.84
ED	1.55+0.06	1.44 - 1.60
TH	6.14+0.08	6.00 - 6.23
BW:SVL	0.526 0.020	0.502 - 0.555

Variable	Mean +SD	Range
[illegible]:BW	0.985 0.046	0.917 - 1.040
[illegible]:SVL	0.160 0.001	0.159 - 0.160
[illegible]:BW	0.717 0.017	0.692 - 0.738
[illegible]:NS	1.296 0.139	1.152 - 1.509
[illegible]:IOS	0.499 0.013	0.474 - 0.510
[illegible]:BH	1.180 0.004	1.175 - 1.185
TMW:BW	0.445 0.027	0.419 - 0.479
SVL:TL	0.339 0.001	0.337 - 0.341
HL:SVL	0.951 0.272	0.694 - 1.201
HL:TL	0.322 0.091	0.237 - 0.407
TAL:TL	0.753 0.033	0.750 - 0.758

Table III: Call features of *Polypedates* species

Species	*P. leucomystax*		*P. himalayensis*		*P. maculatus*	
Location		Borneo	northeast	northeast	Call type A	Call Type B
Call duration		1700 ms	1750 ms	4700 ms	1140 ms	6500 ms
Call peak time	Mean	47.36	0.37	1.977	0.03869	0.057
	Std. Deviation	2.23	0.17	2.378	0.01645	0
Total pulses	Mean	11.768	3.11	8.14	5.333	5
	Std. Deviation	0.445	1.9	4.55	1.366	0
Fft length	Mean	256	256	256	256	256
	Std. Deviation	0	0	0	0	0
Pulse peak	Mean	0.79	0.23	3.654	0.869	0.56
	Std. Deviation	0.0949	0.08	1.276	0.07	0.56
Pulse interval	Mean	3.775	1.32	10.23	14.61	14.33
	Std. Deviation	0.243	2.46	11.62	4.63	8.88
Peak dominant frequency	Mean	2324.4	2024	2160.7	1226.9	1326
	Std. Deviation	38.9	417	110.8	153.9	683
Fundamental frequency	Mean	1162.2	1051.1	1296	608.3	663
	Std. Deviation	19.5	66.9	370	76.1	341
Pulse rate	Mean	0.5929	2.36	0.547	0.3022	0.27
	Std. Deviation	0.069	4.58	0.385	0.1286	0.27
Pulse dominant frequency	Mean	0.202	0.187	0.252	0.336	1289.44
	Std. Deviation	0.024	0.27	0.103	0.12	378
Relative Pulse peak	Mean	0.854	0.77	0.799	0.788	0.82
	Std. Deviation	0.032	0.12	0.074	0.021	0.15