Taxonomic Reassessment of the Arboreal Toad Genus Pedostibes Günther 1876 (Anura: Bufonidae) and Some Allied Oriental Bufonid Genera

S.R. Chandramouli1 AND A.A. Thasun Amarasингhe2,3

1 Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehradun 248001, India
2 Research Center for Climate Change, University of Indonesia, Gd. PAU Lt. 8.5, Campus U1, Depok 16424, Indonesia

ABSTRACT: We reassessed the taxonomic status of an Asian genus of arboreal bufonids, Pedostibes, based on examination of preserved material of the two species currently attributed to this genus. Analysis of their morphological, morphometric, and geographic distribution data revealed that Pedostibes tuberculatus, the type species of this genus from the Western Ghats, southwestern India, is morphologically distinct from the geographically separated member, P. kempi, which is distributed in northeastern India. Hence, the generic nomen Pedostibes is restricted to the type species, rendering it a monotypic genus from the Western Ghats of peninsular India. A re-examination and detailed comparisons of the types of P. kempi with other bufonid genera revealed morphological similarities with another geographically proximate toad, Bufoides meghalayanus, from northeastern India. Hence, this taxon is formally transferred herein to Bufoides with a redescription. The composition of the recently described Southeast Asian toad genus Rentapia is reevaluated and the name-bearing type specimens of the currently ascribed taxa are redescribed. A detailed examination of the types of Rentapia everetti and R. rugosa revealed morphological congruence coupled with geographic sympathy. Hence, the latter nomen is synonymized with R. everetti in accordance with the International Code of Zoological Nomenclature principle of priority.

Key words: Arboreal anuran; Morphometric analyses; Northeastern India; Western Ghats

The Asian genus of arboreal bufonids, Pedostibes Günther 1876, previously shown to be polyphyletic (Bocxlaer et al. 2009; Pyron and Wiens 2011; Ron et al. 2015), has recently been revised by Chan et al. (2016) with the recognition of a new Sundaic genus, Rentapia Chan, Grismer, Zachariah et al. 2016. Although this step has contributed toward providing a taxonomic solution to the problem of polyphyly in Pedostibes to a certain extent, the classification and rearrangement therein has not provided complete taxonomic clarity to Pedostibes. Not having examined any specimens of the taxa Pedostibes kempi and P. everetti, which were ascribed to Pedostibes earlier, Chan et al. (2016) made an explicit remark on their uncertain generic status, and provisionally allocated them to the genera Pedostibes and Rentapia respectively. Although Chan et al. (2016) provided evidence for differentiation of the “Indian” and Sundaic lineages, they did not provide a comprehensive description of the included taxa. Thus, even after the rearrangement by Chan et al. (2016), the genus Pedostibes still shows a disjunct pattern in geographic distribution with two representative species, P. tuberculatus Günther 1876 and P. kempi (Boulenger 1919) occurring in different biogeographic regions—the Western Ghats and the Garo Hills in the eastern Himalayas (both within the political boundary of India). In order to improve the taxonomic resolution of this group, we present results based on morphological examination of the name-bearing type specimens for all of the relevant taxa from these regions and provide detailed redescriptions of the species along with some justified taxonomic rearrangements. In addition, we provide revised diagnoses to the relevant genera based on (1) osteological characters, (2) refining of species content, and (3) comparison with another recently described Southeast Asian arboreal toad (see Chandramouli et al. 2016) that was not available to Chan et al. (2016).

Materials and Methods

Specimens (including types) of the taxa Pedostibes tuberculatus, P. kempi, Rentapia hosii, R. everetti, R. rugosa, and Bufoides meghalayanus were examined in collections (see Appendix). Museum acronyms follow Sabaj Pérez (2014). We obtained comparable morphometric data and distribution records from examined specimens, as well as available literature (Dinesh and Radhakrishnan 2008; Frost 2015). With a dial caliper (±0.1 mm) and a Leica Wild M3Z dissecting microscope, we measured the following characters (on the left side of the body for symmetric characters): snout–vent length (SVL, from the tip of the snout to the anterior margin of the cloaca), axilla–groin length (from the posterior margin of the forelimb at its insertion point on the body to the anterior margin of the hind limb at its insertion point on the body), head length (HL, from the posterior edge of the mandible to the tip of the snout), head width (HW, the maximum width of the head at the angle of the jaws), head depth (HD, the maximum depth of the head at the region between the eye and the parotoid gland), body width (the maximum width of the body at the trunk), eye diameter (ED, the greatest horizontal diameter of the orbit), eye–nostril length (EN, from the anterior border of the orbit to the middle of the nostril), eye–snout length (ES, from the anterior border of the orbit to the tip of the snout), snout–nostril length (NS, from the tip of the snout to the middle of the nostril), tympanum–eye length (TYE, from the posterior border of the orbit to the anterior border of the tympanum), upper eyelid width (UEW, the maximum width of the upper eyelid), interorbital distance (IO, the shortest distance between the dorso-medial margins of the orbits), internarial distance (IN, the shortest distance between the dorsal margins of the nostrils), tympanum diameter (TYD, the greatest horizontal diameter of the tympanum), upper arm length (on the dorsal surface, from the axilla to the inflection of the flexed elbow), lower arm length (LAL, on the dorsal surface, from the posterior margin of the elbow while flexed
to the base of the outer metacarpal tubercle, palm length (PAL, from the posterior border of the outer metacarpal tubercle to tip of the longest finger), femur length (FEL, from the anterior margin of the hind limb at its insertion point on the body to the knee while flexed), tibia length (TBL, from the posterior surface of the knee while flexed to the base of the heel), foot length (FOL, from the base of the inner metatarsal tubercle to the tip of the longest toe), parotoid gland length (PL, the maximum length of the parotoid gland), parotoid gland width (PW, the maximum width of the parotoid gland), and finger and toe lengths (from the tip of the disc to the nearest fork).

A subset of the above measurements (SVL, HL, HW, HD, ED, EN, ES, IO, IN, TYD) was log transformed and subjected to principal components analysis (PCA). Juvenile specimens were excluded from the analysis. Statistically informative tests were not performed on the holotype specimen of Rentapia everetti because it is a subadult specimen. However, extensive comparisons of its morphological characters were made. The data from the R. rugosa holotype were used. The resulting component scores were plotted to examine the distribution of the specimens in multivariate morphological space. A distribution map of these taxa was prepared based on relevant published literature, type localities, and additional collection localities of specimens examined and those of the corresponding species listed in the VertNet database (available at http://portal.vertnet.org/).

One specimen each of Pedostibes tuberculatus and Butofoides meghalayanus was cleared and stained for studying osteological features (following Hanken and Wassersug 1981). The clear-stained specimens were then examined under an illuminated microscope in order to describe the skeletal traits.

**RESULTS**

The PCA of the morphometric data extracted factors that, taken together, explained 97.55% of the variance observed between the samples and separated them into three discrete clusters (Table I; Fig. 1), each pertaining to a particular genus from separate geographic regions. The first cluster comprises the taxa Butofoides Pillai and Yazdani 1973 and Pedostibes kempi from northeastern India. The second cluster consists of only the type species, P. tuberculatus, from the Western Ghats. The third cluster includes the specimens of Rentapia hosii from different parts of Southeast Asia (see Appendix) and the holotype of R. rugosa. Our analysis of morphological data (Table 2) reveals that the specimens allocated to the taxon P. tuberculatus show a distinct morphological separation from P. kempi which, in turn, clusters together with a morphologically similar and geographically proximate taxon, Butofoides meghalayanus (Yazdani and Chanda 1971) from Khasi Hills in the eastern Himalayas. Rentapia hosii and R. rugosa collectively show a morphological separation from the above two clusters (P. tuberculatus and Butofoides + P. kempi).

In addition to the morphometric differences detailed above, Pedostibes tuberculatus is distinguished from P. kempi in having an exposed tympanum (vs. concealed in P. kempi and Butofoides) and from both Rentapia hosii and R. rugosa by the absence of a sharp tarsal fold (vs. present and well-defined). Moreover, we observed the following differences in osteological characters (Fig. 2). Pedostibes tuberculatus and R. hosii have eight presacral vertebrae while Butofoides meghalayanus has seven; sternum is bony in P. tuberculatus while cartilaginous in R. hosii and B. meghalayanus. Terminal phalanges in both fingers and toes are widely expanded to truncate discs in P. tuberculatus, relatively narrower in R. hosii, and with rudimentary expansions in B. meghalayanus. Frontoparietal elements of the skull are long and narrow in P. tuberculatus, trapezoidal with a much broader posterior than anterior end in Rentapia, and ovoid in Butofoides.

Based on our results and the above criteria, we hereby restrict the genus Pedostibes to its type species, P. tuberculatus, from the Western Ghats, southern India. Our results show that the eastern Himalayan taxon, P. kempi, exhibits morphological characters similar to, and diagnostic of, the genus Butofoides Pillai and Yazdani 1973. Based on our examination of the type specimens, we transfer P. kempi to Butofoides. An examination of the types of the geographically sympatric taxa Rentapia everetti and R. rugosa did not reveal any morphological characters that serve to separate these two nominal species. Therefore, we synonymize Rentapia rugosa with R. everetti in accordance with the principle of priority (ICZN 1999: Article 23).

**SYSTEMATICS**

**Bufonidae Gray 1825**

**Pedostibes Günter 1876**

(Tables 2, 3; Figs. 2–4)

**Type species.—**Pedostibes tuberculatus Günter 1876 (by monotypy).

**Diagnosis (redefined herein).—**The genus Pedostibes is diagnosed by having small to moderate adult body size of SVL 35.0–47.2 mm; absence of cephalic ridges; presence of short, rounded parotoid glands; presence of an externally visible tympanum; presence of eight presacral vertebrae; a bony sternum; digit tips widely expanded to spatulate discs with truncate anterior ends; short and broadly expanded sacral diaphysis; absence of tarsal folds; glandular texture of the dorsal skin; presence of partial webbing on fingers and complete webbing on toes (Table 2).

**Comparison.—**The genus, Pedostibes, a member of the largely South Asian Adenominae clade (Boxclaaer et al. 2009), is distinguished from Rentapia and other Asian bufonid genera (comparative traits in parentheses) by having smaller adult body size of SVL 35.0–47.2 mm (52.3–99.5 mm in Rentapia; up to 215 mm in Phrynoidis [iide Malkmus et al. 2002]); absence of cephalic ridges (present in some species of Duttaphrynus, Adenomus, and Xanthophryne); presence of short, rounded parotoid glands (absent in Sabahphrynus); presence of an externally visible tympanum (concealed in Sabahphrynus and Butofoides); presence of partial webbing on fingers (absent in Duttaphrynus, Xanthophryne, Adenomus, Ghatophryne, and Phrynoidis); and glandular texture of the dorsal skin (smooth or granular in Rentapia, Xanthophryne, Adenomus, Ghatophryne, Butofoides, and Phrynoidis).
Chandramouli and Amarasinghe.—Taxonomy of Pedostibes

Table 1.—Factor loadings and the percentage of variance explained by a principal components analysis of morphometric values from five species of arboreal toads in Southeast Asia.

<table>
<thead>
<tr>
<th>Trait</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVL</td>
<td>0.33</td>
<td>0.00</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>HL</td>
<td>0.33</td>
<td>-0.02</td>
<td>-0.20</td>
<td>-0.41</td>
<td>-0.06</td>
</tr>
<tr>
<td>HW</td>
<td>0.33</td>
<td>0.06</td>
<td>-0.19</td>
<td>-0.43</td>
<td>0.08</td>
</tr>
<tr>
<td>HD</td>
<td>0.32</td>
<td>-0.29</td>
<td>-0.25</td>
<td>0.13</td>
<td>-0.33</td>
</tr>
<tr>
<td>ED</td>
<td>0.32</td>
<td>-0.19</td>
<td>-0.39</td>
<td>-0.02</td>
<td>0.35</td>
</tr>
<tr>
<td>EN</td>
<td>0.31</td>
<td>0.12</td>
<td>0.35</td>
<td>-0.06</td>
<td>-0.44</td>
</tr>
<tr>
<td>ES</td>
<td>0.33</td>
<td>0.10</td>
<td>0.21</td>
<td>-0.32</td>
<td>-0.14</td>
</tr>
<tr>
<td>IO</td>
<td>0.31</td>
<td>-0.12</td>
<td>0.52</td>
<td>0.18</td>
<td>0.67</td>
</tr>
<tr>
<td>IN</td>
<td>0.29</td>
<td>0.82</td>
<td>-0.23</td>
<td>0.42</td>
<td>0.02</td>
</tr>
<tr>
<td>TYD</td>
<td>0.31</td>
<td>-0.41</td>
<td>-0.04</td>
<td>0.56</td>
<td>-0.26</td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>8.88</td>
<td>0.35</td>
<td>0.22</td>
<td>0.17</td>
<td>0.15</td>
</tr>
<tr>
<td>% variance</td>
<td>85.77</td>
<td>3.47</td>
<td>2.18</td>
<td>1.66</td>
<td>1.47</td>
</tr>
</tbody>
</table>

* SVL = snout–vent length, HL = head length, HW = head width, HD = head depth, ED = eye diameter, EN = eye–nose length, ES = eye–snout length, IO = interorbital distance, IN = internarial distance, TYD = tympanum diameter.

Redescription based on a voucher specimen (Wildlife Institute of India, Dehradun, India [WIJ 38.6.91 from Tamil Nadu, India].)—An unsexed adult, SVL 47.2 mm. Head slightly convex, smooth, and wider than long (HL 84.0% of HW, 25.0% of SVL), lacking cranial ridges. Nostril oval in shape, laterally oriented, with a slender inner margin. Internarial area smooth and concave. Canthal ridges weakly defined and rounded in dorsal aspect. Snout smooth, flat in lateral aspect and pointed in dorsal aspect (ES 35.8% of HL, 9.0% of SVL). Nostril to snout distance less than distance between eye and nostril (NS 3.0% of EN). Loreal region vertically oval. Parotoid glands weakly distinct, rounded, width less than interorbital width (IN 9.0% of SVL). Nostril to snout distance less than distance between eye and nostril (NS 3.0% of EN). Loreal region oblique and smooth. Large distinctly visible tympanum, vertically oval. Parotoid glands weakly distinct, rounded, small, smooth and undivided (unlobulated). Interorbital area flat, broad and smooth, IN less than interorbital width (IN 52.8% of IO). Upper eyelids concave, their outer edges rounded, width less than interorbital width.

Lower arm shorter than head (LAL 112.0% of HL, 28.0% of SVL). Fingers with basal webbing and tips of fingers sharp and smooth, Finger III the longest. Finger I slightly shorter than II. Relative length of fingers I < II < IV < III. Terminals with widely expanded discs; base of the Finger IV with a large, flat, oval outer metacarpal tubercle.

Femur and tibia equal in length (FEL 46.0% of SVL). Foot length shorter than TBL (FOL 104.5% of TBL, 47.0% of SVL). Two metatarsal tubercles present, a larger lateral tubercle and a smaller medial tubercle; tarsal ridge absent. Toe IV the longest. Toes completely webbed; the dorsal and ventral surfaces of all toes smooth, their tips rounded.

Skin structures.—Dorsal skin glandular in texture; not warty. Small globular glandules present on the dorsal and dorso-lateral regions, more intensely on posterior than on anterior part. Ventral surface with small warts, less dense on anterior and posterior ends but intense on the belly. Groin and undersurfaces of the thigh smooth.

Coloration (in preservative).—Pale brown above with dark and white marbled pattern along the flanks; ventral surfaces with marbled pattern.

Distribution.—Pedostibes is endemic to the Western Ghats of Peninsular India and has been recorded from localities between the Agasthyamalai Hills (8.50°N, 77.47°E, 1000 m elevation; in all cases, datum = WGS84) in the south, northward to Amboli (15.96°N, 73.99°E, 744 m elevation) in the northern portion of the Western Ghats (Fig. 4; Dinesh and Radhakrishnan 2008).

Included species.—Pedostibes tuberculosa Günther 1876 (within the genus Pedostibes being monotypic).

Rentapia Chan, Grismer, Zacharia, Brown, and Abraham 2016

Table 2.—Comparison of the characters of the morphologically similar species of arboreal toads formerly assigned to the genus Pedostibes.

<table>
<thead>
<tr>
<th>Character</th>
<th>Pedostibes tuberculosa (n = 3)</th>
<th>Rentapia hosii (n = 43)</th>
<th>Rentapia everetti (n = 2)</th>
<th>Bufoides kempi (n = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type locality</td>
<td>“Malabar,” South India</td>
<td>Mt. Duitl, Borneo</td>
<td>Mt. Kinabalu, Borneo</td>
<td>Tura, Garo Hills, Northeast India</td>
</tr>
<tr>
<td>Adult snout–vent length (mm)</td>
<td>35.0–47.2</td>
<td>52.3–99.5</td>
<td>74.3 (n = 1)</td>
<td>17.3–29.8</td>
</tr>
<tr>
<td>Cephalic ridges</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Parotoid glands</td>
<td>Short and round</td>
<td>Elongated</td>
<td>Oval</td>
<td>Elliptical</td>
</tr>
<tr>
<td>Tympanum</td>
<td>Distinct</td>
<td>Distinct</td>
<td>Moderately distinct</td>
<td>Hinnen</td>
</tr>
<tr>
<td>Tarsal folds</td>
<td>Absent</td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Dorsal skin</td>
<td>Glandular</td>
<td>Smooth</td>
<td>Granular</td>
<td>Granular</td>
</tr>
<tr>
<td>Webbing on fingers</td>
<td>Partial</td>
<td>Basal</td>
<td>Basal</td>
<td>Basal</td>
</tr>
<tr>
<td>Webbing on toes</td>
<td>Fully</td>
<td>Fully</td>
<td>Fully</td>
<td>3/4</td>
</tr>
<tr>
<td>Throat</td>
<td>Granular</td>
<td>Granular</td>
<td>Smooth</td>
<td>Granular</td>
</tr>
</tbody>
</table>
partial webbing on fingers (absent in Phrynoidis) and complete webbing on toes (incomplete webbing in Sabahphrynus); presence of eight presacral vertebrae (vs. seven in Bufoides and six in Blythophryne); presence of a tarsal ridge (absent in Pedostibes and Bufoides); and smooth or rugose texture of the dorsal skin (granular in Phrynoidis; glandular in Pedostibes).

**Distribution.**—Rentapia occurs in Peninsular Thailand, Malaysia, Borneo, and Sumatra (Fig. 4; Frost 2015; Chan et al. 2016).

**Included species.**—Rentapia hosii (Boulenger 1892) and R. everetti (Boulenger 1896).

Rentapia hosii (Boulenger 1892)

Nectophryne hosii Boulenger 1892:508.


Pedostibes hosei—Inger (1966:9).


**Diagnosis.**—Rentapia hosii is distinguished by having large adult body size of SVL 52.3–99.5 mm, absence of cephalic ridges, presence of elongated parotoid glands, presence of an externally visible tympanum, presence of tarsal folds, smooth texture of the dorsal skin, presence of basal webbing on fingers and complete webbing on toes, and granular texture of the throat skin (Table 2).
FIG. 2.—Cleared and stained specimens of *Pedostibes tuberculosis* (first column), *Rentapia hosii* (second column), and *Bufoides meghalayanus* (third column) showing dorsal views of the following skeletal characters: skull and vertebral column (A–C), pectoral girdle (D–F), feet (G–I), and hand (J–L). FP = frontoparietal; SD = sacral diapophysis; CL = clavicle; COR = coracoid; ST = sternum. A color version of this figure is available online.
Redescription of holotype.—An adult male SVL of 59.8 mm. Head slightly concave, smooth and wider than long (HL 96.7% of HW, 29.9 of SVL). Nostril oval in shape, laterally oriented, with a slender inner margin. Intermarginal area smooth and concave. Canthal ridges prominently defined and rounded in dorsal aspect. Snout smooth, rounded in lateral aspect and pointed in dorsal aspect. Snout with tiny warts, flat and posteriorly smooth. Both sides of the gape without warts, and distal edges of lower and upper jaws are smooth. Anterior end of mandible with symphysis knob. Axilo-to-groin area smooth. Middorsal area smooth and larger warts present on lateral and posterior parts of the body. Both dorsal and ventral surfaces of arms covered with sharp and rough small warts on dorsal aspect. Thigh relatively smooth on both anterior and posterior surfaces.

**Skin structures.**—Throat rough and granulated, but belly smooth. Both sides of the gape without warts, and distal edges of lower and upper jaws are smooth. Anterior end of mandible with symphysis knob. Axilo-to-groin area smooth. Middorsal area smooth and larger warts present on lateral and posterior parts of the body. Both dorsal and ventral surfaces of arms covered with sharp and rough small warts on dorsal aspect. Thigh relatively smooth on both anterior and posterior surfaces.

**Coloration (in preservative).**—Dorsum uniform with olive brown; dorsal surfaces of limbs without any bars; all ventral surfaces similar to dorsal coloration, except for a darker throat.

**Variation.**—In some live specimens from East Kalimantan, we observed a dark variegated skin color pattern in Rentapia hosii.

**Distribution.**—Rentapia hosii occurs in peninsular Thailand, Malaysia, Borneo, and Sumatra (Fig. 4; Frost 2015).

**Rentapia everetti** (Boulenger 1896)

**Nectophryne everetti** Boulenger 1896:450.

**Pedostibes everetti**—(Barbour 1938:192).

**Pedostibes rugosus** Inger 1958:476–478 syn. nov.

**Rentapia rugosus**—Chan et al. 2016:9,11.

**Rentapia rugosa**—Chandramouli and Amarasinghe (2016) [this work].

**Holotype of Nectophryne everetti.**—A subadult male (BMNH 1947.2.18.27; formerly 96.4.29.13), “Mount Kina Balu, North Borneo,” Sabah, East Malaysia (Borneo).

**Nomenclatural note.**—When transferring the taxon Pedostibes rugosus Inger 1958 to the genus Rentapia, Chan et al. (2016) used the combination Rentapia rugosus (sic.). According to the International Code of Zoological Nomenclature (ICZN 1999) Articles 30 and 31, the generic name Rentapia erected by these authors is feminine in gender. Because the specific epithet, rugosus, is an adjective in masculine gender, referring to the rugose texture of its skin, we amend it here as Rentapia rugosa, in accordance with the Article 31.2 (Agreement in Gender).

**Diagnosis.**—Rentapia everetti is distinguished by having large adult body size of SVL 74.3 mm, absence of cephalic ridges, presence of oval parotoid glands, presence of an externally visible tympanum, presence of tarsal folds, granular texture of the dorsal skin, presence of basal webbing on fingers and complete webbing on toes, and smooth texture of the throat skin (Table 2).

**Redescription of the holotype of Nectophryne everetti.**—A subadult male SVL of 33.0 mm. Head slightly concave, wider than long (HW 118.5% of HL, 34.8% of SVL) and with numerous tiny round warts. Nostril round in shape, laterally oriented, with a slender inner margin. Intermarginal area concave with numerous tiny round warts. Nostril round in shape, flat and posteriorly smooth. Both sides of the gape without warts, and distal edges of lower and upper jaws are smooth. Anterior end of mandible with symphysis knob. Axilo-to-groin area smooth. Middorsal area smooth and larger warts present on lateral and posterior parts of the body. Both dorsal and ventral surfaces of arms covered with sharp and rough small warts on dorsal aspect. Thigh relatively smooth on both anterior and posterior surfaces.

**Coloration (in preservative).**—Dorsum uniform with olive brown; dorsal surfaces of limbs without any bars; all ventral surfaces similar to dorsal coloration, except for a darker throat.

**Variation.**—In some live specimens from East Kalimantan, we observed a dark variegated skin color pattern in Rentapia hosii.

**Distribution.**—Rentapia hosii occurs in peninsular Thailand, Malaysia, Borneo, and Sumatra (Fig. 4; Frost 2015).

**Rentapia everetti** (Boulenger 1896)

**Nectophryne everetti** Boulenger 1896:450.

**Pedostibes everetti**—(Barbour 1938:192).

**Pedostibes rugosus** Inger 1958:476–478 syn. nov.

**Rentapia rugosus**—Chan et al. 2016:9,11.

**Rentapia rugosa**—Chandramouli and Amarasinghe (2016) [this work].

**Holotype of Nectophryne everetti.**—A subadult male (BMNH 1947.2.18.27; formerly 96.4.29.13), “Mount Kina Balu, North Borneo,” Sabah, East Malaysia (Borneo).

**Nomenclatural note.**—When transferring the taxon Pedostibes rugosus Inger 1958 to the genus Rentapia, Chan et al. (2016) used the combination Rentapia rugosus (sic.). According to the International Code of Zoological Nomenclature (ICZN 1999) Articles 30 and 31, the generic name Rentapia erected by these authors is feminine in gender. Because the specific epithet, rugosus, is an adjective in masculine gender, referring to the rugose texture of its skin, we amend it here as Rentapia rugosa, in accordance with the Article 31.2 (Agreement in Gender).

**Diagnosis.**—Rentapia everetti is distinguished by having large adult body size of SVL 74.3 mm, absence of cephalic ridges, presence of oval parotoid glands, presence of an externally visible tympanum, presence of tarsal folds, granular texture of the dorsal skin, presence of basal webbing on fingers and complete webbing on toes, and smooth texture of the throat skin (Table 2).

**Redescription of the holotype of Nectophryne everetti.**—A subadult male SVL of 33.0 mm. Head slightly concave, wider than long (HW 118.5% of HL, 34.8% of SVL) and with numerous tiny round warts. Nostril round in shape, laterally oriented, with a slender inner margin. Intermarginal area concave with numerous tiny round warts. Nostril round in shape, flat and posteriorly smooth. Both sides of the gape without warts, and distal edges of lower and upper jaws are smooth. Anterior end of mandible with symphysis knob. Axilo-to-groin area smooth. Middorsal area smooth and larger warts present on lateral and posterior parts of the body. Both dorsal and ventral surfaces of arms covered with sharp and rough small warts on dorsal aspect. Thigh relatively smooth on both anterior and posterior surfaces.

**Coloration (in preservative).**—Dorsum uniform with olive brown; dorsal surfaces of limbs without any bars; all ventral surfaces similar to dorsal coloration, except for a darker throat.

**Variation.**—In some live specimens from East Kalimantan, we observed a dark variegated skin color pattern in Rentapia hosii.

**Distribution.**—Rentapia hosii occurs in peninsular Thailand, Malaysia, Borneo, and Sumatra (Fig. 4; Frost 2015).

**Rentapia everetti** (Boulenger 1896)

**Nectophryne everetti** Boulenger 1896:450.

**Pedostibes everetti**—(Barbour 1938:192).

**Pedostibes rugosus** Inger 1958:476–478 syn. nov.

**Rentapia rugosus**—Chan et al. 2016:9,11.

**Rentapia rugosa**—Chandramouli and Amarasinghe (2016) [this work].
smooth. Small distinctly visible tympanum, vertically oval (TYE 6.9% of HL). Parotoid glands elongated, narrow (posteriorly wider), rough and undivided (unlobulated; PW 39.5% of PL; PL 37.4% of HL). Interorbital area flat and with tiny warts, internarial distance less than interorbital width (IN 40.5% of IO). Upper eyelids concave, their outer edges sharp, width less than interorbital width (UEW 72.9% of IO).

Lower arm shorter than head (LAL 71.3% of HL, 24.8% of SVL). Fingers with basal webbing, web reaching subarticular tubercle of Finger I, beyond basal subarticular tubercle on lateral edge of II. Tips of fingers sharp and smooth, with Finger III being the longest (FL3 51.8% of PAL, 67.1% of LAL, 137.5% of ES). Finger I shorter than II (FL1 40.5% of FL2). Relative length of fingers I < II < IV < III, a nuptial pad on dorsal side of Finger I. Subarticular tubercles on fingers rounded; two palmar tubercles, the lateral one larger than the medial.

Femur shorter than tibia in length (FEL 34.8% of SVL). Foot length shorter than TBL (FOL 83.7% of TBL, 39.1% of SVL). Two metatarsal tubercles present, the medial one oval, the lateral one rounded; tarsal ridge present. Toe IV the longest (TL4 47.3% of FOL, 53.0% of HL, 174.3% of ES, 164.8% of TL3). Toes completely webbed, the dorsal and ventral surfaces of all toes smooth, their tips rounded. Relative length of Toes I < II < III < V < IV.

Skin structures.—Throat smooth and not granulated, belly smooth. Both sides of the gape without warts, and distal edges of lower and upper jaws are smooth. Anterior end of mandible with symphysial knob. Axilla-to-groin area is smooth. Middorsal area, lateral and posterior parts of the body present with larger warts. Both dorsal and ventral surfaces of arms covered with sharp and rough small warts on dorsal aspect. Thigh comparatively smooth on both anterior and posterior surfaces.

Coloration (in preservative).—Dorsum bluish grey and limbs light brown; back with many dark brown blotches, lateral surfaces of head with broad, dark brown bars; dorsal surfaces of limbs cross barred; all ventral surfaces immaculate cream-colored.

Distribution.—Rentapia everetti occurs in Borneo (Fig. 4; Frost 2015).
Bufoides Pillai and Yazdani 1973
(Table 2; Figs. 2–4)

Type species.—Ansonia meghalayana Yazdani and Chanda 1971.

Diagnosis (redefined herein).—A genus of small-bodied (SVL 29.8–47.2 mm), rupicolous toads, characterized by presence of supraorbital, preorbital, and postorbital ridges on the top of the head; presence of short, oval-shaped parotoid glands; absence of an externally visible tympanum; digit tips with rounded, poorly dilated discs; presence of seven presacral vertebrae; presence of a cartilaginous sternum; granular texture of the dorsal skin; absence of tarsal folds; and presence of basal webbing on fingers and complete webbing on toes (Table 2).

Comparison.—Bufoides can readily be distinguished from other oriental bufonid genera (characters in parentheses) by the absence of an externally visible tympanum (exposed in Pedostibes, Blythophryne, Parapelophryne, and Rentapia); presence of parotoid glands (absent in Parapelophryne and Pelophryne); presence of cranial ridges (absent in Pedostibes, Blythophryne, Parapelophryne, and Rentapia); poorly developed digital discs on fingers and toe tips (well developed, widely dilated discs in Pedostibes, Blythophryne, and Rentapia); presence of seven presacral vertebrae (six in Blythophryne, eight in Pedostibes, Parapelophryne, and Rentapia); granular skin texture (glandular in Pedostibes); and the absence of tarsal folds (present in Rentapia).

Distribution.—Bufoides in restricted in distribution to the Garo and Khasi hills of the eastern Himalayas, with one species occurring on each of these hill ranges.

Included species.—Bufoides kempi (Boulenger 1919) comb. nov. and Bufoides meghalayanus (Yazdani and Chanda 1971).

Bufoides kempi (Boulenger 1919) comb. nov.
(Table 2; Figs. 3, 4)

Diagnosis.—*Bufoides kempi* is diagnosed by small to moderate body size (SVL 17.4–29.8 mm); presence of nonkeratinized cranial ridges; presence of short, oval-shaped parotoid glands; absence of an externally visible tympanum; moderate degree of webbing on toes and basal webbing on fingers, with poorly developed terminal discs without lateral expansions.

Redescription of the syntypes.—Characters of Zoological Survey of India, Kolkata, India (ZSI) 18481A followed, when appropriate, by those of ZSI 18481B in parentheses. An adult and a subadult (unsexed) specimen, each measuring 29.8 mm (17.4 mm) SVL; head distinct from body, broader than long. HL 89.0% (87.0%) of HW, 30.0% (33.0%) of SVL. Nostril to snout distance less than distance between eye and nostril, NS 33.0% (23.0%) of EN. Snout rounded in dorsal and truncate in lateral views; canthal fold not pronounced. Loreal region flat; top of the snout concave; tympanum absent; a large conical tubercle present at the jaw angle. Parotoid glands lobulated, short, and bean-shaped, extending from the postorbital region to the axillary region on the dorsum. Interorbital space broader than internarial distance, IN 49.0% (64.0%) of IO. Upper eyelids with dense granules; narrower than interorbital distance.

Lower arm longer than head, LAL 139.0% (115.0%) of HL, 24.0% (26.0%) of SVL. Fingers webbed at the base, fingertips with small discs at tips, damaged and broken in the larger specimen. A large outer palmar tubercle present at the base of the palm.

Femur longer than tibia in the smaller specimen, FEL 57.0% (43.0%) of SVL, tibia broken in the larger syntype. Two oval metatarsal tubercles present; inner one larger than outer; tarsal ridge not discernable. Most of the toes damaged in both the specimens but the left foot of the smaller specimen shows partial webbing between Toes II and III, extending half the length of Toe III and similarly on Toe IV; toe tips with small discs.

Skin structures.—Dorsum granular with small conical warts scattered throughout; more intense toward lateral area than on the dorsal region. Venter with similar granules of smaller size; more intense on the posterior than on anterior end.

Coloration in preservative.—The larger of the two syntypes olive brown above with dark black flanks; the smaller specimen uniform black throughout; undersides without pattern, black in both specimens.

Distribution.—This species is known only from its type locality, Tura, in the Garo Hills of northeastern India.

*Bufoides meghalayana* (Yazdani and Chanda 1971)  
*Ansonia meghalayana* Yazdani and Chanda 1971.

Diagnosis.—*Bufoides meghalayana* is diagnosed by small to moderate adult size (SVL 31.2–47.2 mm); presence of pre-, post-, and supraorbital ridges on the head; presence of short, oval-shaped parotoid glands; absence of an externally visible tympanum; digit tips with rounded, poorly dilated discs; granular texture of the dorsal skin; absence of tarsal folds; presence of basal webbing on fingers and nearly complete webbing on toes, with poorly developed terminal discs.

Description of a voucher specimen (WII uncatalogued, from Khasi Hills, Meghalaya, India).—An unsexed adult, SVL of 31.2 mm. Head depressed, a little broader than long (HL 110.0% of HW; 35.0% of SVL); snout projecting beyond mandible, with a rounded tip in both dorsal and lateral views (ES 39.0% of HL; 14.0% of SVL); nostrils pointing downward, located midway between eyes, a little closer to snout tip than to the eyes (NS 202.0% of EN); loreal region slightly concave with an indistinct canthal fold. Preorbital, postorbital, and supraorbital ridges on the head prominent; not keratinized. Loreal and internarial regions concave. Tympanum absent; parotoid glands slender and slightly elongate (PW 13.0% of PL; PL 45.0% of HL); extending downward from the postorbital ridge. Interorbital distance greater than upper eyelid width (IN 58.0% of IO).

Lower arm much shorter than the head (LAL 70.0% of HL); palm as long as the upper arm, with fleshy webbing extending only to the base of the fingers; relative lengths of fingers I < II < IV < III. Subarticular tubercles on fingers indistinct, outer palmar tubercle large and distinct.

Femur a little longer than the tibia (FEL 43.0% of SVL); foot nearly as long as tibia length (FOL 97.0% of TBL, 39% of SVL). Two metatarsal tubercles present, the medial one oval, the lateral one rounded; tarsal ridge absent. Toes with well-developed webbing; their relative lengths I < II < III < V < IV; digit tips with small fleshy discs without expanded terminal phalanges.

Skin structures.—Dorsum with small, almost uniform granular warts scattered all over the body; arms and legs. Ventral surfaces rough with granules sparsely distributed in the anterior region from the chin, across the throat to the axilla; densely granulated posteriorly.

Coloration in preservative.—Dorsum without pattern, uniform greyish brown; venter pale white in color throughout.

Distribution.—*Bufoides meghalayana* has been recorded from a few localities in the Khasi Hills of Meghalaya near Mawblang, Cherrapunji. Other records from this region were provided by Deuti et al. (2012).

Discussion

After Boulenger (1892, 1896) described *Nectophryn e hosii* and *N. everetti*, Inger (1958) described *Pedostibes rugosus* from “Mennuag, headwaters of the Baleh River” in Sarawak, based on a male holotype (Field Museum of Natural History, Chicago, USA [FMNH] S1297) and a female paratype. This taxon was diagnosed solely on the presence of “large oval parotoid glands, numerous round warts dorsally, and a sharp tarsal fold.” Upon describing this taxon, Inger (1958) remarked that only two species of *Pedostibes*, *P. hosii* and *P. rugosus*, have a sharply defined tarsal fold; thus, he eliminated *P. tuberculosus* from further comparisons and distinguished *P. rugosus* from *P. hosii* based on a set of characters. Two more congeners (after Barbour 1938), *P. kempi* and *P. everetti*, were neither mentioned nor compared. Among them, *P. kempi* is easily distinguishable from the rest of the species by lacking an externally visible tympanum (Boulenger 1919).

The diagnostic characters of *Pedostibes rugosus* in its original description coincide with those described for the taxon *P. everetti* by Boulenger (1896), which was apparently overlooked. Additionally, the type localities of these two taxa (i.e., “Mennuag, headwaters of the Baleh River” for *P. rugosus* and “Mt. Kina Balu, north Borneo” for *P. everetti*)
are situated within the same biogeographical region of Borneo (Fig. 4). Malkmus et al. (2002) remarked on the similarity between \textit{P. rugosus} and \textit{P. everetti}, and cited Manthey and Grossman (1997), who suggested that none of the diagnostic characters of \textit{P. rugosus} were distinct from character states exhibited by \textit{P. everetti}. Although Inger (1966) mentioned additional morphological differences between \textit{P. rugosus} and \textit{P. everetti}, our reexamination of their type specimens leads us to conclude that Inger's (1966) characters are not sufficiently diagnostic to distinguish those species. This is further supported by the fact that \textit{P. everetti} has seldom been mentioned in field-based scientific studies since the name \textit{Pedostibes rugosus} came into being, essentially concealing the former taxon (e.g., see Das 2007; Matsui et al. 2007, 2015; Pyron and Wiens 2011; Ron et al. 2015). Our reexamination of the type specimens (BMNH 1947.2.18.27 and FMNH 81297, respectively) and original descriptions of these two taxa support Manthey and Grossman (1997) in that the morphological distinction between \textit{P. rugosus} and \textit{P. everetti} is effectively absent.

In the original description of \textit{Nectophryne kempi}, Boulegger (1919) distinguished it from "congeners" based on the following diagnostic characters: tympanum hidden; fingers with feebly dilated, truncated tips, 1/3 webbed; toes 3/4 webbed, tips rounded but not dilated; two small metatarsal tubercles, absence of tarsal fold; presence of prominent parotoid glands; and large, yellowish axillary spots. He also remarked on the similarity of \textit{N. kempi} with \textit{N. maculata} in lacking an externally visible tympanum (Boulegger 1919). Barbour (1938: 192) transferred \textit{N. kempi} to \textit{Pedostibes} with some degree of caution by stating "The four species of \textit{Pedostibes} first mentioned and possibly this fifth one as well [\textit{P. kempi}] are alike..." where he refers to the taxa \textit{P. tuberculatus}, \textit{P. hosii}, \textit{P. everetti}, and \textit{P. altitudinis} [the lattermost of which currently represents a synonym of an unrelated species, \textit{Ansonia fuliginea} (Mocquard 1890); see Frost 2015]. Additionally, even after revising \textit{Pedostibes}, Chan et al. (2016) attributed the "Indian" species \textit{kempi} to this genus, making a remark on the uncertainty of this allocation. Moreover, limited taxon sampling has hindered Chan et al. (2016) from comparing this taxon with the other arboreal toad genus \textit{Bufoides} from the eastern Himalayan region.

When erecting it for the taxon \textit{Asonia meghalayana}, Yazdani and Chanda 1971, Pillai and Yazdani (1973) characterized the genus \textit{Bufoides} based on the presence of cranial ridges, unwebbed fingers with dilated tips, almost fully webbed toes, and a concealed tympanum. Das et al. (2009) procured further specimens of \textit{B. meghalayana} from the type locality and identified an unstudied diversification within \textit{Bufoides} endemic to India by referring to specimen MFA 10134 collected from Tura, Garo Hills (the type locality of \textit{Nectophryne kempi}), which is not conspecific with \textit{B. meghalayana}. Prompted by its provenance, we suspect that this specimen could possibly represent the taxon \textit{kempi}. Furthermore, Das et al. (2009) identified a discrepancy from the original description, that the type series of \textit{B. meghalayana} has well-developed parotoid glands. Thus, both the taxa \textit{Pedostibes kempi} and \textit{B. meghalayana} share the following suite of morphological characters considered to be diagnostic: absence of an externally visible tympanum, presence of parotoid glands, and well-developed webbing in toes. The two species occur in two different hill ranges, however: \textit{B. kempi} from Tura, Garo Hills and \textit{B. meghalayana} from Mawbiang, Khasi Hills. Our reexamination of the specimens of these two taxa complies with the above-mentioned set of similarities. Hence, we transferred the taxon \textit{Pedostibes kempi} to the genus \textit{Bufoides} in the new combination, \textit{Bufoides kempi}. Whether \textit{B. meghalayana} and \textit{B. kempi} represent the same species or not, however, is a question that remains open for further research. Pending collection of new specimens referable to \textit{P. kempi} from the Garo Hills, we take a conservative stand and retain them to be specifically distinct.

The systematic status of the South and Southeast Asian \textit{bufonids} at the generic level has long been problematic, as interpreted from the following examples. Once considered to be globally distributed, the genus \textit{Bufo} Garsault 1764 was subjected to several systematic and taxonomic studies resulting in the reevaluation and recognition of several valid genera such as \textit{Adenomus}, \textit{Duttaphrynus}, \textit{Ingerophrynus}, \textit{Phrynoidis}, \textit{Vandijkophrynus}, and \textit{Xanthophryne} (see Manamendra-Arachchi and Pethiyagoda 1998; Frost et al. 2006; Biju et al. 2009). All of these clades show a narrow, finite geographic distribution range (\textit{Adenomus}: Sri Lanka; \textit{Duttaphrynus}, \textit{Ingerophrynus}, and \textit{Phrynoidis}: South and Southeast Asia; \textit{Vandijkophrynus}: South Africa; and \textit{Xanthophryne}: northern portion of the Western Ghats in peninsular India; Frost 2015). Similar cases are also known for certain genera that were once considered to be widely distributed, with some species showing disjunct distribution ranges. Examples include the transfer of \textit{Ansonia ornata} Günther 1876 to \textit{Ghatophryne} by Biju et al. (2009), and validation of \textit{Pedostibes} from the synonymy of \textit{Nectophryne} Buchholz and Peters 1875 by Barbour (1938). Frost (2015) suggested a similar scenario for \textit{Pedostibes} according to its current definition by stating that, instead of providing a taxonomic remedy, Pyron and Wiens (2011) embraced a polyphyletic \textit{Pedostibes}. Chan et al. (2016) also commented on the problem of a polyphyletic \textit{Pedostibes}, and suggested generic transfer of the taxa \textit{hosii} and \textit{rugosus} to \textit{Phrynoidis}, although they were not transferred formally. Chan et al. (2016) resolved this problem by erecting a new generic name \textit{Rentapia} for the Sundiac species \textit{hosii}, \textit{everetti}, and \textit{rugosus}. Because Chan et al. (2016) did not present a comprehensive taxon-sampling (e.g., \textit{Bufoides}) or examination of the name-bearing types, they provided some tentative conclusions at both generic and specific levels in some cases. Chan et al. (2016) expressed uncertainty with such species and thus made some provisional rearrangements within this clade. Our reexamination of the types and other material has revealed finer patterns within this group, and led to a few other taxonomic rearrangements.

Acknowledgments.—SRC thanks Wildlife Institute of India for the award of a junior research fellowship. AA thanks the Ministry of Research and Technology of the Republic of Indonesia, particularly S. Walyono and L. Shalahuddin, for granting research permit; R. Ubaidillah, A. Hanidy, Syaripudin, W. Trilaksana, and other staff members of Museum Zoologicum Bogoriense, Bogor, Indonesia (MZB), and P.D. Campbell of BMNH for facilitating in-house study of specimens under their care. We also thank J. Supriatna and the staff of the Research Center for Climate Change, University of Indonesia, for their support; A. Resetar and R. Grill (FMNH), P.D. Campbell and J. Streecher (BMNH), V. Thakur (vertebrate museum, WII), K. Venkataraman (ZSI), K. Chandra (ZSI), and K. Deuti (ZSI) for access, photographs, and data about the specimens under their care. Finally, we thank the Editor, C.P. Groves, and anonymous reviewers for valuable comments.
Literature Cited


Accepted on 27 January 2016

Associate Editor: Christopher Rayworth

Appendix

Specimens Examined

Buioides kempti (Bouleger 1919).—Garo Hills, Assam, Meghalaya, India: ZSI 18481A–B (syntypes).

Buioides meghalayanus (Yazdani and Chanda 1971).—Meghalaya, Northeast India: WII uncatalogued.

Pedostibles tuberculosus Günther 1876.—Malabar (Western Ghats), South India: BMNH 1947.2.22.70–71 (syntypes); Taman Nadu, South India: WII 38.6.91.

Rentapia everetti (Bouleger 1896).—Mt. Kina Balu, Sahah, Malaysia: BMNH 1947.2.15.27 (holotype); Memang, headwaters of the Boleh River, Third Division, Sarawak, Malaysia: FMNH 51207 (holotype of Pedostibles rugosus Inger 1958).

Rentapia hostii (Bouleger 1892).—Mt. Duitl, Sarawak, Malaysia: BMNH 1947.2.19.29 (holotype); East Kalimantan, Indonesia: MZB 7779, 7780, 7864–67, 8891–99, 8900, 15454, 15455; Central Kalimantan, Indonesia: 3127, 3136, 9091–05, 10804, 10805, 11777, 11778, 10989; West Kalimantan, Indonesia: 4738, 4759, 4761, 7290; South Kalimantan, Indonesia: 6083–89; Aceh, R. Sumatra, Indonesia: BMNH 7756.