



# **Amphibians of the Andaman & Nicobar Islands: distribution, natural history, and notes on taxonomy**

Surendran HARIKRISHNAN<sup>1</sup> & Karthikeyan VASUDEVAN<sup>2\*</sup>

<sup>1</sup>#33, Indian Express Layout, Virupakshapura, Kodigehalli, Bengaluru, Karnataka, India.

<sup>2</sup>Laboratory for Conservation of Endangered Species/CCMB, Hyderguda, Hyderabad  
Telengana, India.

\* Corresponding author. <karthik@ccm.res.in>.

**The Andaman & Nicobar Islands in the Bay of Bengal hosts a little known amphibian fauna. Despite a number of studies on amphibians from these islands in the latter half of the twentieth century, information on distribution, biology and natural history of most species is scanty. As part of a larger ecological study, we undertook surveys in islands across the archipelago. This paper summarizes the information on species distribution from primary surveys, published literature and notes on natural history. We also highlight some of the issues in field identification of some species, stemming from unresolved systematic and taxonomic issues.**

urn:lsid:zoobank.org:pub:24475918-95D5-4C0D-98C5-DEE9AD24CE8F

## INTRODUCTION

Islands were historically not considered amphibian diversity hotspots (Brown & Alcalá 1970; Duellman & Trueb 1994; Inger & Voris 2001; Lomolino 2010). Isolation of islands, freshwater availability and intolerance of amphibians to salinity were all considered reasons behind low species richness of amphibians in islands. Oceans were generally thought to be impassable barrier for natural dispersal of amphibians and presence of amphibians in islands were considered a reflection of past land connectivity to continents. However, several recent studies indicate that oceanic dispersal by amphibians is not as uncommon as once thought to be and that they can host unique amphibian faunas (Evans *et al.* 2003; Vences *et al.* 2003; Bell *et al.* 2015).

The Andaman and Nicobar Island archipelago in the Bay of Bengal hosts a relatively small but distinct herpetofauna, with Indo-Chinese, Sundaland and even Malagasy affinities (Annandale 1917; Smith 1941; Whitaker 1978; Biswas & Sanyal 1980; Das 1994; Das 1999). Although studies on amphibians of these islands began in

the late 19<sup>th</sup> century (Stoliczka 1870; Fitzinger 1860), barring a few sporadic studies through the 20<sup>th</sup> century (Annandale 1917; Cherchi 1954), there was a general lull in exploration and analysis of amphibian fauna in these islands, probably due to the widespread belief that islands have few amphibians. However, in the late 20<sup>th</sup> century, a series of surveys carried out in these islands added several species to the amphibian fauna of Andaman & Nicobar Islands (Pillai 1977; Mansukhani & Sarkar 1980; Pillai & Mehta 1986; Mehta & Rao 1987; Sarkar 1990; Pillai 1991; Das 1994; Das 1995; Das 1996*a*; *b*; Das 1998; Daniels & David 1996). A summary of these past explorations and studies can be found in Das (1999).

Despite the various surveys conducted in the past, the information on distribution and natural history of most species in this archipelago remain scant and there is little information on the island-wise distribution of species. We conducted a preliminary survey in the Nicobar Islands during 2008–2009 (Harikrishnan *et al.* 2011). Following this, in 2010, we initiated intensive surveys in the Andaman and Nicobar Archipelago for terrestrial herpetofauna. This paper summarizes the results of surveys for amphibians across these islands. A closer examination of the amphibian fauna of these islands reveals several issues with the taxonomy and identification of species reported from these islands, often considered conspecific with species found in Southeast Asia. This also indicates that there may be several hitherto unidentified species present in these islands.

## METHODS

### *The Andaman & Nicobar Archipelago*

The Andaman and Nicobar Archipelago is situated in the eastern part of the Bay of Bengal, separated from south-east Asia by the Andaman Sea. There are 512 islands, islets and rocks, in this long island chain covering 8249 km<sup>2</sup> (Anonymous 2013). These islands form parts of two biodiversity hotspots: the Andaman Islands are a part of the Indo-Burma hotspot and the Nicobar Islands are part of the Sundaland hotspot (Myers 2000). These islands are a great arc of mountains (approximately 1126 km long) between Cape Negrais of Myanmar and Achin Head of Sumatra (Smith 1941; Biswas & Sanyal 1980; Das 1999). It is a part of the Great Alpine-Himalayan System (Karunakaran *et al.* 1968). Although they are a result of the north-eastern movement and collision of the Indian tectonic plate into the Eurasian plate, the emergence of these islands above sea level occurred in the Late Miocene, 5–10 million years before present (Lee & Lawver 1995; Voris 2000). The Mentawai Islands, off the coast of Sumatra, appear to be a continuation of the Nicobar Islands (Weeks *et al.* 1967; Rodolfo 1969). Based on the nature of the avian fauna, Ripley & Beehler (1989) suggested that it was possible that the Andaman Islands at their northern tip might have been connected to mainland Asia at some point in the past, which would have enabled the dispersal of amphibians from that region in to the Andaman Islands. The Nicobar Islands appear to be oceanic in nature, having no evidence of ever being connected to other landmasses and surrounded on all sides by deep channels (Ripley & Beehler 1989). The mean annual rainfall in these islands exceeds 3000 mm and wet evergreen forests are predominant across the islands. However, there are 11 major forest types identified in

these island including mangroves, deciduous forests, cane breaks and submontane forests, creating ample habitats for amphibians (Champion & Seth 1968).

Based on their origin and connectivity in the past, these islands can be divided into two major groups: the Andaman Islands in the northern part and the Nicobar Islands in the southern part. Ten-Degree Channel, named so for the latitude at which it is located, separates them. This channel is about 1000 m deep and approximately 140 km wide. This has ensured that the Andaman Islands and the Nicobar Islands remained separated from each other even during maximum sea level drops during the Pleistocene (Lee & Lawver 1995). The deep Andaman Sea on the east separated this island chain from south-east Asia and The Bay of Bengal separates it from the Indian mainland.

Everywhere within the Andaman Islands (with the exception of outlying islands Barren and Narcondam), the sea is relatively shallow (50–100 m), suggesting that all these islands were interconnected during major sea level changes in the Pleistocene. The Nicobar Islands consist of 23 islands south of the Ten Degree Channel. Three clusters of islands can be identified in this group. The northern cluster consists of only two islands, Car Nicobar and Batti Malv. The central cluster is collectively known as Nancowry group and consists of Nancowry, Camorta, Katchal, Trinkat, Bompoka, Terressa, Chowra, Tillangchong, Islets of Mann and Prairie Rock. The southern cluster consists of Great Nicobar, Little Nicobar, Megapode, Pigeon, Kondul, Menchal, Cabra, Meroe, Trac, Treis and Pilo Milo. Great Nicobar is the southernmost island in this group and is only about 300 km north-west of Sumatra.

### *Survey of amphibians*

We carried out intensive surveys in 24 islands the Andaman and Nicobar Archipelago. The distribution of amphibian and reptile species in Andaman and Nicobar Archipelago was assessed through both field surveys and secondary sources (museum specimens and literature). Field surveys were carried from October to June, avoiding peak monsoon. To assess the presence of species in each island bounded quadrat surveys (Harikrishnan & Vasudevan 2015), visual encounter surveys (VES) and pitfall traps with drift fences were used (Crump & Scott 1994; Harikrishnan *et al.* 2012). Each VES was one hour long, where we walked the forests and streams at a slow pace looking for amphibians. VES were carried out after sunset (between 1800–2100 hours). We also used the locality data of specimens in the collection of Zoological Survey of India, Kolkata and Zoological Survey of India, Port Blair. In addition, we used published literature to obtain data on distribution of species. From all such records, we enumerated distribution of species across islands and species richness of each island.

### *Museum abbreviations*

ZMB – Universität Humboldt, Zoologisches Museum, Germany; ZSIC – Zoological Survey of India, Kolkata; ZSI-SRS – Zoological Survey of India, Southern Regional Station, Chennai; MNHNP – Museum National d’Histoire Naturelle, Laboratoire des Amphibiens et Reptiles, Paris; BMNH – The Natural History Museum, London; MSNG – Museo Civico di Storia Naturale Giacomo Doria; FMNH – Field Museum, Division of Amphibians and Reptiles, Chicago; RMNH – Nationaal

Natuurhistorisch Museum, Leiden (now, Naturalis, Leiden); HC & HS – field tag numbers of specimens in the collection at Wildlife Institute of India, Dehradun.

### *Specimens examined*

*Blythophryne beryet* – South Andaman ZSIA–12521– 12530; Little Andaman HC178–183, 186–187, 197–198. *Micryletta inornata* – South Andaman ZSI (Chennai) VA/102. *Duttaphrynus melanostictus* – South Andaman HC043, Little Andaman HC165. *Fejervarya* cf. *cancrivora* – Long Island HC011, South Andaman HC085–HC086, HC091, HC093; Car Nicobar HS52–HS53. *Fejervarya* cf. *nicobariensis* – Camorta HS35–HS36, HS44– HS46. *Chalcorana* cf. *chalconota* – Great Nicobar HS13–HS14. *Amnirana nicobariensis* – Great Nicobar HS18, HS24, HC073–HC074. *Ingerana charlesdarwini* – Long Island HC012, HC016; South Andaman HC045–HC046, HC048– HC051, HC076, HC104; Redskin Island HC115, HC117; Tarmugli HC133–HC134; Little Andaman HC159– HC162, HC189. *Kaloula ghoshi* – Long Island HC019; South Andaman HC103. *Fejervarya* cf. *andamanensis* – South Andaman HC052–HC053, HC077, HC101, HC105, HC110. *Limnonectes shompenorum* – Great Nicobar HS17, HS22. *Fejervarya* sp. – Little Andaman HC194–HC195; Great Nicobar HS09– HS11, HS19, HS20, HS23. *Microhyla chakrapanii* – Long Island HC010, HC075; South Andaman HC095, HC112–HC013, HC184–HC185. *Microhyla heymonsi* – Great Nicobar HS08. *Polypedates insularis* – Great Nicobar HS21.

## RESULTS

During the period of the present study (March 2010–January 2014), 24 islands in the Andaman & Nicobar Archipelago were surveyed for terrestrial reptiles and amphibians. For Nicobar Islands, species distribution in seven additional islands was obtained from Vijayakumar (2005). For each species known from the Andaman and Nicobar Islands, we provide the scientific name, information on types, type locality, images, English names, distribution in the islands, natural history notes and comments on taxonomy and identification. Das (1999) clarified several issues regarding the presence and identity of several species of amphibians erroneously reported from these islands till then and these are not further discussed here other than for cases where our observations differ. The nomenclature used here follows Frost (2018).

### Family *BUFONIDAE*

#### 1. *Duttaphrynus melanostictus* (Schneider, 1799) (fig. 1)

##### Lectotype

ZMB 3462. Type locality: “India orientali” (Dubois & Ohler 1999)

##### English name

Common Asian toad, black-spined toad.

## Occurrence

South Andaman, Middle Andaman, North Andaman, Little Andaman, Rutland, Havelock, Long Island, Neil Island, Alexandria, Car Nicobar, Bompoka, Tillanchong, Tarasa, Katchall, Trinkat, Camorta, Nancowry, Pilo Milo, Little Nicobar, Kondul, Great Nicobar. This species is likely to occur in more islands. Widely distributed in south and south-east Asia.

## Natural history notes

This species is probably distributed in more islands in the A&N. It is particularly abundant in disturbed coastal habitats as well as human habitations. In Great Nicobar, they were abundant in sandy beaches strewn with washed-up garbage adjoining abandoned human habitations. It is also found in undisturbed wet evergreen forest, though at much lower abundance.

SVL:  $75.11 \pm 19.33$  mm,  $n = 46$ ; maximum SVL = 121.5 mm.

## Comments on taxonomy

The first amphibian to be described from these islands was *Docidophryne spinipes* Fitzinger, 1861, which was synonymised with *Bufo spinipes* Steindachner, 1867 by Stoliczka (1870). The type locality was given as “Nikobaren”. The Nicobars have 23 islands, but from the description of collection localities of the “Novara Reise”, the type locality is likely to be Car Nicobar Island, the northernmost island in the group (Gans 1955). The taxon is also a secondary homonym of *Bufo spinipes* (Daudin, 1802). In 1980, *Bufo camortensis* Mansukhani & Sarkar, 1980 was described as a new species from Camorta, in the central group of islands in the Nicobars.

ZSIC A6955, holotype by original designation, type locality: “compound of Camorta Guest House, Camorta, Andaman and Nicobar Islands, India” (Mansukhani & Sarkar 1980). This taxon is currently considered a synonym of *D. melanostictus* (Schneider, 1799) (Crombie 1986). The type localities of both *Docidophryne spinipes* Fitzinger, 1861 and *Bufo camortensis* Mansukhani & Sarkar, 1980 are in the Nicobar group of islands.

2. *Blythophryne beryet* Chandramouli, Vasudevan, Harikrishnan, Dutta, Janani, Sharma, Das & Aggarwal, 2016 (fig. 2)

## Holotype

ZSI\_A-12521. Type locality: “near Mt. Harriet National Park (ca. 11°42’N, 92°44’E, 175 m asl.), within evergreen forests”, South Andaman Island (Chandramouli *et al.* 2016).

## English name

Andaman bush toad.



Figure 1. *Duttaphrynus melanostictus* (Schneider, 1799) from South Andaman Island. Inset: individual from near the type locality of *Bufo camortensis* Mansukhani & Sarkar, 1980.



Figure 2. *Blythophryne beryet* Chandramouli, Vasudevan, Harikrishnan, Dutta, Janani, Sharma, Das & Aggarwal, 2016, individual from Little Andaman Island.

## Occurrence

South Andaman (Mt. Harriet National Park), Little Andaman, Rutland, North Andaman (Saddle Peak National Park), Havelock Island. This species seems to be restricted to the Andaman Islands and has not been recorded from Nicobar Islands. Within the Andamans, it could be more widely distributed, as there is potentially suitable habitat in Middle Andaman & Baratang islands.

## Natural history notes

This species is nocturnal and semi-arboreal. Several individuals were found under leaf litter in evergreen forest during quadrat sampling. At night, calling males were seen on understorey vegetation, perched on twigs and leaves. Calling individuals were seen to elevate the body on all four limbs. This species seems to be an exclusive phytotelm breeder, and eggs were located on the inner walls of water-filled tree-holes as reported in the description of the species (Chandramouli *et al.* 2016). Though known only from a limited number of localities, it seems to be a locally common species. A single specimen from Little Andaman exhibited limb malformation (three forelimbs), while another exhibited ectromelia of right forelimb.

SVL =  $22.54 \pm 2.85$  mm,  $n = 51$ ; maximum SVL = 27.5 mm.

## Family MICROHYLIDAE

### 3. *Microhyla chakrapanii* Pillai, 1977 (fig. 3)

#### Holotype

ZSI-SRS VA/770. Type locality: “Mayabunder (east of Burma temple), North Andamans” (Pillai 1977; Chanda *et al.* 2000)

#### English name

Mayabunder rice frog.

## Occurrence

North Andaman, Middle Andaman, South Andaman, Rutland, Little Andaman, Long Island, Neil Island.

## Natural history notes

A common species in forest edges and clearings in the Andaman Islands, it does not occur in the Nicobar Islands. It is abundant in agricultural areas such as rice fields. During Southwest Monsoons, males were observed calling from the edges of standing water bodies such as small puddles of water in forest clearings, ponds and arice fields.

SVL =  $21.27 \pm 2.88$  mm,  $n = 33$ ; maximum SVL = 27.4 mm.

4. *Microhyla cf. fissipes* Boulenger, 1884

Holotype

BMNH 1947.2.11.85. Type locality: “Taiwanfoo, S. Formosa”, Taiwan, China.

English name

Ornate narrow-mouthed frog.

Distribution

Past reports from South Andaman Island.

Comments

This species is included here on the basis past checklists (Mehta & Rao 1987; Das 1999). Sarkar (1990) mentioned 28 specimens from the South Andaman Island, but added that he had not seen the specimens of *Microhyla chakrapanii* Pillai, 1977, described from Middle Andaman. The individuals we recorded from South Andaman and other islands resembled the description of *M. chakrapanii* and not *M. ornata*. *M. ornata* is a species thought to be widely distributed in the Indian subcontinent, but does not occur in Myanmar, Thailand or other parts of Southeast Asia (Dutta 1997; Dinesh *et al.* 2009; Frost 2018). It is likely that the specimens of *Microhyla ornata* reported from the Andaman Islands belong to *Microhyla cf. fissipes* Boulenger, 1884 (I. Das & A. Ohler, pers. com.). Given the similarity of Andaman fauna with that of Southeast Asia, until further studies on Microhylids of these islands, the indigenous occurrence of this species in the Andaman Islands should be considered doubtful.

5. *Microhyla heymonsi* Vogt, 1911 (fig. 4)

Syntypes

ZMB 21944 (9 specimens). Type locality: “Formosa” [Taiwan], China; restricted to “Kosempo, Formosa” [Taiwan, China] (Parker 1934; Frost 2018)

English name

Taiwan rice frog, Heymons’ narrow-mouthed frog.

Distribution

Great Nicobar & Little Nicobar. Presumably restricted to the southern group of islands and not recorded in any of the surveyed islands north of the Sombrero Channel.





Figure 3. *Microhyla chakrapanii* Pillai, 1977 from Lamiya Bay, North Andaman Island.



Figure 4. *Microhyla heymonsi* Vogt, 1911 from Great Nicobar Island.

## Natural history notes

This species is common in Great Nicobar Island. It was found inside wet evergreen forests, under leaf litter during quadrat sampling. It was more common around water bodies and forest clearings and was abundant along the coastal wetlands in Great Nicobar.

SVL =  $20.17 \pm 1.96$  mm,  $n = 4$ ; maximum SVL = 23.0.

6. *Micryletta inornata* (Boulenger, 1890)

## Syntypes

BMNH 89.11.12.30, BMNH 89.11.12.4. “Deli” or “Langahat”, Sumatra, Indonesia (Parker 1934; Inger 1985)

## English name

Deli paddy frog.

## Distribution

Known only from South Point in South Andaman Island.

## Comments

In the Andaman & Nicobar Islands, this species is known from a single juvenile specimen collected from ‘South Point, Port Blair’ on 18<sup>th</sup> October 1972 by S. Chakrapani & party (Pillai 1977). This specimen is in the collection of Zoological Survey of India, Southern Regional Station, Chennai (Register No. VA/102). The original colour and patterns of this specimen have faded to a dark brown overall. We did not record this species during our surveys. Given that the juvenile specimen was assigned to this species tentatively (Pillai 1977), confirming its presence in the Andaman & Nicobar Islands requires collection of new specimens.

7. *Kaloula ghoshi* Cherchi, 1954 (fig. 5)

## Syntypes

MSNG (Museo Civico di Storia Naturale Giacomo Doria) 2 specimens mentioned as A and B in original publication (Cherchi 1954). Type locality: “Piccole Andamane, fiume Tciongarè” (Little Andaman, River Tciongarè).

## English name

Brown bullfrog.

### Occurrence

North Andaman, Middle Andaman, South Andaman, Little Andaman, Rutland Island and aLong Island. Not recorded from the Nicobar Islands.

### Natural history notes

Potentially occurs in more islands in the Andaman Islands. It does not occur in the Nicobar Islands. It was recorded in primary wet evergreen forest, secondary forests and anear human habitations. During the relatively short dry season in the Andaman Islands, animals were found inside tree holes, under fallen logs and ainside standing rotten tree trunks. During monsoons, individuals were often found on tree trunks up to two metres above ground. According to local people, it is common on coconut trees, hiding close to the trunk at the base of palm leaves. Breeding in this species coincides with the beginning of southwest monsoon when calling males congregate in standing water bodies. The external vocal sac is greatly inflated and males in this position float on the surface of water close to aquatic vegetation.

### Comments

Originally described as *Kaloula baleata ghoshi* Cherchi, 1954. Blackburn *et al.* (2013) showed that *Kaloula baleata* complex was a monophyletic group, with five genetically and geographically distinct lineages – Java (*K. baleata* sensu stricto), Vietnam, Peninsular Malaysia, Palawan and Sulawesi lineages. Later, the Vietnamese lineage was described as *K. indochinensis* Chan *et al.* 2013 and the northern peninsular Malaysian lineage was described as *K. latidisca* Chan *et al.*, 2014 based on molecular and morphological data (Chan *et al.* 2014; Chan *et al.* 2013). None of the studies included the population from the Andaman Islands. If *K. baleata* is considered restricted to Java, then it is unlikely that the Andaman population is a subspecies, given the separation between these populations and the proximity of Andaman Islands to Indochinese region and peninsular Malaysia. Either this population will be conspecific with Indochinese (*K. indochinensis*) or peninsular Malaysian (*K. latidisca*) species, or a species endemic to the Andaman Islands. The name *Kaloula ghoshi* Cherchi, 1954 was applied by Chandramouli & Prasad (2018) while elevating the Andaman population as a full species based on morphometric comparisons (syntypes were not examined) with *K. latidisca*, *K. indochinensis* and *K. baleata*. Interestingly, in the original description, Cherchi (1954) mentioned H. W. Parker's opinion that the characteristics of the two individuals from Little Andaman Island were closer to those of Celebes (Sulawesi) population of *Kaloula baleata* than the Sumatran ones. A complete assessment of the systematic status of this species still requires inclusion of this population in a comprehensive study of the *Kaloula baleata* species complex.

SVL =  $53.07 \pm 7.88$  mm,  $n = 14$ ; maximum SVL = 67.0 mm.

Family *DICROGLOSSIDAE*8. *Hoplobatrachus tigerinus* (Daudin, 1802) (fig. 6)

## Holotype

Lost. Type locality: “Bengale”, India (Frost 2018).

## English name

Indus-valley bull frog or Indian bull frog.

## Distribution

In the Andamans, recorded from North Andaman, Middle Andaman and South Andaman islands.

## Natural history notes

The first report of this species from the Andaman Islands was by Whitaker (1978), which was overlooked by Harikrishnan & Vasudevan (2013). Though reported by Pillai (1991), Das (1999) stated that it was based on specimens of *Limnonectes macrodon* (Duméril & Bibron, 1841) species complex. During our surveys, we found them to be abundant in parts of Mayabunder, Middle Andaman (Harikrishnan & Vasudevan 2013). Subsequently, we also recorded this species from South Andaman and had reports of it from North Andaman. While it seems to be confined to a few localities in the Andaman Islands, the bullfrog has the potential to become yet another problematic invasive in the Andaman Islands. Its large size could enable this species to competitively exclude and predate on other frog species in the Andaman Islands. It is a prolific breeder and the population could increase rapidly. This species breeds in the beginning of the monsoon and the tadpoles are carnivorous, feeding on tadpoles of other species of frogs (Khan 1996). In mainland India, it is also known to feed on small snakes, lizards and rodents, all of which have numerous endemic species in these islands (Das 1997, 1999). This species seems to be deliberately introduced in to Andaman Islands for consumption. It is a species protected by Wildlife (Protection) Act, 1972, Schedule IV Part II.

9. *Fejervarya* cf. *cancrivora* (Gravenhorst, 1829) (fig. 7)

## Neotype

FMNH 256688 (from “Cianjur (06°49’ S, 107°08’ E), West Java, Java (Indonesia)”) (Dubois & Ohler 2000). Type locality: “Java” Indonesia.





Figure 5. *Kaloula ghoshi* Cherchi, 1954 from Long Island, in the Middle Andaman group. Inset: individual from South Andaman Island.



Figure 6. *Hoplobatrachus tigerinus* (Daudin, 1802) from a freshwater stream in Webi, Middle Andaman Island.

## English name

Mangrove frog, crab-eating frog.

## Distribution

South Andaman Island, Long Island, Car Nicobar Island & Great Nicobar Island.

## Natural history notes

In the Andaman Islands, this species was recorded in low elevation wet evergreen forests and mangrove forests. Males were observed calling from shallow puddles in mangrove mudflats during the monsoons. We also sighted an individual on a sandy beach in South Andaman Island, a few meters away from high-tide level.

SVL =  $47.26 \pm 7.02$  mm,  $n = 8$ ; maximum SVL = 53.0 mm.

## Comments

Das (1999) while confirming the presence of this species in Great Nicobar Island, mentioned that the report by Pillai (1991) from Andamans was based on a specimen of *Fejervarya limnocharis* complex. Recent studies have indicated the possible presence of multiple cryptic species within *Fejervarya cancrivora* complex (Kurniawan *et al.* 2011; Kotaki *et al.* 2010). The widespread but patchily distributed populations north of the Isthmus of Kra have been referred to the species *Fejervarya moodei* (Taylor, 1920) (Dubois 1987; Islam *et al.* 2008; Frost 2018;). The records from Andaman and Nicobar Islands are from widely separated areas – the deep Ten Degree Channel separates the Andaman Islands from the Nicobar Islands. The Ten Degree Channel is situated at similar latitude as the Isthmus of Kra. It is unclear whether the populations from Andaman Islands and Nicobar Islands belong to either *F. cancrivora* or *F. moodei*. Given the proximity of Great Nicobar Island to Sumatra (less than 200 km), it is likely that the Nicobar population is conspecific with *F. cancrivora* from Sunda Islands, or a related species.

10. *Ingerana charlesdarwini* (Das, 1998) (fig. 8)

## Holotype

ZSIC A8890. Type locality: “ca. 0.3 km N of summit of Mount Harriet (10°45' N and 92°46' E), Mount Harriet National Park, South Andaman Island, Bay of Bengal, India; altitude 365 m above msl” (Das 1998).

## English name

Charles Darwin's frog.

## Distribution

South Andaman (Mt. Harriet National Park), North Andaman (Saddle Peak National Park), Little Andaman, Rutland, Long Island, Havelock Island, Neil Island, Tarmugli Island, Alexandria Island and Redskin Island.

## Natural history notes

We found males of this species calling from near phytotelmata during both rainy days and nights. In North Andaman, males calling from near phytotelmata were observed at elevations as low as 39 m asl to 600 m asl on Saddle Peak, the highest peak in the Andaman and Nicobar Islands. We located a calling male in Long Island in leaf litter, close to a large leaf on the forest floor holding a small amount of rainwater. During daytime, individuals were located under leaf litter on the forest floor in quadrat samples. The use of phytotelmata and other small, stagnant water bodies for deposition of eggs and tadpole development may have helped this species survive even in small islands devoid of perennial freshwater bodies (Das 1998).

SVL =  $28.69 \pm 3.86$  mm,  $n = 55$ ; maximum SVL = 38.40 mm.

## Comments

Though originally described from Mt. Harriet in South Andaman Island, individuals resembling this species were recorded from Long Island, Havelock Island and aNeil Island, as well as much smaller islands in the Mahatma Gandhi Marine National Park, namely, Tarmugli Island, Alexandria Island and aRedskin Island. Probably occurs in more islands in the Andaman Islands, but it has not been recorded from the Nicobar Islands. Whether the populations from small islands are conspecific with those from Mt. Harriet require further investigation as *Ingerana charlesdarwini* was originally described from an elevation of 365 m asl. The species exhibits some colour variation within populations (Chandramouli 2017). This paper claimed a ‘rediscovery’ of this species a mere 12 years after the original description, during which there were no published surveys of amphibians in the Andaman Islands. Additionally, it was previously reported from Mt. Harriet National Park and Long Island (Chandramouli *et al.* 2011; Harikrishnan *et al.* 2012). There is also a georeferenced photographic record of this species from Mt. Harriet National Park, on 15 October 2003 by S. P. Vijayakumar in the open access biodiversity database India Biodiversity Portal (<http://indiabiodiversity.org/observation/show/331902>). The generic allocation of this species requires further investigation (Das 1998; Chandramouli 2017).

## 11. *Limnonectes shompenorum* Das, 1996 (fig. 9)

### Holotype

ZSIC A8741. Type locality: “ca. 2 km east of Kopen Heat, ca. 14 km on the East-West Road, Great Nicobar, India” (Das 1996a)





Figure 7. *Fejervarya* cf. *cancrivora* (Gravenhorst, 1829) from a beach in Wandoor, South Andaman Island.



Figure 8. *Ingerana charlesdarwini* (Das, 1998) from Little Andaman Island. Inset left: male calling from near a water-filled tree-hole in Saddle Peak, North Andaman. Inset right: Individual from Mt. Harriet National Park, the type locality of the species.



## English name

Shompen frog.

## Distribution

Great Nicobar, Little Nicobar, Pilo Milo & Menchal (southern group of islands in the Nicobar Islands south of the Sombrero Channel). Extralimital distribution in Sumatra (Inger & Iskandar 2005).

## Natural history notes

Described in 1996 from Great Nicobar Island, this species occurs in wet evergreen forests. During daytime, individuals were found in quadrats, hiding under leaf litter and fallen logs. During rainy nights, we observed these frogs along the East-West road passing from Campbell Bay to Kopenheat, but primarily after the road entered the evergreen forests. We also recorded many individuals on the bank of streams in evergreen forest, both during day and night. Das (1996a) remarked that the males are expected to be voiceless. We did not encounter any calling males during our surveys. However, on one occasion, we spotted a large frog resembling *L. shompenorum* that uttered a single, loud, bark-like call from the bank of a stream. It could not be captured and identified.

SVL =  $71.05 \pm 10.28$  mm,  $n = 16$ ; maximum SVL = 83.9 mm.

## Family RANIDAE

12. *Hylarana erythraea* (Schlegel, 1837) (fig. 10)

## Syntypes

RMNH 1744 (four specimens from Sumatra), RMNH 1746 (nine specimens from Sumatra), RMNH 1749 (one specimen from Sumatra), MNHNP 4570–4572 (Java), RMNH 1744 (four specimens from Sumatra) and RMNH 4265 (one specimen from Java) (Ohler & Mallick 2003; Gasso *et al.* 2007; Frost 2018). Type locality: Java and Sumatra, Indonesia.

## English name

Red-eared frog.

## Distribution

Car Nicobar & Great Nicobar. (Vijayakumar 2005) recorded this species from an additional five islands in the central Nicobar Islands. However, we have not recorded

them in three of these islands in post-2004 tsunami assessment surveys. Widespread in south-east Asia.

#### Natural history notes

We encountered this species only in low-lying coastal wet lands and ponds. In both Car Nicobar and Great Nicobar Islands, these habitats occurred close to human habitation, with disturbed vegetation. While such habitats were restricted to coastal areas in the mountainous Great Nicobar Island, in the much flatter Car Nicobar Island, ponds occupied by this species occurred from coast to deep inland. In Car Nicobar, they occurred in orchards and plantations, wherever there were stagnant bodies of freshwater, often in sympatry with *Amnirana nicobariensis*. The inundation of low elevation coastal wetlands which happened extensively in the Nancowry Group of islands in the Nicobar Islands during the December 2004 Banda Aceh earth quake could be a reason behind the decline or even local extinction of these frogs from those islands (Ramachandran *et al.* 2005).

SVL = 58.00 & 54.40 mm.

#### 13. *Amnirana nicobariensis* (Stoliczka, 1870) (fig. 11)

##### Syntypes

ZSIC 2783, ZSIC 2785–86, ZSIC 3562–63, ZSIC 3565–70 (Annandale 1917; Chanda *et al.* 2000). Type locality: “Nicobar” (Nicobar Islands, India).

##### English name

Nicobarese frog.

##### Distribution

Car Nicobar, Tillangchong, Tarasa, Katchal, Camorta, Nancowry, Pilo Milo, Little Nicobar & Great Nicobar. Not recorded from the Andaman Islands.

#### Natural history notes

This species was common on the forest floor in Great Nicobar Island. We encountered this species during both day and night. We recorded calling males on vegetation surrounding ponds and puddles in the forest, though a few individuals were also recorded near slow-flowing streams. Around breeding ponds, we observed predation or attempted predation on this species by two species of snakes *Xenochrophis trianguligerus* and *Boiga wallachi* in Great Nicobar.

SVL =  $46.80 \pm 7.40$  mm,  $n = 7$ ; maximum SVL = 54.70 mm.



Figure 9. *Limnonectes shompenorum* Das, 1996 from Great Nicobar Island. Inset: Reddish colour morph.



Figure 10. *Hylarana erythraea* (Schlegel, 1837) from near Campbell Bay, Great Nicobar Island.

14. *Chalcorana* cf. *chalconota* (Schlegel, 1837) (fig. 12)

## Syntypes

RMNH 5364, 4264 (Dutta 1997; Gassó *et al.* 2007; Frost 2018). Type locality: “im Innern der Insel Java” & “Sumatra” (Frost 2018).

## English name

White-lipped frog.

## Distribution

Great Nicobar Island. Not recorded in any other island in the Andaman & Nicobar Islands.

## Natural history notes

This species was encountered only inside evergreen forests. We found all individuals close to streams. By day, frogs were found resting on leaves of saplings along the edge of streams, from where they jumped in to the water upon disturbance. At night, we encountered males calling from vegetation overhanging streams. We recorded amplexing pairs about 30–40 cm above water on vegetation and roots. All amplexing pairs were above shallow pools along the edges of the streams where the water was still or flowing very slowly. The females were lighter in colour, being a pale yellow all over, while males were green on top with small dark spots, lighter on the sides, with a distinct white upper lip (fig. 12).

SVL =  $37.09 \pm 5.99$  mm,  $n = 8$ ; maximum SVL = 46.9 mm.

## Comments

Das (1996b) first reported *Rana chalconota* from Nicobar Islands. He mentioned that the individuals recorded from Great Nicobar Island had diagnostic characters of *R. chalconota raniceps* (Peters, 1871), considered a subspecies at the time, but currently considered as a valid species occurring in Borneo and south Sumatra (Inger *et al.* 2009). The Great Nicobar frogs were included in a checklist of frogs of India as *Rana raniceps* (Dinesh *et al.* 2009). Inger *et al.* (2009) restricted the range of *C. chalconota* sensu stricto to Java and South Sumatra, while also describing two new species, including *C. rufipes* (Inger *et al.* 2009) from western Sumatra. Recent phylogenetic studies on the ‘*Rana chalconota*’ group of forest frogs indicated that they contained multiple, cryptic species with several island endemics in south-east Asia (Oliver *et al.* 2015; Inger *et al.* 2009; Stuart *et al.* 2006). Frost (2018) lists the population from Great Nicobar as *C. labialis* (Boulenger, 1887), a species occurring in peninsular Malaysia. This assignment seems to be based on the geographical proximity of this region to Peninsular Malaysia. However, Great Nicobar Island is closer to Sumatra, from which it is separated by only about 300 km. The population from Great Nicobar was not part of any of the recent reviews of this group, and it is impossible to assign this population to any of the currently recognized species. Pending further studies of this island population, we conservatively assign the Great Nicobar population to *Chalcorana* cf. *chalconota* (Schlegel, 1837).





Figure 11. *Ammirana nicobariensis* (Stoliczka, 1870) from Great Nicobar Island.



Figure 12. *Chalcorana cf. chalconota* (Schlegel, 1837) from a stream in Great Nicobar Biosphere Reserve, Great Nicobar Island. Inset: male and female.

Family *RHACOPHORIDAE*15. *Polypedates insularis* Das, 1995 (fig. 13)

## Holotype

ZSIC A8731. Type locality: “circa 2 km E mouth of Galathea River, Galathea National Park, Great Nicobar India” (Das 1995).

## English name

Nicobar tree frog.

## Distribution

Great Nicobar, Little Nicobar & Pilo Milo (Vijayakumar 2005). Not recorded in central and northern groups of islands in the Nicobar Islands, nor in the Andaman Islands.



Figure 13. *Polypedates insularis* Das, 1995 from Great Nicobar Island.

## Natural history notes

This is the only rhacophorid species known from the Andaman and Nicobar Islands. This species is common in Great Nicobar Island, both in human habitation and natural forests. Its habits seem to be similar to other widespread species of *Polypedates*, such as *P. leucomystax* (Gravenhorst, 1829) and *P. maculatus* (Gray, 1830). We recorded calling males near ponds and tanks with over-hanging vegetation. We also found males using water-filled barrels and tree-holes as potential breeding habitats. We recorded predation of this species by Humayun's bronzeback (*Dendrelaphis humayuni* Tiwari & Biswas, 1973) and by the Nicobar cat snake (*Boiga wallachi* Das, 1998).

SVL =  $47.97 \pm 7.54$  mm,  $n = 15$ ; maximum SVL = 64.00 mm.

## Comments

Dutta (1997) pointed out that earlier records of the species *Polypedates leucomystax* from the Andaman & Nicobar Islands were based on specimens of *P. insularis*.

Status of *Fejervarya andamanensis* (Stoliczka, 1870),  
*Fejervarya nicobariensis* (Stoliczka, 1870), *Limnonectes doriae* (Boulenger, 1887)  
and *Limnonectes hascheanus* (Stoliczka, 1870),  
in the Andaman & Nicobar Islands (fig. 14)

The type series of *Rana gracilis* var. *andamanensis* Stoliczka (1870) consisted of four specimens, of which three were listed by Sclater (1892) as ZSIC 2732, ZSIC 8538–39 (erroneously given as 3538–9), from Andamans. Chanda *et al.* (2000) pointed out that the registration numbers 3538–9 given by Sclater (1892) were in error and listed ZSIC 8539 as lectotype as designated by Annandale (1917). An additional syntype, BMNH 1947.2.1.23, was identified by Dutta (1997) as belonging to *Limnonectes hascheanus* (Stoliczka, 1870), a species having type locality “higher forests (about 1000 feet above sea level) in the island of Penang”, Malaysia. Dutta (1997) also mentioned that at least two of the syntypes in the collection of ZSI Kolkata belonged to *Limnonectes doriae* (Boulenger, 1887), one of which (ZSI 2732) was already identified as *L. doriae* by Sclater (Chanda *et al.* 2000). Thus, three of the four specimens on which this species was described belong to *L. hascheanus* and *L. doriae*.

Stoliczka (1870) described *Rana gracilis* var. *nicobariensis* based on a single specimen (ZSIC 2679) from “Nicobars in the neighbourhood of Nancouri harbour” (Chanda *et al.* 2000). This species was synonymised with *F. andamanensis* by Dubois (1984) and resurrected by Dubois (1987). However, Dutta (1997) considered it a synonym of *Fejervarya limnocharis* (Gravenhorst, 1829).

*F. andamanensis*, *L. doriae*, *L. hascheanus* & *F. limnocharis* have been included in checklists of amphibians of the Andaman Islands (Das 1999; Harikrishnan *et al.* 2010). Das (1999) also included two unnamed *Limnonectes* species in the Andaman Islands amphibian fauna, while including *L. doriae*, *L. hascheanus* and *F. aff. limnocharis* in the Nicobar Islands amphibian fauna.



Thus, up to seven species (including the two unnamed *Limnonectes* mentioned by Das (1999) and excluding *F. cancrivora* and *L. shompenorum*) of these relatively small Dicroglossid frogs have been reported from the Andaman & Nicobar Islands. Given the fact that the original description of *F. andamanensis* was based on specimens of three species and the description of *F. nicobariensis* based on a single specimen, assessment of systematic and taxonomic status of all these taxa in these islands require further examination of a large series of specimens from across these islands. A recent review of *L. hascheanus* and *L. limborgi* provided evidence that the former is restricted to southern parts of Malay Peninsula and expressed doubts on its occurrence in the Andaman & Nicobar Islands (Inger & Stuart 2010). We have not yet recorded any species that matched the redescription of *L. hascheanus* provided by Inger & Stuart (2010). Therefore, the identities of frogs assigned to any of these names by past publications should be considered tentative (e.g. Sarkar 1990; Das 1998; Das 1999; Harikrishnan *et al.* 2012; Chandramouli *et al.* 2015).



Figure 14. Small Dicroglossid frogs from the Andaman & Nicobar Islands: a) Great Nicobar, b) Little Andaman, c) Little Andaman, d) Little Andaman, e) Camorta and f) South Andaman.



## CONCLUSIONS

Evidently, the amphibian fauna of the Andaman and Nicobar Islands is in need of thorough taxonomic investigations. A major hurdle for biologists working in these islands has been the affinity of the fauna to south-east Asia with which they are often unfamiliar. Conversely, studies on related taxa in south-east Asia have left out populations from the Andaman & Nicobar Islands, perhaps due to the difficulties in obtaining data from these islands that are considered as strategically important by the Indian government. A better understanding of the amphibian diversity of these islands is only possible with studies that span across the political boundaries using modern methods including morphological, acoustic and molecular data.

## ACKNOWLEDGEMENTS

This work was supported by Department of Science and Technology (DST), Government of India (Grant No. SR/SO/AS–08/2009). We thank the Department of Forests and Wildlife, Andaman and Nicobar Islands, for providing necessary permits to conduct fieldwork in the Andaman and Nicobar Islands (File No. CWLW/WL/134/161). We are grateful to The Andaman and Nicobar Environmental Team (ANET) for logistical support. For help in fieldwork in the Andaman Islands we thank Nitya Prakash Mohanty, S. R. Chandramouli, Chetan Rao and our field assistants Saw Glen, SebeHoro, Anand James Tirkey and Sudhir Kumar Ekka.

## LITERATURE CITED

- Annandale, N. (1917) Zoological results of a tour in the Far East. Batrachia. *Memoirs of the Asiatic Society of Bengal*, **6**: 119–155.
- Anonymous (2013) *Forest Statistics 2013*. Port Blair, India (Department of Environment and Forests, Andaman and Nicobar Islands): 1–141.
- Bell, R. C., Drewes, R. C., Channing, A., Stuart, B. L., Zamudio, K. R., Kielgast, J. & Stefan, L. (2015) Overseas dispersal of *Hyperolius* reed frogs from Central Africa to the oceanic islands of São Tomé and Príncipe. *Journal of Biogeography*, **42**: 65–75.
- Biswas, S. & Sanyal, D. P. (1980) A report on the Reptilia fauna of Andaman and Nicobars Islands in the collection of Zoological Survey of India. *Records of the zoological Survey of India*, **77**: 255–292.
- Blackburn, D. C., Siler, C. D., Diesmos, A. C., McGuire, J. A., Cannatella, D. C. & Brown, R. M. (2013) An adaptive radiation of frogs in a Southeast Asian island archipelago. *Evolution*, **67** (9): 2631–2646.
- Boulenger, G. A. (1887) An account of the Reptiles and Batrachians obtained in Tenasserim by M. L. Fea of the Genoa Civic Museum. *Annali del Museo Civico di Storia naturale di Genova*, **2** (5): 474–486.
- Brown, W. C. & Alcalá, A. C. (1970) The zoogeography of the herpetofauna of the Philippine Islands, a fringing archipelago. *Proceedings of the California Academy of Sciences*, **38** (6): 105–130.
- Champion, H. G. & Seth, S. K. (1968) *A revised survey of the forest types of India*. Dehradun (Natraj Publishers, Publication Division): i–xxvii + 1–404.
- Chan, K. O., Blackburn, D. C., Murphy, R. W., Stuart, B. L., Emmett, D. A., Ho, C. T. & Brown, R. M. (2013) A new species of narrow-mouthed frog of the genus *Kaloula* from Eastern Indochina. *Herpetologica*, **69** (3): 329–341.
- Chan, K. O., Grismer, L. & Brown, R. M. (2014) Reappraisal of the Javanese bullfrog complex, *Kaloula baleata* (Müller, 1836) (Amphibia: Anura: Microhylidae), reveals a new species from Peninsular Malaysia. *Zootaxa*, **3900** (4): 569–580.
- Chanda, S. K., Das, I. & Dubois, A. (2000) Catalogue of amphibian types in the collection of the Zoological Survey of India. *Hamadryad*, **25** (2): 100–128.

- Chandramouli, S. R. (2017) Rediscovery and redescription of a little known, insular endemic frog, *Ingerana charlesdarwinii* (Das, 1998) (Amphibia: Anura: Dicroglossidae) from the Andaman Islands, Bay of Bengal, *Alytes*, **33** (1): 47–54.
- Chandramouli, S. R., Vasudevan, K., Harikrishnan, S., Dutta, S. K., Janani, S., Richa, S., Das, I. & Ramesh, A. (2016) A new genus and species of arboreal toad with phytotelmonous larvae, from the Andaman Islands, India (Lissamphibia, Anura, Bufonidae) *ZooKeys*, **555**: 57–90.
- Cherchi, M. A. (1954) Una nuova sottospecie di *Kaloula baleata* delle Isole Andamane. *Doriana, Genova*, **1** (47): 1–4.
- Crombie, R. I., (1986) The status of the Nicobar toads *Bufo camortensis* Mansukhani & Sarkar, 1980 and *Bufo spinipes* Fitzinger in Steindachner, 1867. *Journal of Bombay natural History Society*, **83**: 226–228.
- Crump, M. L. & Scott Jr, N. J. (1994) Visual encounter surveys. In: Heyer, W. R., Donnelly, M. A., McDiarmid, R. W., Hayek, L. C., Foster, S. M. (ed.) *Measuring and monitoring biological diversity: standard methods for amphibians*, Washington, D.C. (Smithsonian Institution Press): 84–92.
- Daniels, R. J. & David, P. V. (1996) The herpetofauna of Great Nicobar Island. *Cobra*, **25**: 1–4.
- Das, I. (1994) A check-list of the amphibians and reptiles of Andaman and Nicobar Islands. *Journal of Andaman Science Association*, **10** (1&2): 44–49.
- Das, I. (1995) A new species of tree frog (genus *Polypedates*) from Great Nicobar, India (Anura: Rhacophoridae) *Hamadryad*, **20**: 13–20.
- Das, I. (1996a) *Limnonectes shompenorum*, a new species of Ranid frog of the *Rana macrodon* complex from Great Nicobar, India. *Journal of South Asian natural History*, **2** (1): 127–134.
- Das, I. (1996b) Geographic Distribution. *Rana chalconata* (Copper-cheeked frog). *Herpetological Review*, **27** (1): 30.
- Das, I. (1997) *An ecological reconnaissance of Mount Harriet National Park, Andaman Islands, India. Port Blair*. North Wandoor, South Andaman (Report to Andaman and Nicobar Islands Environmental Team).
- Das, I. (1998) A remarkable new species of ranid (Anura: Ranidae) with phytotelmonous larvae, from Mount Harriet, Andaman Island. *Hamadryad*, **23** (1): 41–49.
- Das, I. (1999) Biogeography of the amphibians and reptiles of the Andaman and Nicobar Islands, India. In: Ota, H. (ed.). *Tropical island herpetofauna: origin, current diversity, and conservation*. Amsterdam, Lausanne, New York, Oxford, Shannon, Singapore, Tokyo (Elsevier Science B. V.): 43–77.
- Dinesh, K. P., Radhakrishnan, C., Gururaja K. V. & Bhatta, G. K. (2009) *An annotated checklist of Amphibia of India with some insights into the patterns of species discoveries, distribution and endemism*. Records of Zoological Survey of India, Occasional Paper, **302**: 1–153.
- Dubois, A. (1984) Note préliminaire sur le groupe de *Rana limnocharis* Gravenhorst, 1829 (Amphibiens, Anoures). *Alytes*, **3**: 143–159.
- Dubois, A. (1987) Miscellanea taxinomica Batrachologica (I). *Alytes*, **5**: 7–95.
- Dubois, A. & Ohler, A. (1999) Asian and Oriental toads of the *Bufo melanostictus*, *Bufo scaber* and *Bufo stejnegeri* groups (Amphibia, Anura): a list of available and valid names and redescription of some name-bearing types. *Journal of South Asian natural History*, **4** (2): 133–180.
- Dubois, A. & Ohler, A. (2000) Systematics of *Fejervarya limnocharis* (Gravenhorst, 1829) (Amphibia, Anura, Ranidae) and related species. 1. Nomenclatural status and type-specimens of the nominal species *Rana limnocharis* Gravenhorst, 1829. *Alytes*, **18**: 15–50.
- Duellmann, W. E. & Trueb, L. (1994) *Biology of amphibians*, London (Johns Hopkins University Press): i–xxi + 1–670.
- Dutta, S. K. (1997) *Amphibians of India and Sri Lanka (checklist and bibliography)*. Bhubaneswar (Odyssey Publishing House): i–xiii + 1–342 + i–xxii.
- Evans, B. J., Brown, R. F., McGuire, J. A., Supriatna, J., Andayani, N., Diesmos, A., Iskandar, D., Melnick, D. J. & Cannatella, D. C. (2003) Phylogenetics of fanged frogs: testing biogeographical hypotheses at the interface of the Asian and Australian faunal zones. *Systematic Biology*, **52** (6): 794–819.
- Fitzinger, L. J. (1860) Die Ausbeute der österreichischen Naturforscher an Säugethieren und Reptilien während der Weltumsegelung Sr. Majestät Fregatte Novara. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche **42**, “1861”: 383–416.
- Frost, D. R. (2018) *Amphibian species of the world: an online reference*. Version 6.0. New York (American Museum of Natural History). <<http://research.amnh.org/herpetology/amphibia>>. [Accessed March 2018].

- Gans, C. (1955) Localities of the herpetological collections made during the “Novara Reise.” *Annals of the Carnegie Museum*, **33** (17): 275–285.
- Gassó M. M. E., Ostende, L. W. H. & Arntzen, J. W. (2007) Type specimens of amphibians in the National Museum of Natural History, Leiden, The Netherlands. *Zootaxa*, **1482**: 25–68.
- Harikrishnan, S., Vasudevan, K. & Choudhury, B. C. (2010) A review of herpetofaunal descriptions and studies from Andaman and Nicobar Islands, with an updated checklist. In: Ramakrishna, Raghunathan, C. & Sivaperuman, C. (ed.). *Recent Trends in biodiversity of Andaman and Nicobar Islands*, Kolkata (Zoological Survey of India): 387–398.
- Harikrishnan, S., Chandramouli, S. R. & Vasudevan, K. (2012) A survey of herpetofauna on Long Island, Andaman and Nicobar Islands, India. *Herpetological Bulletin*, **2012** (119): 19–28.
- Harikrishnan, S. & Vasudevan, K. (2013) Recent introduction and spread of Indian Bullfrog *Hoplobatrachus tigerinus* (Daudin, 1802) in to the Andaman Islands. *Aliens*, **33**: 42–43.
- Harikrishnan, S. & Vasudevan, K. (2015) The devil is in the detail: estimating species richness, density, and relative abundance of tropical island herpetofauna. *BMC Ecology*, **2015** (15): 18.
- Harikrishnan, S., Vasudevan, K. & Choudhury, B. C. (2011) Frog-hopping islands: a study on the patterns in anuran distribution and species co-occurrence in the Nicobar Islands. In: Das, I. & Tuen, A. A. (ed.), *Biology and conservation of tropical Asian amphibians. Proceedings of the Conference “Biology of the amphibians in the Sunda Region, South-East Asia”*. Organized by Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia, 28–30 September 2009: 72–78
- Inger, R. F. (1985) *Microhyla inornata* In: Frost, D. R. (ed.). *Amphibian species of the world: a taxonomic and geographical reference*. Lawrence, Kansas (Association of Systematics Collections and Allen Press): 386.
- Inger, R. F. & Voris, H. K. (2001) The biogeographical relationships of the frogs and snakes of Sundaland. *Journal of Biogeography*, **28**: 863–891.
- Inger, R. F. & Iskandar, D. T. (2005) A collection of amphibians from West Sumatra, with description of a new species of *Megophrys* (Amphibia: Anura). *Raffles Bulletin of Zoology*, **53**: 133–142.
- Inger, R. F., Stuart, B. L. & Iskandar, D. T. (2009) Systematics of a widespread Southeast Asian frog, *Rana chalconota* (Amphibia: Anura: Ranidae). *Zoological Journal of the Linnean Society*, **155**: 123–147.
- Inger, R. F. & Stuart, B. L. (2010) Systematics of *Limnonectes (Taylorana)* Dubois. *Current Herpetology*, **29** (2): 51–68.
- Islam, M. M., Kurose, N., Khan, M. M. R., Nishizawa, T., Kuramoto, M., Alam, M. S., Hasan, M. K., Kurniawan, N., Nishioka, M. & Sumida, M. (2008) Genetic divergence and reproductive isolation in the genus *Fejervarya* (Amphibia: Anura) from Bangladesh inferred from morphological observations, crossing experiments, and molecular analyses. *Zoological Science*, **25**: 1084–1105.
- Karunakaran, C., Ray, K. K. & Saha, S. S. (1968) A revision of the stratigraphy of Andaman and Nicobar Islands, India. *Bulletin of the national Institute of Science*, **38**: 436–441.
- Khan, M. S. (1996) The oropharyngeal morphology and feeding habits of tadpole of tiger frog *Rana tigerina* Daudin. *Russian Journal of Herpetology*, **13** (2): 163–171.
- Kotaki, M., Kurabayashi, A., Matsui, M., Kuramoto, M., Djong, T. H. & Sumida, M. (2010) Molecular phylogeny of the diversified frogs of genus *Fejervarya* (Anura : Dicroglossidae), *Zoological Science*, **27** (5): 386–395.
- Kurniawan, N., Djong, T. H., Islam, M. M., Nishizawa, N., Belabut, D. M., Sen, Y. H., Wanichanon, R., Yasir, I. & Sumida, M. (2011) Taxonomic status of three types of *Fejervarya cancrivora* from Indonesia and other Asian countries based on morphological observations and crossing experiments. *Zoological Science*, **28** (1): 12–24.
- Lee, T. & Lawver, L. A., (1995) Cenozoic plate reconstruction of Southeast Asia. *Tectonophysics*, **251**: 85–138.
- Lomolino, M. V. (2010) Four Darwinian themes on the origin, evolution and preservation of island life. *Journal of Biogeography*, **37** (6): 985–994.
- Mansukhani, M. R. & Sarkar, A. K. (1980) On a new species of toad (Anura: Bufonidae) from Camorta, Andaman and Nicobar, India. *Bulletin of the zoological Survey of India*, **3** (1&2): 97–101.
- Mehta, H. S. & Rao, G. C. (1987) Microhylid frogs of Andaman and Nicobar Islands. *Journal of Andaman Science Association*, **3** (2): 98–104.
- Myers, N. (2000) Biodiversity hotspots for conservation priorities. *Nature*, **403**: 853–859.
- Ohler, A. & Mallick, P. K., (2003) *Rana (Hylarana) sensu* Dubois (1992) in India and the identity of *Hylarana tytleri* Theobald, 1868. *Hamadryad*, **27**, ‘2002’: 62–70.

- Oliver, L., Prendini, E., Kraus, F. & Raxworthy, C.J. (2015) Systematics and biogeography of the *Hylarana* frog (Anura: Ranidae) radiation across tropical Australasia, Southeast Asia, and Africa. *Molecular Phylogenetics and Evolution*, **90**: 176–192.
- Parker, H.W. (1934) *A monograph of the frogs of the family Microhylidae*. Trustees of the British Museum, London: 1–208.
- Pillai, R.S. (1977) On two species of frogs of the family Microhylidae from Andamans including a new species. *Proceedings of the Indian Academy of Science*, **86** B (2): 135–138.
- Pillai, R.S. (1991) Contribution to the amphibian fauna of Andaman and Nicobar with a new record of the mangrove frog, *Rana cancrivora*. *Records of the zoological Survey of India*, **88**: 41–44.
- Pillai, R.S. & Mehta, H.S. (1986) Frogs and toads in Bay Islands. *The Daily Telegrams*, **186**: 12–19.
- Ramachandran, S., Anitha, S., Balamurugan, V., Dharanirajan, K., Vendhan, K.E., Divien, M.I.P., Vel, A.S., Hussain, I.S. & Udayaraj, A. (2005) Ecological impact of tsunami on Nicobar Islands (Camorta, Katchal, Nancowry and Trinkat). *Current Science*, **89** (1): 195–200.
- Ripley, S.D. & Beehler, B.M. (1989) Ornithogeographic affinities of the Andaman and Nicobar Islands. *Journal of Biogeography*, **16**: 323–332.
- Rodolfo, K.S. (1969) Bathymetry and marine geology of the Andaman Basin, and tectonic implications for Southeast Asia. *Geological Society of America Bulletin*, **80**: 1203–1230.
- Sarkar, A.K. (1990) Taxonomic and ecological studies on the amphibians of Andaman and Nicobar Islands, India. *Records of the zoological Survey of India*, **86**: 103–117.
- Sclater, W. L. (1892) *List of the batrachia in the Indian Museum*. London (Taylor & Francis): i–viii + 1–43.
- Smith, M. A. (1941) The herpetology of the Andaman and Nicobar Islands. *Proceedings of the Linnean Society of London*, **1940**: 150–158.
- Stoliczka, F. (1870) Observations on some Indian and Malayan Amphibia and Reptilia. *The Journal of the Asiatic Society of Bengal*, **39** (2): 134–157.
- Stuart, B. L., Inger, R. F. & Voris, H. K. (2006) High levels of cryptic species diversity revealed by sympatric lineages of Southeast Asian forest frogs. *Biology Letters*, **2**: 470–474.
- Vences, M., Vieites, D. R., Glaw, F., Brinkmann, H., Kosuch, J., Veith, M. & Meyer, A. (2003) Multiple overseas dispersal in amphibians. *Proceedings of the royal Society B: Biological Sciences*, **270** (1532): 2435–2442.
- Vijayakumar, S. P. (2005) *Status and Distribution of Amphibians and Reptiles of the Nicobar Islands, India*. Final Report. Rufford Foundation/Madras Crocodile Bank Trust/Wildlife Institute of India: 1–48.
- Voris, H. K. (2000) Maps of Pleistocene sea levels in Southeast Asia: shorelines, river systems and time durations. *Journal of Biogeography*, **27**: 1153–1167.
- Weeks, L. A., Harrison, R. N. & Peter, G. (1967) Island arc system in Andaman Sea. *Bulletin of the American Association of petrological Geology*, **51**: 1803–1815.
- Whitaker, R. (1978) Herpetological survey in the Andamans. *Hamadryad*, **3**: 9–16.

Submitted: 18 April 2018.

Accepted: 7 May 2018.

Published: 4 June 2018.

Corresponding editor: Annemarie Ohler.