Russian Journal of Herpetology Vol. 26, No. 5, 2019, pp. 247 – 260

DOI: 10.30906/1026-2296-2019-26-5-247-260

REAPPRAISAL OF HERPETOFAUNA RECORDED FROM JAFFNA PENINSULA IN NORTHERN SRI LANKA WITH REMARKS ON CONSERVATION, DIVERSITY, AND DISTRIBUTION

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Submitted January 11, 2017

Jaffna peninsula is quite an unexplored area of Sri Lanka's lowland dry zone. We constructed a species checklist for all herpetofauna of this area based on a short-term field survey, a comprehensive literature review, museum specimens, and observations made by field herpetologists. Based on 200 × 10 m belt transects, we surveyed herpetofauna both during day and night time, in 10 different types of habitats. The species checklist we compiled comprised 44 species of reptiles (including three nationally threatened, one globally threatened, and eight endemic species) and 15 species of amphibians (including one nationally threatened and three endemic species). Based on published literature, museum specimens, expert opinions, and current field survey, we documented 85 species of herpetofauna in this area. Of this entire list, we were unable to record the presence of 25 species through our field survey. Our field survey documented 18 species that were not previously reported from Jaffna Peninsula. Our study revealed that inland water bodies, cultivated lands, home gardens, and coastal beaches are of high importance for native herpetofauna of Jaffna peninsula. Many human disturbances, such as habitat alterations, vengeful killing, consumption overexploitation, and road mortality are the key threats encountered by herpetofauna in Jaffna. Our intention of this study is to compile baseline information on diversity of amphibians and reptiles to support more detailed studies in future and assist conservation and management decisions within the region. We believe that our study will provide a basic foundation for conservation planning and future research.

Keywords: Amphibians; biodiversity explorations; dry zone; habitats; Red List; Reptiles; threats.

INTRODUCTION

The Indian oceanic tropical island of Sri Lanka, along with neighboring Western Ghats of India, is considered a global biodiversity hotspot (Mittermier et al., 2004). The diversity and endemism among Sri Lankan herpetofauna is remarkable (Bossuyt et al., 2004, 2005). Extensive studies on taxonomy of Sri Lanka's herpetofauna has been conducted in the wet zone located in the southwestern of the island (average annual rainfall >2000 mm) (Meegaskumbura and Manamendra-Arachchi, 2005; Wickramasinghe et al., 2013; Amarasinghe et al., 2014). In addition, many herpetofaunal inventories have been compiled for the wet zone of Sri Lanka (Wijesinghe and Dayawansa, 2002; Surasinghe and Wijesinghe, 2005; S. Karunarathna et al., 2008; Kudavidanage et al., 2012). However, herpetofaunal surveys in the dry zone (average annual rainfall <1500 mm) are sparse; existing studies mostly focus on small-sized local habitats (Karunarathna et al., 2008; Karunarathna and Amarasinghe, 2012). There is a scarcity of landscape-scale studies inventorying the diversity of amphibians and reptiles in the dry zone of Sri Lanka.

The present survey was undertaken to document the herpetofaunal diversity of Jaffna peninsula, an extensive swath of dry zone landscape located in northern Sri Lanka. The herpetofaunal diversity of Jaffna peninsula is

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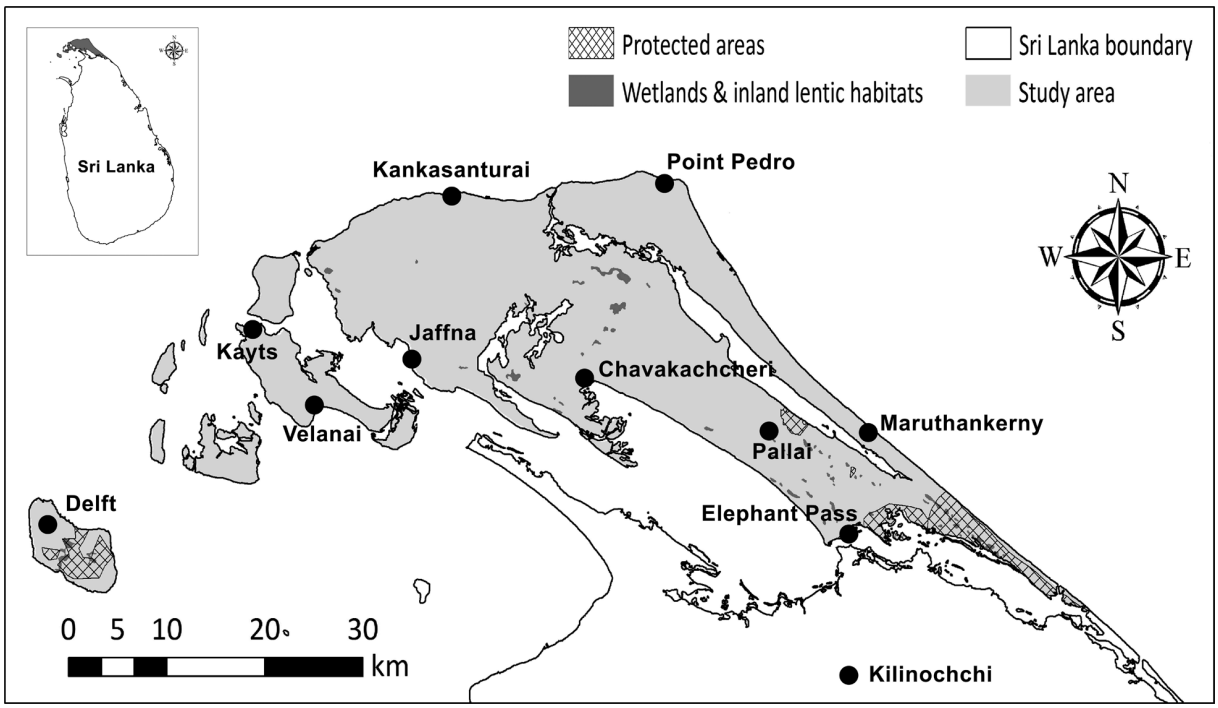

Fig. 1. Study area Jaffna peninsula, Sri Lanka: Basic landscape features of the study area, including the inland aquatic and wetland habitats, protected areas, and major towns.

largely unexplored, partly due to the three-decades long civil unrest in the area (de Silva, 2006a). However, there are a few noteworthy studies conducted in this region. Based on a survey on eight islands around Jaffna peninsula, De Silva (1957) reported eight amphibians and 18 reptiles. De Silva (2006b) listed three species of sea turtles that potentially nest in the northern beaches of Sri Lanka. Abyerami and Sivashanthini (2008a) recorded 18 species of terrestrial snakes representing four families. Abyerami and Sivashanthini (2008b) surveyed the diversity of sea snakes of Jaffna Peninsula and reported occurrence of nine species belonging to two families. De Silva et al. (2011) documented basic reproductive biology of six species of sea snakes in Jaffna seascapes.

A major drawback in conservation of Sri Lanka's herpetofauna is the lack of spatially explicit records on species taxonomy and biogeography (Gabadage et al., 2014). This study intends to provide a compilation of records from this less-studied area, to support future surveys, and conservation and management decisions within the region.

MATERIAL AND METHODS

The present study was conducted from October to December 2015 with a total of 12 field days (15 h/day). Our survey period overlapped with the onset of the monsoons. We surveyed 10 different habitat types (Fig. 2): polyculture croplands, coastal beaches, grasslands, home gardens, mangroves, commercial-scale or abandoned monoculture plantation, road verges, salt marshes, scrublands, and inland water bodies (mostly brackish waters) (Table 1). At a given habitat, we walked four, 200 × 10 m belt transect with four persons (nearly 800 man-hours for the overall survey) while actively searching the transect area and visually scanning for reptiles and amphibians. We carried our field surveys at both day (10 h [07:00 – 17:00]) and night (5 h [19:00 – 24:00]). We identified and recorded all captured herpetofauna and released them back to the site of capture. All capture sites were geo-referenced with Garmin eTrex® 10 GPS (Garmin, Taiwan). In addition to our field observations, we examined museum specimens collected from the same study area (National Museum of Sri Lanka, Colombo, Sri Lanka), consulted four herpetologists, and referred all available relevant literature to build up the inventory of amphibians and reptiles of the region. All specimens were identified based on field guides and identification keys (Das and De Silva, 2005; Manamendra-Arachchi and Pethiyagoda, 2006).

Study area. Jaffna peninsula (929 km^2) is located in the northern Sri Lanka (9°25′09.53″ – 9°52′08.13″ N

Fig. 2. Major habitat types of the study region of Jaffna peninsula, Sri Lanka: *a*, coastal beaches at Maruthankerni; *b*, grasslands at Karaveddai; *c*, mangroves at Elluthumaduval; *d*, monoculture plantations at Delft Island; *e*, road verges; *f*, salt marshes at Kayts; *g*, scrub forests; *h*, natural inland water bodies; *i*, artificial inland water bodies at Aliavalai; and waste disposal sites at Delft Island (*j*), Valigamam (*k*), and Elathumaduval (*l*).

and 79°36′28.12″ – 80°45′06.18″ E) with elevations ranging from 1 – 10 m (Fig. 1). Biogeographically, Jaffna Peninsula lies within the low country dry zone (average annual temperature 29.5°C, annual average precipitation 910.5 mm). The geological substrate of Jaffna peninsula is limestone as this region was submerged in the Indian Ocean during Miocene. The climate and hydrology of Jaffna peninsula is largely dependent on monsoon rains. Annual precipitation ranges from 696 mm to 1125 mm and more than 90% of the annual rainfall results from the north-east monsoons during the shorter wet period (October and January) (Survey Department of Sri Lanka, 2012). The temperature ranges from 26.2 to 33.5°C. According to Gunatilleke and Gunatilleke (1990), our study area falls within the coastal and marine belt floristic region. Characteristic natural vegetation types include marine, mangroves, salt marsh, sand dunes and strand vegetation (Fig. 2). In addition, many wetland habitats were located in our study region: salt marshes, wet grasslands, flood-plain wetlands and riverine forests (IUCN Sri Lanka and Central Environmental Authority, 2006).

TABLE 1. Detail Description of Dominant Habitat Types in Currently Explored Areas in Jaffna Peninsula, Sri Lanka (Sources: Gunatilleke and Gunatilleke, 1990; Senaratna, 2001)

Habitat types	Description of habitat type
Polyculture croplands	Found in rural and sub urban areas these cultivations are of seasonal crop plants with a mixture of creepers and shrubs (1 – 3 m tall and 20 – 50% shady) such as: *Musax paradisiaca* (Kesel), *Mangifera indica* (Amba), *Carica papaya* (Gas-Labu), *Vitis vinifera* (Midi), *Manihot esculenta* (Mangyokka), *Capsicum annuum* (Miris), *Vigna unguiculata* (Mea-Karal), *Abelmoschus esculentus* (Bandakka), *Momordica charantia* (Karawila), *Cucurbita maxima* (Wattakka), and *Lycopersicon esculentum* (Takkali). Thin quite dry leaf litter (1 – 2 cm) layer available and decaying logs are very rare (10%).
Coastal beaches	Most sandy surfaces are protected by creepers *Ipomoea pescaprae* (Bimthamburu). Beyond the creepers zone towards land low shrubs occurs (10 – 60 cm tall and 10 – 20% shady), thin and scattered leaf litter (2 – 5 cm) layer available and decaying logs are rare (20%). Common species are: *Spinifex littoreus* (Maha Ravana-Revula), *Sesuvium portulacastrum* (Maha Sarana), *Cyperus stoloniferus*, *Aloe vera* (Komarika), *Catharanthus roceus* (Mini Mal), *Phyla nodiflora* (Hiramanadetta), *Scaevola taccada* (Takkada), *Calotropis gigantea* (Wara), *Clerodendrum inerme* (Wal Gurenda), *Pupalia lappacea* (Karal Heba), *Premna obtusifolia* (Maha Midi), *Pedalium murex* (Et-Nerenchi), and *Citrullus colocynthis* (Yak Komadu).
Grasslands	Scattered grasslands patches were observed in many places within the study area including most of islands (10 – 40 cm tall and 05 – 10% shady). This habitat contains grass species such as *Cynodon dactylon*, *Cressa cretica*, *Blumea obliqua*, *Cyperus stoloniferus*, and *Phyla nodiflora* (Hiramanadetta). No leaf litter layer available and decaying logs are very rare (10%).
Home gardens	This habitat can be characterized by multi-storied structure with mixed but compatible species islands (1 – 10 m tall and 30 – 50% shady). Common species are: *Cocos nucifera* (Pol), *Borassus flabellifer* (Thal), *Areca catechu* (Puwak), *Azadirachta indica* (Kohomba), *Phyllanthus emblica* (Nelli), *Gliricidia sepium* (Weta Mara), *Mangifera indica* (Amba), *Tamarindus indica* (Siyambala), *Moringa oleifer* (Murunga), and *Thespesia populnea* (Suriya). A thick wet leaf litter (2 – 8 cm) layer is available and decaying logs are common (50 – 70%).
Mangroves	This habitat is restricted to a narrow belt (2 – 5m tall and 30 – 60% shady) and dominant plant species observed in this habitat included true mangrove species such as *Lumnitzera racemosa* (Beriya), *Excoecaria agallocha* (Tela Kiriya), *Rhizophora mucronata* (Kadol), *Avicennia marina* (Kanna), *Acanthus ilicifolius* (Katu Ikili) and mangrove associates such as *Tamarix indica* (Kiri), *Premna obtusifolia* (Maha Midi), *Clerodendrum inerme* (Burenda), and *Derris trifoliata* (Kala Wel).
Monoculture plantations	This is another interesting land area both naturalized and planted (2 – 15 m tall and 40 – 70% shady). Include trees like *Borassus flabellifer* (Thal) or *Cocos nucifera* (Pol) or a mixture of the two. Thick dry or wet leaf litter (10 – 20 cm) layer available and decaying logs are very common (75 – 90%). Monoculture plantations are also found in paddy fields where *Oryza sativa* (Goyam) is grown and in *Casuarina equisityfolia* (Kasa-Gas) cultivations.
Road verges	Found in marginal areas in rural, sub-urban and urban landscape along rods. Prominent tree speciesinclude, *Mangifera indica* (Amba), *Azadirachta indica* (Kohomba), *Phyllanthus emblica* (Nelli), *Gliricidia sepium* (Weta Mara), *Tamarindus indica* (Siyambala), *Moringa oleifer* (Murunga), and *Thespesia populnea* (Suriya) which are around 3 – 10 m tall, 40 – 60% shady. Thick wet or dry leaf litter (4 – 10 cm) layer available and decaying logs are common (50 – 70%). Sometimes randomly (0.5 – 1 m tall, randomly distributed on open soil and 10 – 20% shady) scrubland are present.
Salt marshes	This occurs where salt water and mudflats are present. Occupied by salt-tolerant herbaceous plant species (10 – 40 cm tall and randomly distributed on open soil). Plant diversity in salt marshes areas is relatively low, common herb species such as *Halosarcia indica*, *Salicornia brachiata*, *Cressa cretica*, *Blumea obliqua*, *Cyperus stoloniferus*, *Atriplex repens*, *Suaeda maritima*, *Cynodon dactylon*, *Sesuvium portulacastrum* (Maha Sarana), *Atriplex repens*, and *Blumea oblique*. No leaf litter layer available and decaying logs are very rare (5%).
Scrub forests	Abandoned after human use or due to excessive degradation of forest (1 – 3 m tall and randomly distributed on open soil). Randomly, scattered trees are found within the scrub. Common species are: *Cassia auriculata* (Ranawara), *Ziziphus oenoplia* (Heen Eraminiya), *Cissus quadrangularis* (Heressa), *Catunaregam spinosa* (Kukurumanna), *Phoenix pusilla* (Indi), *Syzygium cumini* (Madan), *Flueggea leucopyrus* (Katupila), *Gmelina asiatica* (Demata), *Carissa spinarum* (Heen Karamba), *Azadirachta indica* (Kohomba), *Ixora pavetta* (Maha Ratambala), *Dichrostachys cinerea* (Andara), *Morinda coreia* (Ahu). Thin leaf litter (1 – 3 cm) layer available and decaying logs are uncommon (30 – 50%).
Inland water bodies	Areas that is mainly dependent on rain water and completely or partially dried during the dry season. Aquatic vegetation such as *Nelumbo nucifera* (Nelum), *Nymphoides hydrophylla* (Kumudu), *Nymphaea pubescens* (Olu), *Hygrophila schulli* (Niramulliya), *Tamarix indica* (Kiri), *Panicum repens* (Etora), *Premna obtusifolia* (Maha Midi), *Clerodendrum inerme* (Burenda), and *Typha angustifolia* (Hambupan). Habitats with open water bodies are covered by macrophytes (40 – 60%) and marginal areas 10 – 30% shaded.

RESULTS

Our study, with the combination of field survey, interviews with four herpetologists with field experience in the region, museum records, and literature survey revealed a total of 84 species, including 15 amphibians and 69 reptiles (Table 2). Of the overall herpetofaunal species list we compiled, 25 species of reptiles were not recorded in our field survey, and were only found based on published literature, museum specimens, and observations made by expert field herpetologists of Sri Lanka. In contrast, all amphibians in the checklist were confirmed during the field survey. Among the total herpetofauna of Jaffna peninsula, 13 species were considered nationally threatened and five were globally threatened. Among the nationally threatened herpetofauna species, the snake-eye lizard, *Ophisops lechenaulti lankae*, is considered "Critically Endangered." In addition, eight more herpetofauna species were listed "Endangered" while four more were listed "Vulnerable" and other four were listed "Near Threatened." According to the global Red List Assess-

TABLE 2. A Checklist of Herpetofauna in Jaffna Peninsula, Sri Lanka

Family and Species	National status[1]	Global status[2]	Previous studies	Recorded in current study?
			SNAKES	
Boidae				
Eryx conicus	VU	NE	Deraniyagala (1955)	Yes
Colubridae				
Ahaetulla nasuta	LC	NE	No records	Yes
Ahaetulla pulverulenta	LC	NE	No records	Yes
Amphiesma stolata	LC	NE	Abyerami and Sivashanthini (2008), De Silva (1969)	Yes
Argyrogena fasciolata	DD	NE	De Silva (1980)	No
Atretium schistosum	LC	NT	Abyerami and Sivashanthini (2008), Deraniyagala (1955)	Yes
Boiga beddomei	NT	DD	No records	Yes
B. ceylonensis	LC	NE	No records	Yes
B. trigonata	LC	LC	Abyerami and Sivashanthini (2008), Deraniyagala (1955)	Yes
Chrysopelea taprobanica	LC	NE	Deraniyagala (1955)	No
Coelognathus helena	LC	NE	Abyerami and Sivashanthini (2008), De Silva (1980)	Yes
Dendrelaphis tristis	LC	NE	Abyerami and Sivashanthini (2008), Deraniyagala (1955)	Yes
Dryocalamus nympha	LC	NE	De Silva (1957, 1980), Abyerami and Sivashanthini (2008), Deraniyagala (1955)	No
Lycodon aulicus	LC	NE	De Silva (1957), Abyerami and Sivashanthini (2008), Deraniyagala (1955)	Yes
*L. carinatus**	EN	NE	De Silva (1969, 1980), Deraniyagala (1955)	No
*L. oanamallensis**	LC	LC	No records	Yes
Lycodon striatus	LC	NE	No records	Yes
Oligodon arnensis	LC	NE	De Silva (1957, 1980), Abyerami and Sivashanthini (2008), Deraniyagala (1955)	Yes
O. taeniolatus	LC	LC	Abyerami and Sivashanthini (2008)	Yes
Ptyas mucosa	LC	NE	De Silva (1957), Abyerami and Sivashanthini (2008), Deraniyagala (1955)	Yes
Fowlea cf. *piscator**	LC	NE	Abyerami and Sivashanthini (2008), De Silva (1969)	Yes
Elapidae				
Bungarus caeruleus	LC	NE	Abyerami and Sivashanthini (2008), Deraniyagala (1955), De Silva (1980)	No
Naja naja	LC	NE	De Silva (1957), Abyerami and Sivashanthini (2008), Deraniyagala (1955)	No
Hydrophis cyanocintus			De Silva et al (2011)	No
H. curtus	LC	NE	De Silva et al (2011)	Yes
H. fasciatus			De Silva et al (2011)	No
H. gracilis			De Silva et al (2011)	No
H. jerdonii	LC	LC	De Silva and Ukuwela (2017)	No
H. lapemoides	LC	LC	De Silva and Ukuwela (2017)	No
H. spiralis	LC	NE	No records	Yes
H. stokesii	LC	NE	Deraniyagala (1955)	No
H. viperina	LC	NE	De Silva et al (2011)	Yes
Homalopsidae				
Cerberus rynchops	LC	LC	Abyerami and Sivashanthini (2008)	No
Pythonidae				
Python molurus	LC	NT	Abyerami and Sivashanthini (2008)	No
Typhlopidae				
Indotyphlops braminus	LC	NE	Abyerami and Sivashanthini (2008)	No
Indotyphlops sp.[1]*	NE	NE	No records	Yes
Indotyphlops sp.[2]*	NE	NE	No records	Yes
Viperinae				
Daboia russelii	LC	NE	Abyerami and Sivashanthini (2008)	No
Echis carinatus	VU	NE	De Silva (1957), Abyerami and Sivashanthini (2008), Deraniyagala (1955)	Yes
Hypnale hypnale	LC	NE	No records	Yes

TABLE 2 (continued)

Family and Species	National status[1]	Global status[2]	Previous studies	Recorded in current study?
			OTHER REPTILES	
Crocodylidae				
Crocodylus palustris	NT	VU	Sivaruban and de Silva (2013)	Yes
Bataguridae				
Melanochelys trijuga	LC	NT	De Silva (1957)	Yes
Cheloniidae				
Caretta caretta	EN	EN	Twynam (1889a, 1889b)	No
Chelonia mydas	EN	EN	Thushan Kapurusinghe (personal communication), Twynam (1889a, 1889b)	No
Lepidochelys olivacea	EN	VU	Thushan Kapurusinghe (personal communication), Twynam (1889a, 1889b)	No
Dermochelidae				
Dermochelys coriacea	EN	CR	Deraniyagala (1953)	No
Testudinidae				
Geochelone elegans	NT	LC	No records	Yes
Trionychidae				
*Lissemys ceylonensis**	LC	NE	De Silva (1957)	Yes
Agamidae				
Calotes calotes	LC	NE	Erdelen (1984)	Yes
C. versicolor	LC	NE	De Silva (1957), Erdelen (1984)	Yes
Sitana cf. *devakai**	NE	NE	Deraniyagala (1953), De Silva (1957)	Yes
Chameleonidae				
Chamaeleo zeylanicus	EN	NE	Somaweera and Somaweera (2009)	No
Gekkonidae				
Gehyra mutilata	LC	NE	No records	Yes
*Hemidactylus depressus**	LC	LC	Deraniyagala (1932)	Yes
H. frenatus	LC	LC	De Silva (1957), Deraniyagala (1932)	Yes
*H. triedrus**	LC	NE	De Silva (1957)	Yes
H. leschenaultii	LC	NE	De Silva (1957), Deraniyagala (1932, 1953)	Yes
H. parvimaculatus	LC	NE	De Silva (1957), Deraniyagala (1932)	Yes
Lacertidae				
*Ophisops lechenaulti lankae**	CR	NE	Deraniyagala (1953)	No
Ristellidae				
*Lankascincus fallax**	LC	NE	Balasubramaniam and Krishnarajah (2004), Abyerami and Sivashanthini (2006)	No
Scincidae				
*Dasia haliana**	NT	NE	Deraniyagala (1953)	No
Eutropis beddomei	EN	NE	No records	Yes
E. bibronii	EN	NE	Deraniyagala (1953)	No
E. carinata	LC	NE	De Silva (1957), Abyerami and Sivashanthini (2006)	Yes
E. madaraszi	VU	NE	No records	Yes
*E. tammanna**	LC	NE	No records	Yes
Lygosoma punctata	LC	NE	De Silva (1957), Abyerami and Sivashanthini (2006)	Yes
Varanidae				
Varanus bengalensis	LC	LC	De Silva (1957)	Yes
V. salvator	LC	LC	No Records	Yes
			AMPHIBIANS	
Bufonidae				
Duttaphrynus melanostictus	LC	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes
D. scaber	VU	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes

TABLE 2 (continued)

Family and Species	National status[1]	Global status[2]	Previous studies	Recorded in current study?
Microhylidae				
Microhyla ornata	LC	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes
*M. mihintalei**	LC	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes
Uperodon systoma	LC	NE	Manamendra-Arachchi and Pethiyagoda (2006)	Yes
U. taprobanicus	LC	NE	Balasubrabanian et al. (2003)	Yes
*U. rohani**	LC	NE	No records	Yes
Dicroglossidae				
Euphlyctis cyanophlyctis	LC	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes
E. hexadactylus	LC	NE	Balasubrabanian et al. (2003)	Yes
Fejervarya limnocharis	LC	NE	Balasubrabanian et al. (2003)	Yes
Hoplobatrachus crassus	LC	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes
Sphaerotheca breviceps	LC	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes
S. rolandae	LC	NE	Balasubrabanian et al. (2003)	Yes
Ranidae				
*H. gracilis**	LC	NE	No records	Yes
Rhacophoridae				
Polypedates maculatus	LC	NE	De Silva (1957), Balasubrabanian et al. (2003)	Yes

Abbreviations. CR, critically endangered; EN, endangered; VU, vulnerable; NT, near threatened; LC, least concerned; NE, not evaluated; * Endemic species.
[1] National conservation status was determined based on MOE-SL (2012).
[2] Global conservation status was determined based on IUCN (2015).

TABLE 3. Relative Abundance of Amphibians and Reptiles Recorded in the Field Survey in Jaffna Peninsula – 2015

Species	Poly-culture crop-lands	Home gardens	Mono-culture planta-tions	Grass-lands	Coastal beeches	Salt marshes	Man-groves	Inland water bodies	Scrub forests	Road verge	Total
Eryx conicus	0	0	0	0	1	0	0	0	1	0	2
Ahaetulla nasuta	0	1	0	0	0	0	0	0	0	1	2
Ahaetulla pulverulenta	0	0	1	0	0	0	0	0	1	0	2
Amphiesma stolata	0	0	1	1	0	0	0	0	0	0	2
Atretium schistosum	0	0	0	0	0	1	1	1	0	0	3
Boiga beddomei	0	1	0	0	0	0	0	0	0	0	1
Boiga ceylonensis	0	1	0	0	0	0	0	0	0	0	1
Boiga trigonata	1	0	1	0	0	0	0	0	0	0	2
Coelognathus helena	1	0	1	1	0	0	0	0	1	1	5
Dendrelaphis tristis	1	1	0	0	1	0	0	0	1	1	5
Lycodon aulicus	0	0	1	0	1	0	0	0	0	0	2
Lycodon anamalensis	0	1	0	0	0	0	0	1	0	0	2
Lycodon striatus	0	0	0	1	0	0	0	0	0	0	1
Oligodon taeniolatus	1	0	0	0	0	0	0	0	0	1	2
Ptyas mucosa	1	1	1	1	0	0	0	1	1	0	6
Fowlea cf. *piscator*	0	0	0	0	1	1	1	2	0	0	5
Hydrophis curtus	0	0	0	0	1	0	0	0	0	0	1
Hydrophis spiralis	0	0	0	0	1	0	0	0	0	0	1
Hydrophis viperina	0	0	0	0	1	0	0	0	0	0	1
Indotyphlops sp.[1]	1	1	0	0	0	0	0	0	0	0	2
Indotyphlops sp.[2]	0	1	0	0	0	0	0	0	0	0	1
Echis carinatus	0	0	1	0	1	0	0	0	0	0	2
Hypnale hypnale	1	1	0	0	0	0	0	0	1	0	3

TABLE 3 (continued)

Species	Poly-culture crop-lands	Home gardens	Mono-culture planta-tions	Grass-lands	Coastal beeches	Salt marshes	Man-groves	Inland water bodies	Scrub forests	Road verge	Total
Crocodylus palustris	0	0	0	0	0	0	2	0	0	0	2
Melanochelys trijuga	0	0	0	0	0	0	0	6	0	0	6
Geochelone elegans	1	0	0	0	0	0	0	0	0	0	1
Lissemys ceylonensis	0	0	0	0	0	0	0	2	0	0	2
Calotes calotes	1	1	0	0	0	0	0	0	0	1	3
Calotes versicolor	5	2	28	0	9	2	0	2	15	0	63
Sitana cf. *devakai*	0	0	0	0	17	0	0	0	2	0	19
Gehyra mutilata	0	3	5	0	0	0	0	0	0	0	8
Hemidactylus depressus	0	1	2	0	0	0	0	0	0	0	3
Hemidactylus frenatus	2	7	7	0	4	0	0	0	0	0	20
Hemidactylus triedrus	0	0	2	0	0	0	0	0	0	2	4
Hemidactylus leschenaultii	0	0	2	0	0	0	0	0	3	0	5
Hemidactylus parvimaculatus	7	2	6	0	2	0	0	0	0	0	17
Eutropis beddomii	0	0	0	0	1	0	0	0	0	0	1
Eutropis carinata	1	0	1	0	0	0	0	0	0	0	2
Eutropis madaraszi	1	0	0	1	0	0	0	0	0	0	2
Eutropis tammanna	0	0	4	2	4	0	0	0	2	0	12
Lygosoma punctatus	0	1	2	0	0	0	0	0	4	0	7
Varanus bengalensis	2	0	1	0	0	0	0	0	2	0	5
Varanus salvator	0	0	0	0	0	0	0	1	0	0	1
Duttaphrynus melanostictus	2	4	2	0	1	1	0	7	0	2	19
Duttaphrynus scaber	0	0	5	0	2	0	0	5	7	0	19
Microhyla ornata	0	0	0	3	1	0	0	5	0	0	9
Microhyla mihintalei	0	0	0	12	4	0	0	12	0	0	28
Uperodon systoma	0	0	0	1	0	2	0	4	0	0	7
Uperodon taprobanicus	1	0	0	0	1	0	0	2	0	0	4
Uperodon rohani	0	0	0	0	0	1	0	9	0	0	10
Euphlyctis cyanophlyctis	0	0	0	0	0	0	16	32	0	0	48
Euphlyctis hexadactylus	0	0	0	0	0	0	6	8	0	0	14
Fejervarya limnocharis	13	0	0	2	0	0	0	5	0	0	20
Hoplobatrachus crassus	1	0	0	0	0	0	2	1	0	0	4
Sphaerotheca breviceps	0	0	2	0	0	0	0	2	5	2	11
Sphaerotheca rolandae	0	2	1	0	0	0	0	5	1	4	13
Hydrophylax gracilis	1	0	1	0	1	0	0	2	0	2	7
Polypedates maculatus	3	5	0	0	0	0	2	8	0	0	18
Total	48	55	25	37	30	78	17	8	47	123	468

ment, five species of herpetofauna that occur in our study area were considered "Threatened." Among the globally threatened herpetofauna species, one species of marine turtle, *Dermochelys coriacea*, is considered "Critically Endangered." In addition, two species were listed "Endangered" while two were listed "Vulnerable" and another three were listed "Near Threatened."

Our current field survey only recorded 59 species and a total of 468 herpetofauna individuals, including 44 reptilian spices and 15 amphibian species (Table 3). Eighteen of the species we found in the field appeared neither in previous studies nor among museum records from the study area, and thus are new records for the checklist of Herpetofauna in Jaffna Peninsula. Of the 59 species of herpetofauna, five were nationally threatened (*Eutropis madarazi* and *E. macularia*, *Eryx conicus*, *Echis carinatus*, *Duttaphrynus scaber*) and one was globally threatened (*Crocodylus palustris*). The reptile community of Jaffna peninsula comprised of 20 families which included both snakes and tetrapod reptiles (Fig. 3). Of the 44 reptile species recorded, *Lissemys ceylonensis*, *Hemidactylus depressus*, *Eutropis tammanna* are endemic; probably endemic *Fowlea* cf. *piscator*, *Sitana* cf. *devakai* and two unidentified probably endemic *Indotyphlops* species were also recorded. However, endemic species such as *Lankascincus fallax* (formerly, *Sphenomorphus*

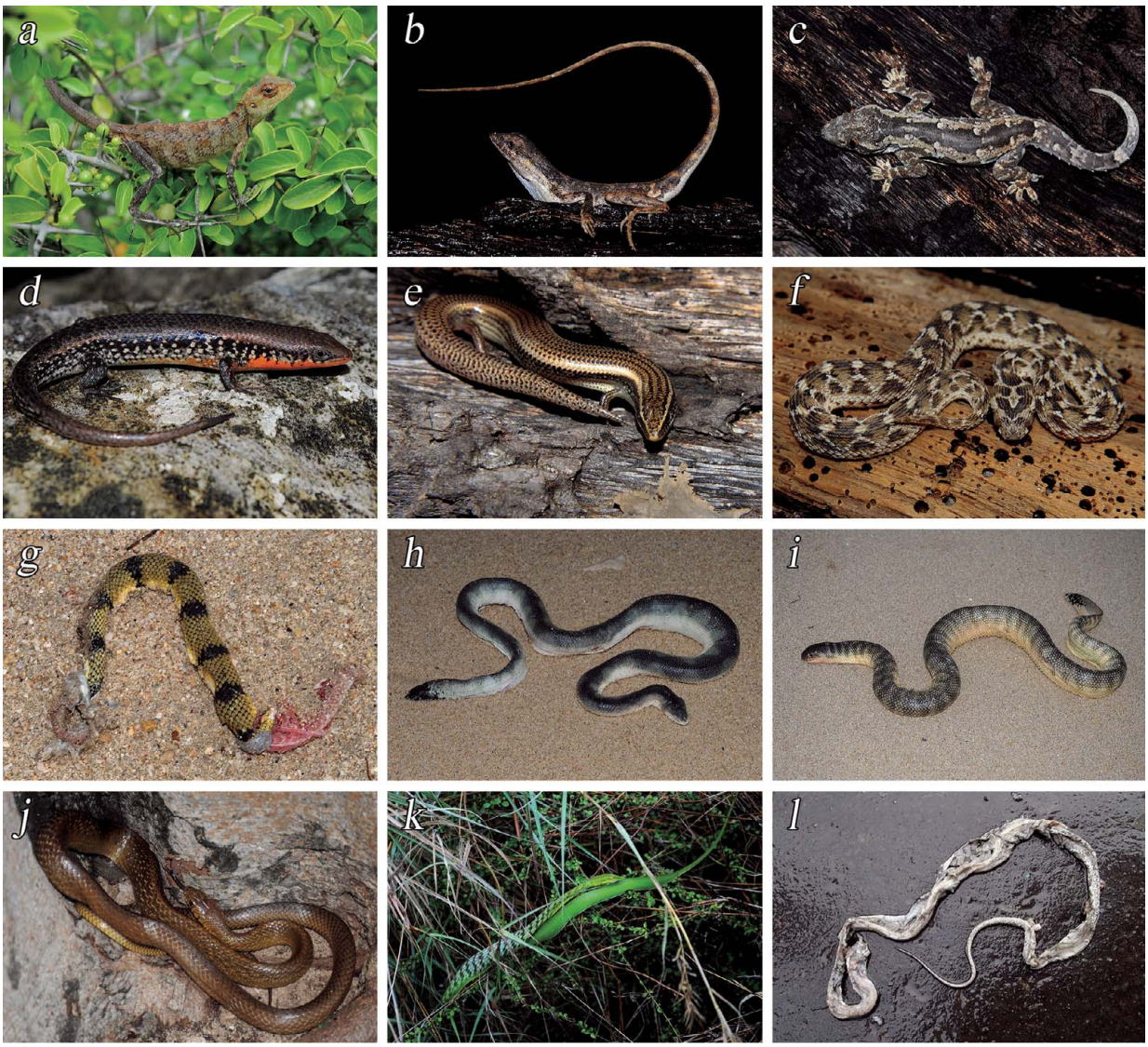

Fig. 3. Reptiles recorded in Jaffna peninsula during the study: *a*, *Calotes versicolor* female at Delft Island; *b*, *Sitana* cf. *devakai* adult male; *c*, *Hemidactylus leschenaultii*; *d*, *Eutropis tammanna* male; *e*, *Lygosoma punctatus*; *f*, *Echis carinatus*; *g*, *Hydrophis spiralis* (killed by fishermen); *h*, *Hydrophis viperina*; *i*, *Hydrophis curtus*; *j*, *Ptyas mucosa* at Palali; *k*, *Ahaetulla nasuta* at Kopaiy; *l*, *Boiga ceylonensis* roadkill at Pallai.

rufogulus), *Dasia haliana*, and *Lycodon carinatus* (formerly, *Cercaspis carinatus*) were not recorded despite been mentioned in earlier records. The amphibian communities of Jaffna peninsula were represented by five anuran families. The three endemic amphibians found in our study was the ranid *Hydrophylax gracilis*, *Microhyla mihintalei*, and *Uperodon rohani*. Among the amphibians in our checklist, *Duttaphrynus scaber* is considered vulnerable according to the national Red List (Fig. 4). No "globally threatened" amphibians occurred in Jaffna peninsula.

Among the amphibians recorded in our field survey, *Euphlyctis cyanophlyctis* was the most abundant (48 individuals). Among reptiles, *Calotes versicolor* was the most abundant reptile (63 individuals) whereas *Ptyas mucosa* (six individuals) was the most abundant species of snake. Seven species of snakes and three species of non-serpentine reptiles were only represented by one specimen each. Among different habitat surveyed, both monoculture plantations and inland water bodies had the highest species richness for all herpetofauna (23 species) whereas the lowest species richness was found in salt-marshes (6 species). Inland waterbodies had the highest

Fig. 4. Amphibians recorded in Jaffna peninsula during the study: *a*, *Polypedates maculatus* amplexus; *b*, *Duttaphrynus melanostictus* yellow color morph; *c*, *Duttaphrynus scaber*; *d*, *Uperodon rohani*; *e*, *Microhyla ornata*; *f*, *Microhyla mihintalei*; *g*, *Uperodon systoma*; *h*, *Sphaerotheca breviceps*; *i*, *Sphaerotheca rolandae*; *j*, *Uperodon taprobanicus* at Delft Island; *k*, a roadkill specimen of *Hoplobatrachus crassus*; *l*, a roadkill specimen of *Hydrophylax gracilis* roadkill at Karaveddai.

overall abundance ($n = 123$) of all herpetofauna while saltmarshes had the lowest overall abundance ($n = 8$). The highest species richness and abundance of amphibians was recorded from inland waterbodies; the equivalent figure for reptiles was recorded in monoculture plantations (Fig. 5).

DISCUSSION

We are not aware of any comprehensive amphibian and reptile surveys conducted in Jaffna peninsula in the recent past. Most studies conducted in this area focused on a certain sub-group of reptiles and are limited to "gray literature" such as technical reports and conference proceedings (Balasubramaniam and Krishnarajah, 2001; Balasubramaniam et al., 2003; Sivaruban, 2013; Sivaruban and de Silva, 2013). Such studies, despite their scientific rigor, have not reached a broader scientific community and hence did not substantially influence conservation actions or contribute to our scientific knowledge on Jaffna biodiversity. The reptile richness we recorded for

Jaffna peninsula represented more than 65% of the reptile species found in Sri Lanka's dry zone (de Silva 2006a; Somaweera and Somaweera, 2009a, 2009b). Similarly, the amphibian species richness we documented in Jaffna peninsula accounted for 75% of species found in Sri Lanka's dry zone (MOE, 2012).

The herpetofaunal diversity we recorded in Jaffna peninsula is comparable to other studies conducted in monsoon forests and dry zone habitats in Sri Lanka. For instance, Karunarathna et al (2008b) and Karunarathna and Amarasinghe (2011) documented 100 species of herpetofauna in a lowland tropical dry, mixed-evergreen forest in Nilgala. Kumarasinghe et al (2013) documented 63 species of herpetofauna in dry zone at Eluwankulam. Abayarathna (2010a, 2010b) reported 10 species of amphibians and 31 species of reptiles in Girithale Nature Reserve. Somaweera et al (2004) reported 14 species of amphibians and 43 species of reptiles in Panama, Eastern province. The high herpetofaunal diversity found in the monoculture plantations was remarkable. These plantations were single-crop (e.g., *Cocos nucifera*, *Borassus flabellifer*) large (1 – 2 ha), intensive, commercial scale farm fields. In stark contrast to our findings, many previous studies have shown that intensive, commercial scale monoculture plantations are the least suitable for amphibians and reptiles (Scales and Marsden, 2008; Wilcove and Koh, 2010). Suitability of agricultural landscapes for herpetofauna depends on of farming methods, type of the crops, harvesting intensity, and intensity of land management (Scales and Marsden, 2008; Scherr and McNeely, 2008). Reptiles largely accounted for the higher diversity of the herpetofauna in these anthropogenic habitats. Although higher availability of light and heat can deter most reptiles, high abundance of prey organisms such as insect pests, rats, and other human commensals in monocrop farmlands could have resulted in the high species richness and abundance of reptiles (McDade, 1994). The species detectability is higher in open habitats such as farmlands than in structurally-complex closed habitats such as forests. Influence of environmental complexity and habitat heterogeneity on impact detection has been well researched which is much applicable to herpetofauna (Bailey et al., 2004).

The high diversity of herpetofauna recorded in home gardens, polyculture croplands, and inland water bodies are noteworthy. Home gardens and polycrop eco-friendly farming systems, such as organic farming, forest gardening, and agroforestry are known to substantially contribute to native biodiversity (Somathilaka, 2007; Scherr and McNeely, 2008; Junqueira et al., 2010). Inland water bodies that are small wetlands with a shorter hydroperiod are free of aquatic predators and lower in competitive stress thus may serve as suitable breeding grounds, foraging habitats, and as refugia for many amphibians and reptiles (Gopal and Krishnamurthy, 1993; Snodgrass et al., 2000; Semlitsch and Bodie, 2003; Gibbons et al., 2006). Among 59 herpetofauna species we recorded in the field survey, 13 species were found only in one habitat type and 20 were only found in two habitat types each. Only two species (*Calotes versicolor* and *Duttaphrynus melanostictus*) occurred in more than seven habitats. These observations suggested that the mosaic nature of the Jaffna landscapes is critical for persistence of herpetofaunal communities.

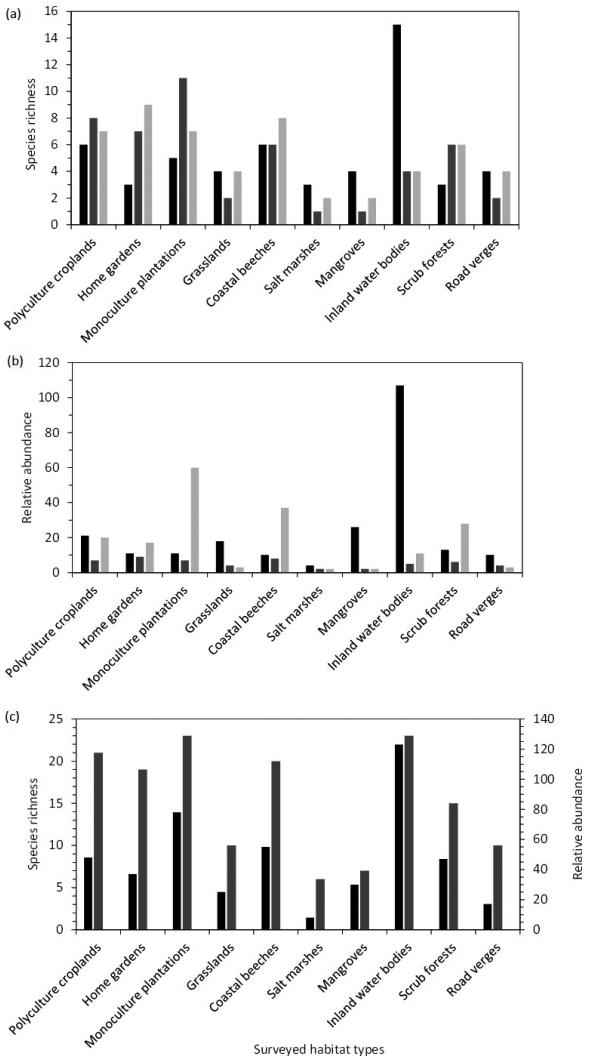

Fig. 5. Diversity of herpetofauna across the ten major surveyed habitat types in Jaffna peninsula *a*, Species richness (black, amphibians; dark gray, non-serpentine reptiles; light gray, snakes); *b*, relative abundance (black, amphibians; dark gray, non-serpentine reptiles; light gray, snakes); *c*, total species richness (gray) and overall relative abundance (black) of all herpetofauna (amphibians, non-serpentine reptiles, and snakes combined).

We found relatively lower diversity of amphibians and reptiles in saltmarshes and mangroves. These habitats present much variations in terms of salinity, hydrology, and temperature (Trebitz et al., 2005); hence present adverse environmental conditions that warrant specific physiological adaptations which limits species richness of those saline habitats. Further, we found substantially lower diversity in grasslands and scrub forests. The acreage of both of those habitats are small in Jaffna Peninsula (Balasubramaniam et al., 2003), and both habitats are susceptible to grazing and intentional burning- both of which may reduce suitability of these habitats for herpetofauna. The road verges appeared to be lower in diversity as well. Roadside mud puddles might attract some pond-breeding amphibians; asphalt surfaces of roads might be conducive for reptiles for thermoregulation (Spellerberg, 1998; Trombulak and Frissell, 2001; Coffin, 2007). Road verges are likely to act as ecological traps since roadside ditches dry prematurely; road verge inhabitants are also vulnerable to road kills (Schlaepfer et al., 2002).

The herpetofauna community of Jaffna peninsula is under a multitude of anthropogenic threats. Among the snakes we documented, only four terrestrial species (two elapids and two viperids) are venomous to humans. Yet, almost all snake species have become victims of vengeful killing (Abyerami and Sivashanthini, 2008). Similarly, despite the low traffic density, roadkills are common in the region. Domesticated animals, such as cats, dogs, and fowls are known to predate on amphibians and reptiles (Bambaradeniya, 2002). On-going development activities such as construction of human settlements, exurban development, and infrastructure development as well as extraction of forest products (firewood and timber) have led to substantial loss of native vegetation. Loss of native vegetation can lead to reduced shade and increased moisture depletion. Moisture and shade are important microclimatic features for many amphibians and reptiles, especially when they seek refuge under drought conditions and during the dry season (Abyerami and Sivashanthini, 2008). There is a historical practice of consuming turtle meat in Jaffna peninsula which can substantially reduce their populations in the local seascapes (Tennent, 1868; Twynam, 1889). Those studies documented that ~3000 turtles were consumed annually. Conservation of these unique herpetofaunal communities and their habitats must be taken into consideration in regional land use planning, natural resource management, infrastructure development and rural development. Informal educational activities conducted through community-based programs can help mitigate vengeful killing and other consumption-driven threats.

Although our survey was conducted in a shorter time frame, since we surveyed multiple habitat types in the on-set of the monsoon season, our field excursions may have recorded a substantial proportion of the herpetofauna in the region. In addition, consultation of expert field herpetologists and published literature may have substantially helped account for our lower sampling efforts. However, observations on sea turtles in Jaffna beeches are highly dependent on seasonal nesting and reproduction (Twynam, 1889). Hence, absence of sea turtles in our survey can be attributed to lack of long-term observations. We believe that the record of the snake *Lycodon carinatus* was a mistaken identity in the previous studies since currently this snake is only found in Sri Lanka's southwestern wet zone. To verify the presence of 23 species we could not record through our field survey, long-term multi-seasonal intensive sampling efforts must be implemented. We strongly suggest to incorporation of species occupancy modelling to account for imperfect detectability of cryptic herpetofauna (Bailey et al., 2004). Our intention of this study is to produce a checklist of herpetofauna to support on-going conservation efforts and to form a foundation for long-term future research on conservation and ecology of amphibians and reptiles of Jaffna peninsula. Similar approaches, such as rapid biodiversity assessments and baseline biodiversity surveys, have yielded valuable information for biodiversity inventories elsewhere in less-explored biomes (Kerr et al., 2000; Kipson et al., 2011). We believe that our study have enhanced knowledge and understanding of the current status of amphibian and reptile biodiversity of Jaffna peninsula. Such baseline information can be pivotal to explore current and future trends in regional faunal assemblages and propose science-based conservation and management actions targeting dry zone ecosystem complexes of Jaffna Peninsula.

Acknowledgments. We would like to express our sincere gratitude to N. Gamage, N. Karunarathna, A. Udayakumara, M. Bahir, K. Ukuwela, A. Kumarasinghe, C. Ratnapala, D. Ratnapala, and villages of Jaffna peninsula for various help and logistic support. We would like to give our special thanks to S. Kasthuriarachchi, N. Wickramasinghe, L. Somaratne, M. Nandasena, C. Munasinghe and R. Dasanayake (NMSL) for assistance during examining collections under their care; P. Abeykoon, H. Wickramasinghe, D. Perera, M. Ranaweera, and Biodiversity Secretariat (BDS) of Ministry of Environment (MOE) for partially financial assistant. Finally, we would like to give our special thanks to R. Somaweera, T. Amarasinghe and anonymous reviewers for useful comments. The Animal Care and Use Committee of Bridgewater University approved all the research methods. Research permits were obtained from the Department of Wildlife Conservation, Sri Lanka.

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