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RESEARCH ARTICLE

Assessment of Historical and Current Distribution Records of the Indo-Pacific Slender Gecko, *Hemiphyllodactylus typus* Bleeker, 1860, in Sri Lanka

Hareschandra Bandula Jayaneththi[1,*] and Daniel Jablonski[2]

[1]*Young Zoologists' Association of Sri Lanka, National Zoological Garden, Dehiwala, Sri Lanka*
[2]*Department of Zoology, Comenius University in Bratislava, Mlynská dolina, Ilkovičova 6, 842 15 Bratislava, Slovakia*

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Abstract: *Hemiphyllodactylus typus* is a widespread but low abundant parthenogenetic taxon, which is widely distributed through Southeast Asia and the entire tropical Pacific Ocean of New Guinea to some other Oceanic Islands. The present study has reviewed the data from a combination of literature together with our unpublished field records. A total of 36 localities of *H. typus* were detected, including four recent observations or repeated observations. Some information regarding the natural history, autecology and biogeography of *H. typus* in Sri Lanka are given.

Keywords: parthenogenetic species, new records, syntopic occurrence, allochtony, human-mediated introduction.

INTRODUCTION

Hemiphyllodactylus typus is a widespread, unisexual (parthenogenetic) species and thus the populations comprise only of females with developed precloacal and femoral pores. This species is distributed through Southeast Asia and the entire tropical Pacific Ocean west of New Guinea to the Sunda Islands and eastward towards the islands and atolls of eastern Polynesia reaching Pitcairn Island. The species has probably been introduced into the Philippines, Taiwan, Andaman and Nicobar (India) and Mascarene Islands, Ryukyu and Iriomotejima Islands (Japan), New Caledonia (questionable) and Hawaiian Islands in the USA (Das, 1999; Lever, 2003; Zug, 2010; Chandramouli *et al*., 2012; Fisher *et al*., 2013; Holden *et al*., 2014). Its apparent scarcity is certainly related to its small size, strictly nocturnal mode of life, and secretive behaviour (Zug, 2010).

Batuwita & Alagiyawadu (2004) presented that individuals from coastal zones are more or less slender bodied while those from the central hills are robust. However, populations of *Hemiphyllodactylus* from Sri Lanka are also possibly formed by bisexual populations, which is not examined so far (see Somaweera & Somaweera, 2009; Zug, 2010). *H. typus* is considered as an endangered species in Sri Lanka, The Red-List criterion has amended in 2012 under the 'Nationally Vulnerable' B1 ab (ii) (MENR, 2012).

MATERIAL AND METHODS

This article provides a combination of information from published literature together with our unpublished field records. This is necessary in view of insularity of the study region, exceptionally high species diversity of reptiles, probable presence of both unisexual and bisexual populations of *Hemiphyllodactylus* and the possibility of its introductions through accidental human transport.

All records were georeferenced. However, coordinates of some historical records correspond to the closest village/regions nearby and do not represent the exact sites of the recorded finding. Based on obtained coordinates (see Table 1) we generated a distribution map for *H. typus* in Sri Lanka using DIVA-GIS 7.5 (Hijmans *et al*., 2012). The records were divided into two categories, already published and our new records. Field observations of *H. typus* were encountered during three regular field visits and one random spot between 2004 and 2015 (Table 1). Visual spotting on habitats with occasional hand capture was done during the diurnal and

**Corresponding Author's Email*: bjayaneththi@gmail.com

nocturnal observations. Some measurements were taken with a digital vernier scale (Mannesmann Electronic Precision/0-150 mm). Specimens were identified following Smith (1935), Deraniyagala (1953), Somaweera & Somaweera (2009) and Zug (2010). No voucher specimens were collected.

RESULTS

A total of 36 localities of *H. typus* were detected including four recent observations (see Table 1 and Figure 1). All observation sites were from wet and intermediate zones of the island and the locations were confined to lowland, sub-montane or montane and moist monsoon forests (see Table 1; cf. Somaweera & Somaweera, 2009). Habitats of recent sightings are described below. All observed specimens were females.

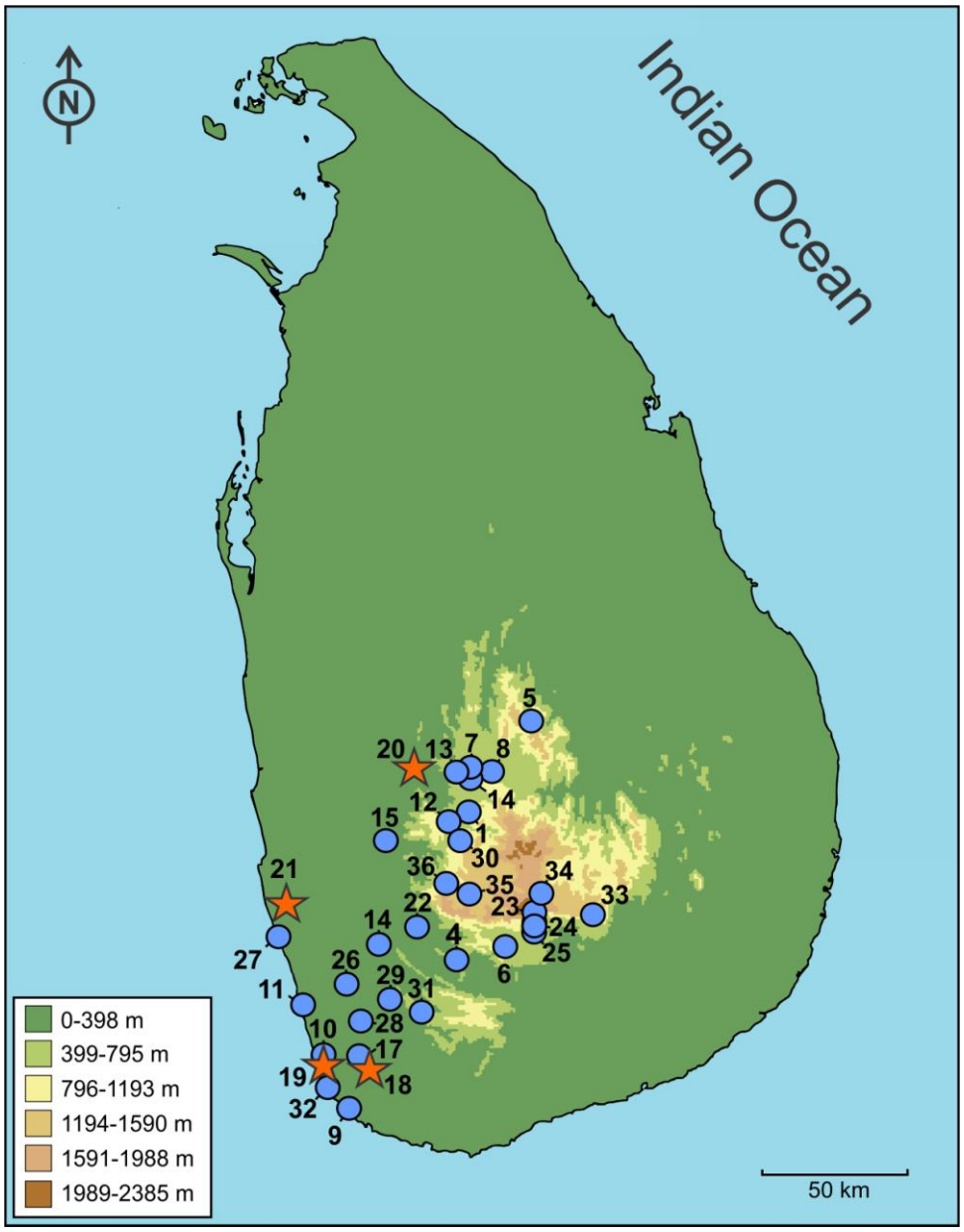

Figure 1: Updated distribution map of *Hemiphyllodactylus typus* in Sri Lanka based on published (blue spots) and new records in the present study (orange stars). See Table 1 for other details.

Table 1. Distribution sites and descriptions of published records including new localities of *Hemiphyllodactylus typus* in Sri Lanka.

No.	Location	District	Habitat & notes	Latitude (N)	Longitude (E)	Altitude (m)	Source/s
1	Gampola	Kandy	First record in Sri Lanka/ Beddome Collection	7°7'28.15"	80°34'44.86"	595	Boulenger 1885, 1890
2	Ceylon	not given	Deraniyagala's collection	Not available	Not available		Smith, 1935
3	Ceylon	not given	Probably equal to Site No. 2	Not available	Not available		Daraniyagala, 1953 (in 1932)
4	Palmadulla	Rathnapura	Location not specified	6°38'4.14"	80°31'47.83"	150	Deraniyagala, 1953
5	Kalupahana Knuckles Range	Matale	Location not specified	7°26'28.58"	80°47'48.85"	~1200	Ginige, 1994, cited in Goonewardene *et al.*, 2006, p.82; and De Silva *et al.*, 2005
6	Balangoda	Ratnapura	Location not specified	6°39'15.82"	80°41'54.41"	547	Deraniyagala, 1953 (observation made in 1940) Manamendra-Arachchi, 1997
7	Gannoruwa	Kandy	Human settlements	7°16'48.56"	80°35'28.21"	473	Batuwita, 2000
8	Ampitiya (near Dodanwela)	Kandy	Home garden	7°15'55.84"	80°39'39.50"	565	Somaweera *et al.*, 2001
9	Pitiwela (near Boossa)	Galle	Location not specified	6°5'15.81"	80°9'43.63"	18	Batuwita & Alagiyawadu, 2004; Batuwita & Bahir, 2005; Manamendra-Arachchi *et al.*, 2007
10	Polwatta (near Ambalangoda)	Galle	Location not specified	6°15'40.12"	80° 4'0.08"	13	Batuwita & Alagiyawadu, 2004
11	Aluthgama	Kalutara	Location not specified	6°26'58.97"	80° 0'1.20"	13	Batuwita & Alagiyawadu, 2004
12	Pussellawa	Kandy	Location not specified	7°5'39.54"	80°30'17.67"	734	Batuwita & Alagiyawadu, 2004
13	Pilimathalawa	Kandy	Location not specified	7°15'52.15"	80°32'10.65"	512	Batuwita & Alagiyawadu, 2004
14	Penideniya	Kandy	Location not specified	7°15'10.73"	80°35'20.97"	507	Batuwita & Alagiyawadu, 2004
15	Kegalle	Kegalle	Location not specified	7°15'4.79"	80°20'46.95"	227	Somaweera & Somaweera, 2009
16	Kukulugala	Ratnapura and Kalutara	Secondary forest	6°39'41.81"	80°15'41.41"	485	Karunarathna & Amarasinghe, 2010; Karunarathna *et al.*, 2015
17	Beraliya-Mukalana (near Elpitiya)	Galle	Primary montane forest (near Elpitiya)	6°16'20.09"	80°11'48.16"	134	Karunarathna & Amarasinghe, 2012; Karunarathna *et al.*, 2015

No.	Location	District	Habitat & notes	Latitude (N)	Longitude (E)	Altitude (m)	Source/s
18	Morankanda Mukalana	Galle	Tea plantation with rocky scrub and anthropogenic features	6°13'16.39"	80°14'0.17"	54	Jayaneththi, 2015; Jayaneththi *et al.*, 2015; This study
19	Godahena (near Ambalangoda)	Galle	Mangrove forest in Madampa Lake with manmade building; anthropogenic habitat	6°14'6.94"	80°4'18.22"	11	Jayaneththi *et al.*, 2015; This study
20	Pinnawala	Kegalle	anthropogenic habitat	7°18'3.34"	80°23'26.20"	96	Present study
21	Kasbewa	Colombo	Escaped individual from location 16; shaded home garden	6°48'2.83"	79°56'29.64"	22	Present study
22	Ratnapura	Ratnapura		6˚42'26.17"	80˚22'53.07"	70	Karunarathna *et al.*, 2015
23	Nanperial estate	Ratnapura		6˚45'42.01"	80˚47'25.72"	1380	Karunarathna *et al.*, 2015
24	Belihuloya	Ratnapura		6˚42'37.01"	80˚47'12.08"	609	Karunarathna *et al.*, 2015
25	Mungasthenna	Ratnapura		6˚41'44.03"	80˚47'09.09"	534	Karunarathna *et al.*, 2015
26	Matugama	Kalutara		6˚31'15.31"	80˚07'23.00"	80	Karunarathna *et al.*, 2015
27	Panadura	Kalutara		6˚43'06.01"	79˚54'33.71"	12	Karunarathna *et al.*, 2015
28	Yagirala	Kalutara		6˚22'38.63"	80˚10'15.97"	120	Karunarathna *et al.*, 2015
29	Kalugala	Kalutara		6˚27'55.83"	80˚14'41.09"	140	Karunarathna *et al.*, 2015
30	Nawalapitiya	Kandy		7˚03'20.16"	80˚31'29.09"	650	Karunarathna *et al.*, 2015
31	Sinharaja	Ratnapura/Kalutara		6˚24'36.60"	80˚22'50.18"	360	Karunarathna *et al.*, 2015
32	Telwatta	Galle		6˚10'24.04"	80˚05'26.61"	12	Karunarathna *et al.*, 2015
33	Koslanda	Monaragala		6˚44'32.99"	81˚01'12.18"	700	Karunarathna *et al.*, 2015
34	Ohiya	Badulla		6˚49'04.00"	80˚50'38.56"	1600	Karunarathna *et al.*, 2015
35	Maskeliya	Nuwara-Eliya		6˚50'36.35"	80˚34'49.66"	1300	Karunarathna *et al.*, 2015
36	Nortonbrige	Nuwara-Eliya		6˚53'52.10"	80˚31'08.24"	1100	Karunarathna *et al.*, 2015

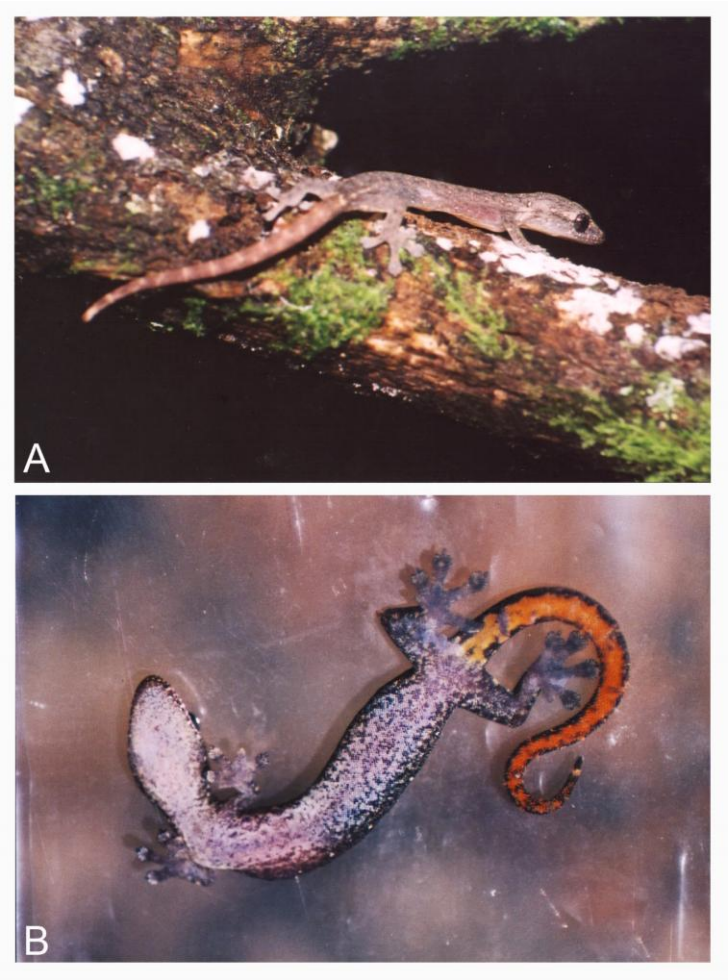

Figure 2: A, B: Juveniles of *Hemiphyllodactylus typus* from Morankanda Mukalana (loc. 18). The black caecum characteristic mainly for unisexual species is visible (2B).

Morankanda Mukalana, Elpitiya, (location 18)

The locality is a secondary forest, located in Indigahawila in Kahaduwa, Elpitiya (Galle District: Southern Province). Habitat of *H. typus* was anthropogenic and mostly surrounded with plant species such as *Camellia sinensis*, *Cocos nucifera*, *Mangifera indica*, *Piper nigrum*, *Garcinia mangostana* and *Musa paradisiaca*. During November 2004 to December 2009, a total of 15 observations were made in this site. These observed specimens were three new born, three juveniles and nine adults or subadults (31-41 mm SVL).

Godahena, Ambalangoda (location 19)

This site is located on the eastern boundary of Madampa Lake along the southwestern coastline of Sri Lanka, next to southern boundary of the RAMSAR wetland "Maduganga" Lagoon, Galle District. The vegetation is comprised mainly of mangroves with species including, *Bruguiera sexangula*, *Sonneratia caseolaris* and *Nypa fruticans*. From April 2009 to August 2010 only three specimens of *H. typus* were observed (two adults: 40.1 mm, 37.2 mm SVL and one juvenile).

Pinnawala Elephant Orphanage (location 20)

Pinnawala is located in a rural area, 13 km northeast of Kegalle town in the Sabaragamuwa Province. In November 2008, a single *H. typus* adult (3.8 mm SVL) was recorded inside a local building. It is an abandoned building surrounded by vegetation including *Mangifera indica.*

Kesbewa (location 21)

Two specimens were recorded in Kesbewa. The first specimen was recorded in October 2007, a single adult (36.2 mm SVL). This specimen was observed in nursery plants, which transported from location 18 (Morankanda-Mukalaana) in the same day. Thus, we assumed that the particular adult specimen was an accidental

introduction to Kesbewa site. However, the second specimen recorded in August 2008 was a juvenile of *H. typus*.

DISCUSSION

Initial records of *H. typus* from Sri Lanka appeared in Boulenger's (1885) classification referred as the Beddome's collection (holotype BMNH 74.4.29.1326, location given as Gampola, Ceylon; see Table 1) as *Lepidodactylus ceylonensis* (synonym) on Catalogue of the Lizards in the British Museum (CLBM) (see also Boulenger, 1890). Subsequently Stejneger (1899) corrected the genus name as a *H. ceylonensis* and stated nomenclature as *H. ceylonensis* (see Werner, 1913; Zug, 2010). Later Smith (1935) listed it as a subspecies *H. typus.* Populations from Sri Lanka are currently designated as *H. typus* because the morphology of the holotype (BMNH 74.4.29.1326) was confirmed to be of this species. The situation in Sri Lanka is, however, more complicated due to historical evidence of unisexual and bisexual specimens and different morphology between populations (see below and Batuwita & Alagiyawadu, 2004; Zug, 2010).

Hemiphyllodactylus typus is uncommon or scattered in many countries where it is been recorded (Zug, 2010; Grismer, 2011; Fisher *et al*., 2013). Based on present observations and available literature, the recorded sympatric geckoes were listed in Table 2. *Hemiphyllodactylus typus* recorded in number of different types of habitats in Sri Lanka (mangrove, plantations, primary and secondary forests, and anthropogenic habitats). Some of these records come from an elevation of above 1,000 m (Table 1). Observed pattern suggests that fragmented populations on the island. Most of observed sites were located in the south-western part of the island, especially in coastal regions and central hills.

The current considered pattern of *H. typus* distribution, can be separated into two sub-populations, one is covers south-west lowlands with coastal plains and the other is central hills above the 1000 m. The theoretical explanation for this two separated populations will be explored further.

However, (i) the slightly disjunctive pattern of distribution of this species in Sri Lanka (Figure 1), (ii) historical records of existence of both unisexual and bisexual populations (Zug, 2010) and (iii) morphological differentiation between lowland and central hills populations (Batuwita & Alagiyawadu, 2004; Zug, 2010), we can suggest that populations of *Hemiphyllodactylus* on the island can be formed by two species; unisexual *H. typus* morph type and bisexual, presumably classified as *H. aurantiacus* morph type distributed also in southern and eastern India (Maqsood-Javed *et al*., 2010; Zug, 2010). On the other hand, we cannot exclude the fact that the latter is a new undescribed species (Zug, 2010).

Table 2: Syntopic species of family Gekkonidae recorded on some of *Hemiphyllodactylus typus* localities (* = endemic species): Gm= *Gehyra mutilata*; Hp= *Hemidactylus parvimaculatus*; Hf= *Hemidactylus frenatus*; Hd= *Hemidactylus depressus**; Ll= *Lepidodactylus lugubris*; Cs= *Cnemaspis silvula**; Cm= *Cnemaspis molligodai**; GEt= *Geckoella triedrus**; PFR= Proposed Forest Reserve; += presence (see references in Table 1).

Location No.	Location	Gm	Hp	Hf	Hd	Ll	Cs	Cm
9	Pitiwela	+	+	+				
11	Aluthgama	+	+	+		+		
12	Pussellawa	+	+	+				
14	Penideniya	+	+	+	+			
16	Kukulugala PFR	+	+	+	+	+	+	+
17	Beraliya-Mukalana PFR	+	+	+	+	+	+	+
18	Morankanda-Mukalana	+	+	+		+	+	+
19	Godahena Sanctuary	+	+	+	+	+		
20	Pinnawala	+	+	+				
21	Kesbawa	+	+	+		+		

The status of this genus in Sri Lanka can be confirmed through a widespread sampling and molecular/chromosomal evaluation. At present, the taxonomic status of the Sri Lankan bisexual population is indecipherable owing to paucity of data. Both morphotypes (presumably equal to *H. typus* and *H. aurantiacus*) are members of very diverse *typus* genetic group (mitochondrial *ND2* marker; Grismer *et al*., 2013) and according to this phylogenetic hypothesis both fall into different clades of this group. In accordance with this hypothesis and with current distribution of the species (and colonization ability of *H. typus*) we can speculatively discuss that the origin of the one (bisexual) morphotype is natural (*H. aurantiacus*) while the second (unisexual) is the result of human-mediated introduction on the island (most of the current records come from the vicinity of main ports of the island, i.e. Colombo and Galle; Figure 1).

In general, very little information is known about the origin of parthenogenetic species in Sri Lanka (see Jayaneththi *et al*., 2015 for *Lepidodactylus lugubris*), and molecular investigation could uncover the answer. Geckoes are one of the top ten most successful introduced animal group in the world (Bomford *et al*., 2005) and parthenogenetic unisexual species are a well-known example for that (see Zug, 2010; Daza *et al*., 2012). Considering the very dense maritime transportation in Sri Lanka (Indian Ocean) since the colonial period in the last 200 years, it is possible that *H. typus* naturalised in Sri Lanka after the colonial era. This hypothesis supports the occurrence of this species in Mascarene, Andaman and Nicobar Islands of the Indian Ocean where it is also a non-native (see Bour & Moutou, 1982; Das, 1999; Lever, 2003; Chandramouli, *et al*., 2012). A similar phenomenon is supposed for *L. lugubris* in Sri Lanka (Jayaneththi *et al*., 2015). We are focusing further studies in par with Zug's (2010) original hypothesis, which states that the entire distribution of *H. typus* instigates from human-mediated transport (ships), possibly during the last two centuries. Further studies on these species will continue to evaluate dispersal events of *H. typus* and *L. lugubris* in Sri Lanka.

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