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NATURAL HISTORY NOTE

Bats in the Maldives: a review of historical data and first record of a vagrant Long-winged Tomb Bat (Emballonuridae: *Taphozous longimanus*)

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ABSTRACT

The Maldives is a country made up entirely of coral atolls with very limited terrestrial habitat diversity and only one known resident bat species: the Maldivian Flying Fox, *Pteropus medius ariel*. Here we report the first confirmed record of any insectivorous bat from the Maldives: a single bat that flew on board a boat off Raa Atoll in the north of Maldives on 13 February 2019. Wind trajectory analysis suggests that it had flown from Kerala, south India. From photos and morphometric estimates, we could identify it as a Long-winged Tomb Bat *Taphozous longimanus*. Reports of Flying Foxes from the Maldives (*P. medius ariel* and *P. hypomelanus maris*) are also reviewed. The former is widespread and common, while the latter is known only from a single disputed and now apparently missing specimen.

Keywords: insectivorous bat, monsoon, new record, *Pteropus hypomelanus maris, Pteropus medius ariel,* Sheath-tailed bat

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INTRODUCTION

The Republic of Maldives, off the southwest coast of India, is a country made up entirely of coral atolls. There are about 1,200 islands, all of which are small, low sandy cays with no high, rocky islands. As a result, both terrestrial habitat diversity and total land area are very limited, the latter being of the order of just 250 km^2 (Naseer & Hatcher 2004, Maldives Land and Survey Authority 2022).

The only bat resident in the Maldives is an endemic subspecies of the Indian Flying Fox, *Pteropus medius ariel* Allen 1908 (Hill 1958, Bates & Harrison 1997, O'Brien 2011). This is common throughout the Maldives, is widely considered a pest by fruit growers (Dolbeer et al. 1988) and is regularly seen flying between roosting and feeding islands at dusk. It was until recently known as *Pteropus giganteus ariel*. In addition, there is a single record of a single specimen of the Small-island Flying Fox, *Pteropus hypomelanus* (Allen 1936).

There are no other resident bats, nor any published reports of insectivorous bats. Nevertheless, the relatively close proximity of south India and Sri Lanka does suggest that the occasional vagrant bat might appear, most likely in the northern atolls during the northeast monsoon season (December to March) when winds blow, sometimes strongly, from India to Maldives. Here we report the first record of an insectivorous bat from the Maldives, and we also review the taxonomic status of Maldivian flying foxes.

RESULTS AND DISCUSSION

Detection of a vagrant *Taphozous longimanus* on a boat

During a cetacean survey around the northern Maldives, the first author (RCA) was on board a vessel off the west coast of Raa Atoll (5°14.1'N 72°49.6'E) on the morning of 13 February 2019. At 11:30h, what appeared to be a small bird approached the boat from the east at an altitude of about 10 m above the sea surface. It flew around the bows and down the port side of the boat, disappearing from view. The animal was on board and hanging from a bunch of bananas tied up on the stern, where it was identified by RCA as a small bat.

Numerous photos were taken with a Nikon D610 and 105 mm macro lens (Fig. 1). After some time, when it became apparent that the bat was not disturbed by our proximity, it was measured using a 30 cm ruler about 10 cm away from the animal. It was estimated to be 8 cm long, from the tip of the snout to the rump (excluding the tail). The bat was not handled and this total length estimate was the only measurement taken; it was subsequently used to estimate forearm length from photos. The bat stayed on board for the rest of the day, even after we came to anchor near an island

Fig. 1 - A) Long-winged Tomb Bat, *Taphozous longimanus*, off Raa Atoll, Maldives, 13 February 2019. This individual was approximately 8 cm long, from the tip of the snout to the rump. B) Detail of head and ear crenulations. Photos: R.C. Anderson.

inside Raa Atoll, at about 16:00h. By the following morning it was gone.

During the two days preceding the bat's arrival, the wind had been blowing moderately strongly from the ENE/NE (Beaufort force 3-5, roughly 15-35 km/h), which suggests that the bat may have originated from southwest India. To provide a more objective and precise estimate of the possible source of the bat, we carried out a wind trajectory analysis using the HYSPLIT (HYbrid Single Particle Lagrangian Integrated Trajectory) model developed by the U.S. National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (Stein et al. 2015), with the GDSA1 dataset. This generated a backwards trajectory from our boat's location to the likely area of origin (www.ready.noaa.gov/hypub-bin/trajasrc.pl).

From the photographs taken, the bat was first identified at the generic level as a Sheath-tailed or Tomb Bat (Emballonuridae) based on the following characteristics (Bates & Harrison 1997, Bonaccorso 2019): (a) its characteristic ear shape and structure, including a club-shaped tragus; (b) its tail being enclosed within and projecting from its tail membrane; (c) its plain muzzle without nose-leafs or other outgrowths; and (d) the first phalanx of its third digit folded towards the back of the metacarpal.

The assumption that this bat arrived from southwest India was supported by the wind trajectory analysis, which confirmed that winds had been blowing from the southern tip of India immediately prior to the bat's arrival on our vessel (Fig. 2). The model suggested that air blown from southern Kerala would have arrived at our location after about 18h. There are four species of Emballonuridae known from South India (Kerala and Tamil Nadu), three of which also occur in Sri Lanka (Phillips 1980, Bates & Harrison 1997, Lumsden 2017, Monadjem et al. 2017, Bonaccorso 2019, Srinivasulu & Srinivasulu 2019, Srinivasulu et al. 2021).

These four species are listed in Table 1, with their key distinguishing features. Forearm length is one of the critical identification characteristics, and for our individual forearm length was estimated from six photographs to be about 57 mm (average of six different estimates, range: 52-64mm) (Table 1), which corresponds to the Long-winged Tomb Bat, *Taphozous longimanus* Hardwicke 1825.

We note that there appear to be differences in the details of ear morphology between *T. longimanus* and *T. melanopogon*. For example, Bates & Harrison (1997) noted that the ears of the latter are larger than those of the former. The same authors describe *T. melanopogon* with distinct crenulations on the leading (anterior) edges of the ears. Such prominent crenulations appear to be absent from *T. longimanus* (e.g. Teo 2018) and the Maldives individual. Although identifying bats from photos is often problematic, ears often show well in photos. A detailed study of ear morphology, characterising inter-specific, ontogenetic and individual variation, may provide additional traits for separating *Taphozous* species.

This is the first report of any insectivorous bat with proven evidence in the Maldives and the first report of a Long-winged Tomb Bat, *T. longimanus,* for the country. Although one anecdotal report of an insectivorous bat in the Maldives exists (in 2012 a single individual was reported to have flown out of a shipping container delivered to the island of Kulhudhuffushi in Haa Dhaalu Atoll in the north of Maldives), that report has never been confirmed, and we are unaware of any photos or additional details to support it. From the Lakshadweep Islands, immediately north of the Maldives, there is also a single report of an Egyptian Free-tailed Bat *Tadarida aegyptiaca* (Geoffroy, 1818) (Deshpande et al. 2015).

The occurrence of this bat in the Maldives in February, during the northeast monsoon and a period of strong northeast winds, suggests that it was wind-blown from Kerala (Fig. 2), where *T. longimanus* is known to occur. Our wind trajectory analysis further suggests that the bat could have been blown offshore the previous night and carried with the NE winds to northern Maldives. The distance from the Kerala coast to our boat's position was about 600 km. Similar examples of vagrancy from India to the Maldives are known for birds (Anderson & Shimal 2020).

The wing morphology of *Taphozous* bats suggests that they are fast fliers and are capable of gliding (Norberg & Rayner 1987). Radiotracking studies of Theobald's Tomb Bat, *Taphozous theobaldi,* in Thailand demonstrated that, when foraging, they reach altitudes of up to 800 m above ground level and travel up to 48 km during foraging flights (Roeleke et al. 2018). In the Andaman Islands, the Black-bearded Tomb Bat, *T. melanopogon,* has been observed feeding out over the straits between islands (R. Chakravarty pers. obs.). *T. longimanus* might be expected to reach similar altitudes and travel similar distances every night (depending on the distribution and abundance of insect prey). In addition to the open-space foraging behaviour of *Taphozous* bats, the combined effect of flight altitude and their propensity for gliding may render them vulnerable to being drifted by strong winds.

Flying Foxes in the Maldives

The only bats previously recorded from the Maldives are two flying foxes, one common and widespread (*Pteropus*

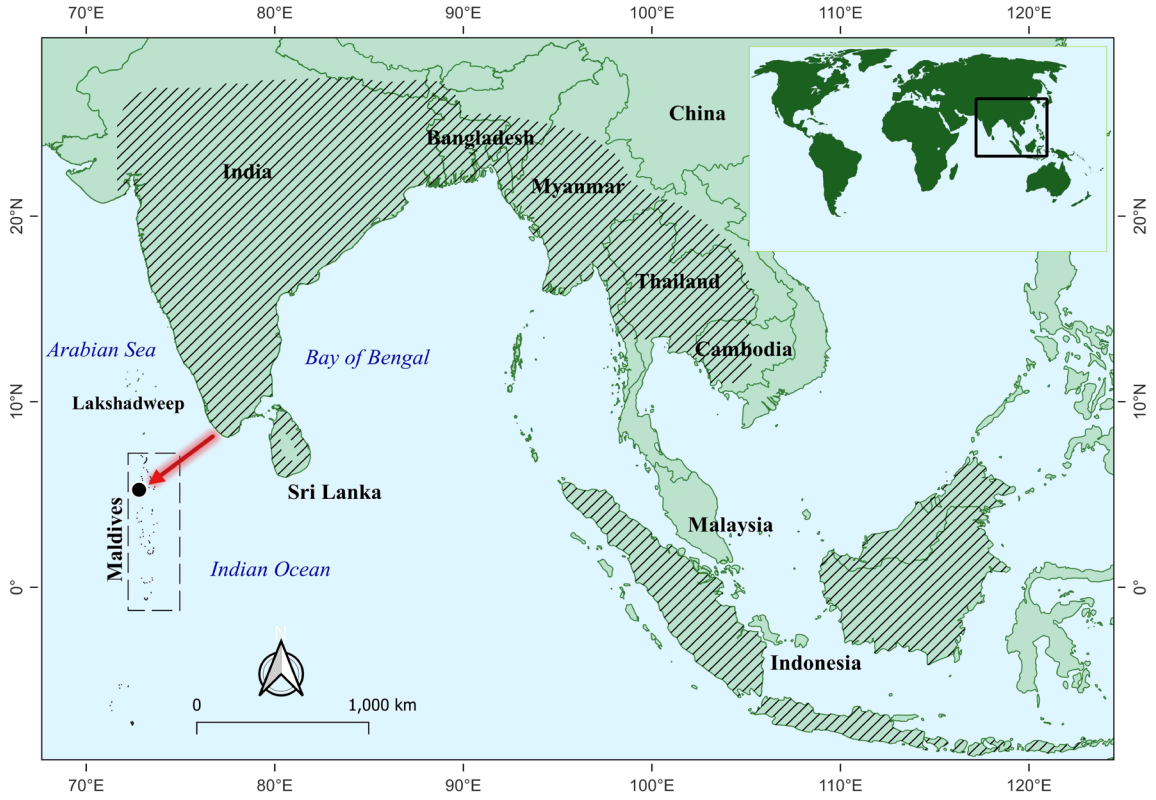

Fig. 2 - Map illustrating the location of bat sighting in the northwest Maldives, estimated trajectory from southwest India, and range of *Taphozous longimanus*.

Table 1 - Characteristics of the Maldives bat compared with the four species of Emballouridae found in south India and Sri Lanka.

	Maldives individual	*Taphozous longimanus* Hardwicke, 1825	*Taphozous melanopogon* Temminck, 1841	*Taphozous nudiventris* Cretzschmar, 1830	*Saccolaimus saccolaimus* (Temminck, 1838)
Head-body length	Approx. 80mm	72-86mm	67-86mm	90-105mm	80-93mm
Forearm (FA) length	Approx. 57mm	55-62mm	60-68mm	70-80mm	63-68mm
3rd metacarpal length relative to FA length	Uncertain, but appears as long as FA	Long 95-109%	Short 85-93%	na	na
Pelage colour	Brown	Brown	Brown	Brown	Black with irregular white patches
Rump	Hairy	Hairy	Hairy	Naked	Hairy
Chin	Uncertain, but at least partially naked	Naked	Hairy, mature males with black beard	Naked	Short hairs
Wing attachment	Uncertain, but photos show skin fold on ankle suggesting ankle attachment	Ankles	Tibiae	Tibiae	Ankles
Anterior edge of ear	Weakly crenulated	Smooth or weakly crenulated	Prominently crenulated	na	na
Tail tip	Blunt ended	Tapered	Enlarged	na	na

Sources: Phillips (1980), Bates & Harrison (1997), Srinivasulu et al. (2010), Bonaccorso (2019), Raman et al. (2021)

medius) and the other known from just a single specimen (*Pteropus hypomelanus*).

Pteropus medius Temminck 1825

The common Maldivian Flying Fox (Fig. 3, known locally as *vaa*, and usually referred to in English as a fruit bat) was first reported as an Indian Flying Fox *P. medius* Temminck 1825 by Gardiner (1906) after his expedition to the Maldives in 1899-1900. However, following Miller (1903), most authors throughout the twentieth century used the name *P. giganteus* for this species. The Maldivian Flying Fox was shortly afterwards described as a new species, *Pteropus ariel* by Allen (1908) based on an adult male collected from North Malé Atoll in December 1901 during the Agassiz Expedition (Agassiz 1903). Andersen (1912), referring to another adult male specimen from the Maldives (collected by Gardiner), noted that "its differences from … the continental species are rather slight, and it is not unlikely that, on the basis of a sufficiently large series [of museum specimens] from the Maldives, *Pt. ariel* would prove to be only subspecifically distinguishable from *Pt. giganteus*." That prediction has subsequently been borne out. Allen (1936) himself later referred to the Maldivian Flying Fox as "a small insular race of the Indian *Pteropus giganteus* group", while Ellerman & Morrison-Scott (1951) listed it as a "form" of *P. giganteus*. The first use of the subspecific name *P. giganteus ariel* appears to have been by Hill (1958), who had a series of six specimens collected by Phillips (1958a) from Malé Atoll and currently in the Natural History Museum, London (BMNH 1957-399 to 404). During a second visit to Maldives from May 1958 to April 1959, Phillips (1959) collected a further 12 specimens from Addu (=Seenu) Atoll in the south of the country, which are also at the Natural History Museum, London (BMNH 1959-525 to 536). Ghosh (2005) noted that the Zoological Survey of India Museum in Kolkata held a single specimen of '*Pteropus ariel*' from the Maldives, collected on Heratera Island, Addu Atoll, in 1922. The specimen (ZSI 10944) lacked the skull, had a forearm length of 106 mm and was "very much allied to *Pt. giganteus*". That single dried specimen is still in the ZSI collection (C. Venkatraman, Officer-in-Charge, Mammal and Osteology Section, Zoological Survey of India, Kolkata, *pers. comm.*, 5 November 2021). More recently, Mlíkovský (2012) suggested that the name *P. medius* is the correct name for this species, as used initially for Maldivian Flying Foxes by Gardiner (1906). Although the name *P. giganteus* is still used by some authorities (e.g. Tsang 2020, Srinivasulu et al. 2021), the use of the name *P. medius* now seems established (e.g. Giannini et al. 2019, American Society of Mammalogists 2022, Simmons & Cirranello 2022).

Pteropus hypomelanus Temminck 1853

The second fruit bat reported from the Maldives was based on a single specimen from Addu Atoll, the southernmost atoll in the country. It was described as an endemic subspecies of the Small-island (or Variable) Flying Fox of Southeast Asia, *Pteropus hypomelanus maris*, by Allen (1936). He stated that the type specimen of *P. hypomelanus maris* was an "adult female No. 10932, Indian Museum, in spirit with the skull separate and dry, from Heratara, Addu Atoll, south end of Maldive Archipelago, Indian Ocean. Donated by the Marine Survey of India,

Fig. 3 - Maldivian Flying Fox, *Pteropus medius ariel*, Dhidhdhoofinolhu Island, South Ari Atoll, Maldives, 15 May 2006. Photo: R.C. Anderson.

1922" (Allen 1936). Phillips (1958b) reported on the ecology and behaviour of flying foxes from Addu Atoll, which he believed to be *P. hypomelanus maris* but later realised were *P. giganteus (=medius) ariel* (Phillips 1959). Jones & Kunz (2000) were presumably unaware of that correction, as they used examples of behaviour and ecology from Phillips (1958b) in their review of *P. hypomelanus*. Apart from the single specimen first described by Allen (1936), no other *P. hypomelanus* have ever been recorded from Maldives, despite the work of Phillips (1958b, 1959), Dolbeer et al. (1988) and Holmes et al. (1994). It has, therefore, been suggested that the Maldivian subspecies might now be extinct (Holmes et al. 1994, O'Brien et al. 2009, O'Brien 2011). Alternatively, it may be that the sole specimen was a vagrant or was mislabelled (Holmes et al. 1994). In either case, another search for *P. hypomelanus* in the southern atolls seems justified.

The type specimen now appears to be missing from the Indian Museum in Kolkata, as it was not listed by Ghosh (2005) and has recently been confirmed as absent (C. Venkatraman, *pers. comm.*, 5 November 2021). The fate of this specimen is unknown. However, it is possible that it was transferred with many other specimens from Kolkata to Varanasi for safekeeping during the Second World War, when eastern India was under threat of invasion. Unfortunately, parts of the collection were submerged during the flooding of the River Varuna at Varanasi in September 1943, and many specimens were lost (Chopra 1946). The apparent loss of the type specimen of *P. hypomelanus maris* should be confirmed, and its conservation status reviewed.

CONCLUSIONS

In conclusion, we present the first documented record of an insectivorous bat from the Maldives. The bat (identified as *Taphozous longimanus*) is adapted to foraging in open environments, and this habit may make it vulnerable to being blown offshore by strong winds. Additionally, in view of the lack of any sightings of *Pteropus hypomelanus maris* and the apparent loss of the sole specimen, the status of this species as a resident Maldivian mammal should be reviewed.

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