

SHORT NOTES

**First record of *Thyroptera discifera* (Chiroptera: Thyropteridae)
in the Cerrado of Central Brazil**

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Key words: *Thyroptera discifera*, geographic distribution, Cerrado, calcar morphology

The family Thyropteridae contains only one genus, *Thyroptera* Spix, 1823, and three extant species: *T. tricolor* Spix, 1823, *T. discifera* (Lichtenstein and Peters, 1854), and *T. lavalii* Pine, 1993. The disk-winged bats inhabit the Neotropical region, from Mexico to Southern Brazil (Wilson, 1978; Koopman, 1993; Pine, 1993), and its main generic diagnostic character is the presence of circular suction disks with short stalks on the soles of the feet and at the base of the well-developed claw of the thumb, which are histological and anatomically different from the Old World sucker-footed bat (*Myzopoda* sp.; see Nowak, 1999).

Thyroptera tricolor is widely distributed through the Neotropical region occurring from southern Mexico to Bolivia, Trinidad, and southern Brazil, whereas *T. discifera* occurs from Nicaragua southwards to the Guianas and to at least 10°S in Peru, at 13°10'S and 64°13'W in Bolivia, and Belém, Pará State, and Aripuanã, Mato Grosso State, Brazil (e.g., Wilson and Findley,

1977; Wilson, 1978; Mok *et al.*, 1982; Torres *et al.*, 1988; Pine, 1993; Anderson, 1997; Herrera-Bernal *et al.*, 1999; Nowak, 1999; Tschapka *et al.*, 2000). Both species apparently occur in lowland forest areas. *Thyroptera lavalii* is known from a few localities, including the type locality, Yavari Mirim River, Loreto Department (Pine, 1993), and at Camisea, Cuzco Department, and Alto Madre de Dios River, in Manu Biosphere Reserve, Peru (Solari *et al.*, 2004), Orinoco Delta, Venezuela (Linares, 1998), Yasuni National Park, Napo Province, Ecuador (Reid *et al.*, 2000), and Alter do Chão, Pará State, Brazil (Bernard and Fenton, 2002).

Thyroptera tricolor and *T. discifera* may be distinguished by their size, the number of cartilaginous projections in the calcar and their fur color (Wilson and Findley, 1977; Wilson, 1978). *Thyroptera lavalii* differs from both *T. tricolor* and *T. discifera* mainly by its larger size, larger free tail portion, wrist suction disk oblong, and more or less

unicuspidate third lower incisors (Pine, 1993). The morphological variation in the genus *Thyroptera* is still poorly known and might have been underestimated, because some populations superimposed in several characters, including those usually used in diagnoses and identification keys (Pine, 1993).

Specimens of this genus are rare in scientific collections and few researchers have observed or captured them in the wild (Wilson, 1978). Consequently, information on its ecology and distributional range is scarce in the current literature. Herein, we report the first record of *T. discifera* in the Cerrado of Central Brazil.

Two males and one female of *T. discifera* were found in the Mammal Collection of the Universidade de Brasília identified as *T. tricolor*. They were caught between January 23 and 10 February 2000, during a rescue operation, from the rising waters of the hydroelectric dam of Manso ($14^{\circ}52'S$, $55^{\circ}48'W$), localized between the Chapada dos Guimarães National Park and another protected area, the Area de Proteção Ambiental Cabeceiras do Rio Cuiabá, Municipality of Chapada dos Guimarães, Mato Grosso State, Brazil (Fig. 1). There was not information on the method of capture on labels or protocols. This record extends by ca. 1,000 km the southern limit of the

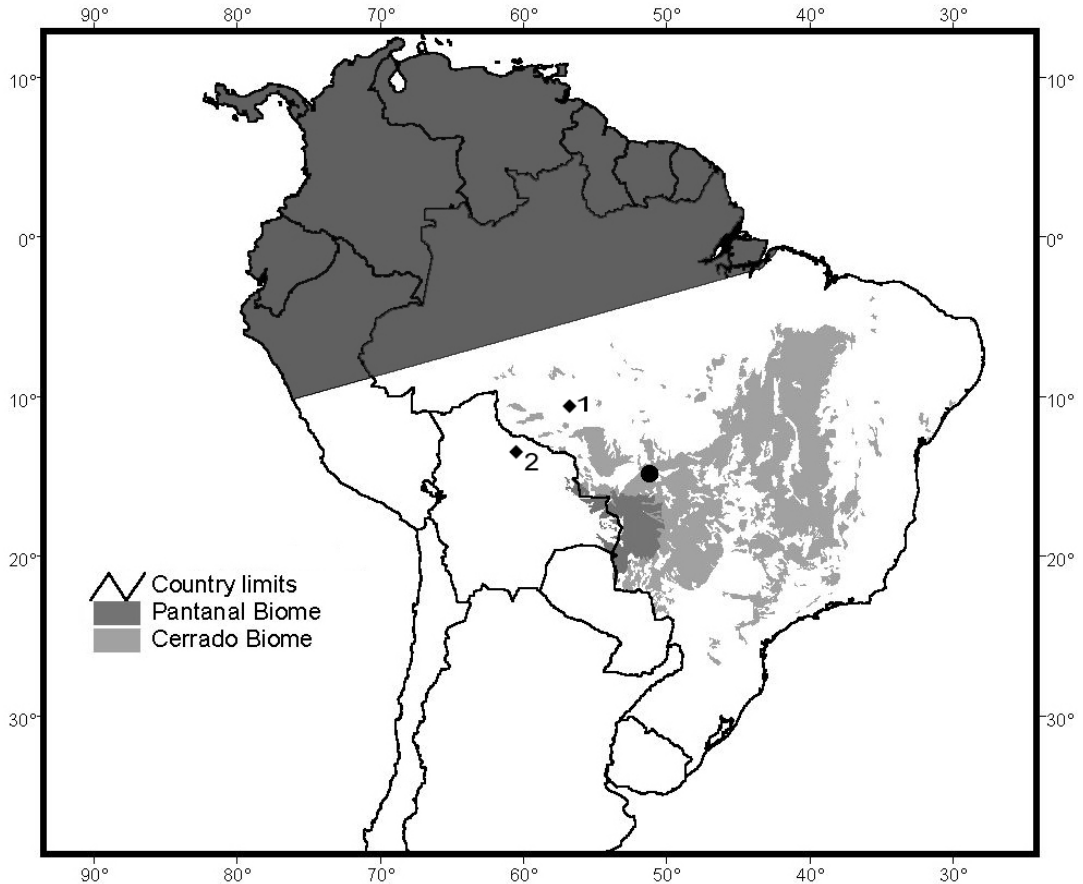


FIG. 1. Geographic distribution of *Thyroptera discifera*. Darker shaded area indicates previous distribution, lighter shaded area is Cerrado, solid lozenges represent previous isolated records [1 — Aripuana, Mato Grosso State, Brazil, Mok *et al.* (1982); 2 — La Cobaya, Department of Beni, Bolivia, Torres *et al.* (1988)], and solid circle is the new record. Map modified from Wilson (1978)

distribution of *T. discifera*, and is also the first occurrence of this species and probably also for the genus in the Cerrado biome.

The three specimens were collected in cerrado sensu stricto, a woodland with an open canopy and some grass covering the ground, near to evergreen gallery forests along the watercourses of Manso and Casca Rivers. The identification of *T. discifera* specimens was done using the current literature (Wilson and Findley, 1977; Wilson, 1978; Pine, 1993), and by direct comparison with specimens housed in the Museu Nacional — Universidade Federal do Rio de Janeiro (MN), Museu de Zoologia da Universidade de São Paulo (MZUSP), and Field Museum of Natural History (FMNH). *Thyroptera lavalii*: FMNH 89121 (holotype); *T. discifera*: MZUSP 5628, and MZUSP 16394; *T. tricolor*: MN 3262, MZUSP 5702, MZUSP 8584, MZUSP 8586, MZUSP 14180, MZUSP 14181, and MZUSP 16393. The three *T. discifera* voucher specimens were deposited in the Mammal Collection of the Departamento de Zoologia, Universidade de Brasília as numbers CHUNB 982 (♂), CHUNB 989 (♂), and CHUNB 990 (♀). In addition to the literature and materials from Brazilian museums (CHUNB, MN, and MZUSP), we also consult the holdings of *Thyroptera* specimens housed in the

FMNH, American Museum of Natural History (AMNH), and National Museum of Natural History (NMNH) to confirm the first record of the genus for the Cerrado biome.

The color of the venter, which is slightly paler than the dorsum, and the calcar with a single cartilaginous projection extending into posterolateral border of uropatagium (Fig. 2) are present in the Chapada dos Guimarães specimens and are typical characters of *T. discifera* (Wilson, 1978). The pale or white venter, contrasting sharply with the dorsum, and the presence of two cartilaginous projections on the calcar are typical of *T. tricolor* (Wilson and Findley, 1977). The averages of body size and forearm length (Tab. 1) are also smaller than reported for *T. lavalii* (Pine, 1993; Reid *et al.*, 2000). The wrist suction disk is more circular than oblong, and the third lower incisors are tricuspid. This confirmed the identification of these specimens (see also Table 1). With the objective of comparing the three *Thyroptera* species, we also include measurements taken of *T. discifera* and *T. tricolor* specimens deposited in the MN and MZUSP, and from previously published studies (Husson, 1962; Pine, 1993).

Bats of the genus *Thyroptera* are considered to be locally rare (Wilson and Findley, 1977; Wilson, 1978). However, mist-netting

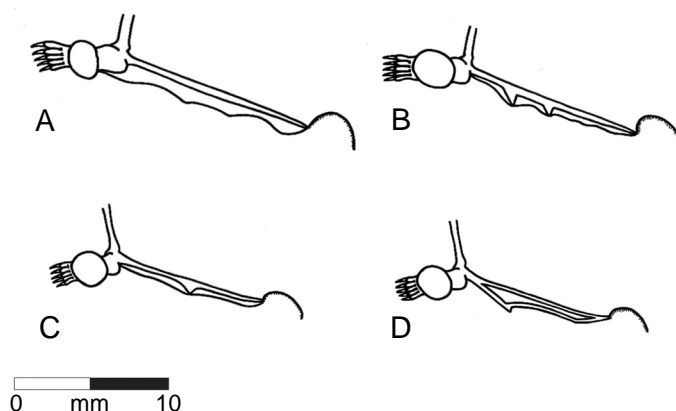


FIG. 2. Qualitative variation in the cartilaginous projection of the calcar: A — *Thyroptera lavalii* (FMNH 89121), B — *T. tricolor* (MN 3262), C — *T. discifera* (CHUNB 982), and D — variation in the CHUNB 990 specimen

TABLE 1. External and cranial measurements (in mm) of *Thyroptera discifera* specimens from the Chapada dos Guimarães, Brazil, and specimens of the three *Thyroptera* species from museums and literature. Specimen MZUSP 5628 is a skin preparation. Abbreviations: TL — total length, TAIL — tail length, HF — length of hind foot, TIB — tibia length, EAR — ear length, FA — forearm length, TH — thumb length, 3FF — 3rd finger formula, CBL — condylobasal length, CM² — maxillary toothrow length, MW — molar width, ZB — zygomatic breadth, BB — braincase breadth. Measurements according to Anderson (1972)

Origin	TL	TAIL	HF	TIB	EAR	FA	TH	3FF	CBL	CM ²	MW	ZB	BB
<i>Thyroptera discifera</i>													
BRAZIL													
Chapada dos Guimarães,													
Mato Grosso													
CHUNB 982 (♂)	65.0	25.8	6.0	16.3	11.34	35.8	4.56	34.8–16.0–10.4	14.0	6.75	1.22	7.11	6.92
CHUNB 989 (♂)	64.2	24.9	5.4	16.3	9.55	35.9	2.65	35.3–16.2–10.8	—	—	1.12	—	—
CHUNB 990 (♀)	66.6	24.6	6.1	17.0	11.56	38.3	3.12	37.2–17.9–11.0	14.2	7.04	1.22	7.59	6.93
Carixicatuba, Pará													
MZUSP 5628 (♂)	61.1	24.3	4.6	15.4	—	32.1	3.01	—	—	—	—	—	—
Belém, Pará (in Pine, 1993)													
MPEG 3779 (♂)	—	—	—	15.2	—	34.0	3.01	33.1–14.7–10.1	—	—	—	—	—
PERU													
Cumaría (in Pine, 1993)													
FMNH 46160 (♂)	—	—	—	15.3	—	33.2	—	33.3–14.3–9.9	13.8	5.9	—	—	6.9
COLOMBIA													
La Costa, El Tambo (in Pine, 1993)													
FMNH 140791 (♀)	—	—	—	15	—	34.2	—	35.1–15.6–10.4	—	5.9	—	—	6.8
Socorré (in Pine, 1993)													
FMNH 69509 (♂)	—	—	—	16	—	33	—	33.1–14.0–9.2	13	5.5	—	—	6.8
PERU													
Loreto (in Pine, 1993)													
FMNH 89121 (♀) holotype	87	30	7	18.1	8	39.4	—	40.5–17.4–11.6	15.0	6.50	—	—	7.10
FMNH 89118 (♂) paratype	74	23	6	17.5	8	38.8	—	37.7–17.1–10.4	14.6	6.20	—	—	7.30
FMNH 89119 (♀) paratype	80	30	7	18.3	8	40.7	—	39.5–17.3–10.7	14.9	6.50	—	—	7.30
FMNH 89120 (♀) paratype	87	31	7	17.6	8	39.7	—	39.3–16.4–11.2	14.9	6.40	—	—	7.20
<i>T. lavali</i>													

TABLE 1. Continued

Origin	TL	TAIL	HF	TIB	EAR	FA	TH	3FF	CBL	CM ³	MW	ZB	BB
<i>T. tricolor</i>													
BRAZIL													
Cametá, Pará (in Pine, 1993)													
FMNH 19521 (♂)	-	-	-	16.9	-	37.6	-	36.2-15.6-11.1	-	-	-	-	-
FMNH 19522 (♀)	-	-	-	17.7	-	38.6	-	36.6-15.5-9.2	14.2	6	-	-	7.4
Abaetetuba, Pará													
MZUSP 8584 (♀)	65.4	26.7	4.2	18.3	11.2	36.7	3.3	32.0-9.3-6.4	-	-	-	-	-
MZUSP 8586 (♀)	68.2	27.7	4.2	19.1	11.0	38.1	3.1	34.9-9.4-7.5	-	-	-	-	-
Jequiá, São Paulo													
MZUSP 5702 (♂)	60.7	24.7	4.6	18.5	12.0	34.1	3.9	30.4-8.6-5.9	-	-	-	-	-
SURINAME (in Husson, 1962)													
RMNH 17551 (♀)	-	27	5	17	-	37.5	-	36-15-9	12.7	5.5	5.1	-	7.3
RMNH 17552 (♂)	-	27	5	17	-	36.0	-	33.5-15-8.5	13.1	5.6	5.1	-	7.2
SMN 1301, 4 (♂)	-	23	5	16	-	34.3	-	34-14-8	-	-	-	-	-
SMN 1301, 3 (♀)	-	27	5	19	-	37.5	-	35.5-15-9	13.7	5.8	5.3	-	7.6

does not seem to be an efficient method to catch thyropterid bats. Since they are forest and clearing aerial insectivores (Findley, 1993), their sonar systems probably can detect the nets. Therefore, hand-capture could be a more successful method in this case. Hand-captures are generally made at roosts.

Thyropterids roost inside the rolled leaves of some species of Heliconiaceae (Wilson, 1978; Torres *et al.*, 1988; Tschapka *et al.*, 2000). Roosts inside curled leaves of banana tree (*Musa sp.*) have also been reported for *T. discifera* (Wilson, 1978; Torres *et al.*, 1982; Nowak, 1999). Thyropterids are nomadic and the colonies remain in the roost only when the leaves are rolled, which generally lasts approximately 24 hours. Once the leaf opens, the colony is forced to move to another plant (Findley and Wilson, 1974).

Costa (2003) found that “the Central Brazilian forests are an integral part of the evolutionary scenario of lowland small mammals”, and emphasized the importance of forested habitats in central Brazil (gallery forests, semideciduous and dry forests) as a bridge to the dispersion of lowland small mammals between Amazon and Atlantic Forest domains, as already discussed by other authors (e.g., Redford and Fonseca, 1986). The Chapada dos Guimarães region is the southwestern geographic limit of Amazonian fauna and a transition zone between the Amazon and Cerrado domains. The present study emphasizes the importance of the forest habitats of the Cerrado domain as corridors for species from Amazon and Atlantic Forest, which contributes to the diversity of the Cerrado mammal assemblage.

ACKNOWLEDGEMENTS

We are grateful to Cleber Alho coordinator of the Operação Tapiti, his team, and Furnas Centrais Elétricas S.A. for providing the opportunity for collecting biological material at Rio Manso region; to Bruce

Patterson (FMNH) for the courtesy of taking and sending us the photos of the holotype of *T. lavalii*, and to João Oliveira (MN) and Mario de Vivo (MZUSP) for permitting access to specimens. We also thank to collection managers and curators of the FMNH (internet access), AMNH (Teresa Pacheco), and NMNH (Craig Ludwig) for the supply us data of *Thyroptera* specimens, to Ana Paula Carmignotto for the distribution map, to Marco Tschapka and Erica Sampaio for the send us some important papers, and John Hay for reviewing the text. Wiesław Bogdanowicz and two anonymous reviewers made helpful comments the greatly improved the manuscript. Conservação Internacional and Conselho Nacional de Desenvolvimento Científico e Tecnológico provided financial support to AMRB and JMF (CNPq Procs. 141899/2004-2 and 300591/86-1, respectively). FET received a graduate scholarship (MSc) from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

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Received 21 December 2004, accepted 23 April 2005

Tent use by *Vampyressa nymphaea* (Chiroptera: Phyllostomidae) in *Cecropia insignis* (Moraceae) in Costa Rica

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Key words: cloud forest, Costa Rica, leaf modification, lowland rain forest, roost, tent-making bats, *Vampyressa nymphaea*

INTRODUCTION

More than half of the bat species around the world use plants as roost sites, including hollow trees, logs, foliage, branches, and under bark (Kunz and Lumsden, 2003). To date, twenty-one species of bats have been recorded using leaves modified as roosts (usually called 'tents'). Including the recent report of *Platyrrhinus helleri* using a tent in *Eirmocephala megaphylla* (Tello and Velazco, 2003), and accepting the split of *Vampyressa pusilla* into two species — *V. pusilla* in South American and *V. thyone* in Central America (Lim *et al.*, 2003), at least 17 species of bats use leaf tent roosts in the Neotropics (Kunz and Lumsden, 2003). All these species belong to the family Phyllostomidae, and most to the frugivore subfamily Stenodermatinae; only *Rhinophylla pumilio* belongs to the piper specialist subfamily Carollinae.

The big yellow-eared bat (*Vampyressa nymphaea*) ranges from southeastern Nicaragua to northeastern Ecuador. It is considered to be a rare or uncommon species of poorly known habits in primary and late secondary forests below 900 m a.s.l. (Reid, 1997; LaVal and Rodríguez-H., 2002). The species is known in Costa Rica only from Caribbean lowland forest below 600 m a.s.l. (LaVal and Rodríguez-H., 2002). Reproduction is bimodal and involves formation of

harem groups (Brooke, 1987). The genus *Vampyressa* recently was subdivided into the genera *Vampyressa* and *Vampyriscus* (*V. brocki*, *V. bidens* — Porter and Baker, 2004). Following Koopman (1993) and Lim *et al.* (2003), the genus *Vampyressa* has four species (*V. melissa*, *V. nymphaea*, *V. pusilla* and *V. thyone*), and the last three of these are known to use tents. Tent use appears to be common within the genus *Vampyressa*, at least among the three species known to use tents: *V. pusilla* used tents in *Heliconia sparthocircinata*, *H. richardiana*, and *Simira* aff. *eliezeriana* (Zortea and De Brito, 2000); *V. thyone* was found in *Philodendron* sp., *P. macrophylla*, *Rhodospatha wendlandii*, and *Pentagonia donnell-smithii* (Timm, 1984; Kunz *et al.*, 1994; Rodríguez-H. *et al.*, 2001). The only two roosts known to date for *V. nymphaea* were found in *P. donnell-smithii* (Brooke, 1987) and *Anthurium* sp. (López and Vaughan 2004), both at La Selva Biological Station. Following the classification proposed by Kunz *et al.* for leaf tent architecture (1994), the tents known for the genus show an apical shape (*V. thyone* and *V. nymphaea*) or a mix between boat/apical shape (*V. thyone*; Zortea and De Brito, 2000). In the present paper we report the use of a new plant species as tent roost by *V. nymphaea*, one with an architecture that differs from those known to date for the species.

MATERIAL AND METHODS

The observations were made in October 1996 at La Selva Biological Station (10°26'N, 83°59'W), Heredia Province, in northeastern Costa Rica. A mosaic between primary lowland rain forest and abandoned cacao plantations characterizes the vegetation at the study site (McDade *et al.*, 1994). We used a ladder to get as close as possible to the bat tent in order to take photographs for identification of the bats, using a SLR camera with a 90 mm lens (Sigma) and a flash.

RESULTS

We found a young *Cecropia insignis* tree with a leaf in which all lobes were folded downward, located about two meters off the side of a broad, paved trail (La Selva trail code STR 150). This leaf was located near the tip of the tree, at a height of approximately 5 meters. Closer investigation showed within the folded leaf a group of seven small bats that were characterized by prominent white facial stripes, short rostrum, and yellow-tinged ears. An indistinct white line ran from the nape of the animals down the back. While the dorsal pelage of four individuals was light brown, in three of the animals the general body color tended more towards grey and the yellow tinge of the ears was considerably weaker, suggesting that these were juveniles. Based on overall body size, head shape, and the shape and distinctness of the stripes on the animals' face and back, we concluded that these were *Vampyressa nymphaea*. We did not attempt to capture the bats due to the height and location of the leaf tent, but were able to take photos to support our identification (Fig. 1). *Cecropia insignis* has palmate leaves with a prominent mid-vein on each lobe. On the modified leaf, each of these veins was cut on the underside at approximately 3 to 5 cm from the petiole. Bats were hanging primarily on these main veins. Lobes were folded downward at angles between about 20 and 80

degrees. Judging from discoloration of the cuts on the veins the leaf appeared not to be freshly cut.

DISCUSSION

Vampyressa nymphaea is a rare bat at La Selva. Tschapka (1998) captured 2,341 bats between August 1994 and February 1997 at the station, and only six of these were *V. nymphaea*. In spite of the fact that we and other researchers assume that bats construct the tents, no one has so far ever observed any species of neotropical bats actually making a tent (Kunz and McCracken, 1996; Kunz and Lumsden, 2003). Thus, even though we recorded the use of these tents by *V. nymphaea*, we have not observed tent construction by the species.

The group of *V. nymphaea* observed in the *C. insignis* at La Selva might well have been a harem. The group could have contained an adult male with three adult females and their young. Although this is speculation, we note that Brooke (1987) reported harems with similar numbers and adult/juvenile ratios of *V. nymphaea* in tents in *Pentagonia donnell-smithii*.

The tent type we describe here for *C. insignis* fits best into the umbrella style (Kunz *et al.*, 1994), where bats partially cut the venation of the lobes so that these fold down and shelter the bats. The use of the genus *Cecropia* for bat tents was first described by Buchanan (1969), who observed it for *Uroderma bilobatum* on Trinidad and Tobago, but did not give more information on the architecture of the tent, nor was the species of *Cecropia* identified. The leaf modifications observed in *C. insignis* also appear similar to those made by larvae of the butterflies *Colobura dirce*, *Tigridia acesa*, and *Historis odius* (Nymphalidae). However, these caterpillars roost during the day under the folded lobes, but eat the leaf during their nightly foraging activities (De Vries, 1987).

In contrast to these similar looking structures, the bat-inhabited leaves observed on *C. insignis* showed no signs of herbivory (Fig. 1).

ACKNOWLEDGEMENTS

Our sincere thanks go to Richard K. LaVal and Robert M. Timm for their comments on the paper, to Orlando Vargas for identification of the *Cecropia*, and to the GLASNOST project for providing the ladder that was crucial for gaining access to the animals.

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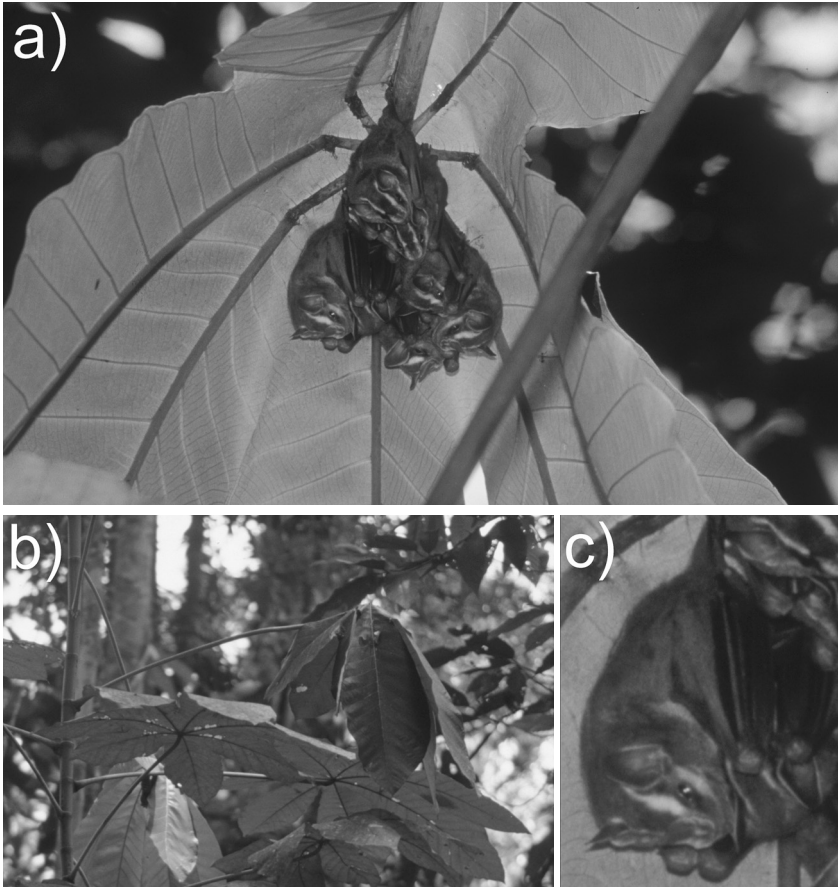


FIG. 1. a) — Group of seven *V. nymphaea* roosting beneath a modified leaf of *Cecropia insignis*. Photo taken in the field by M. Tschapka, October 1996, La Selva Biological Station, Costa Rica; b) — same leaf tent, side view; c) — close-up of one of the bats

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Received 27 October 2004, accepted 28 May 2005

Distributional status of the Indian flying fox *Pteropus giganteus* in Sri Lanka

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Key words: Pteropodidae, *Pteropus giganteus*, distribution, Sri Lanka

The Indian flying fox *Pteropus giganteus* (Brünnich, 1782) is common and widespread on the Indian subcontinent, including Sri Lanka (Corbet and Hill, 1992). During the day, these giant bats roost in large

and noisy flocks on emerging trees, while their flying appearance is ‘one of the features of the evening sky’ (Phillips, 1980). *Pteropus giganteus* is thus more easily seen than any other wild mammal of Sri Lanka,

with the possible exception of the toque monkey (*Macaca sinica*) and the Indian palm squirrel (*Funambulus palmarum*). Not surprisingly, as early as the 1850s, Kelaart (1852–1854) wrote that it is ‘very common throughout the lower parts of the Island; less so in the Kandian provinces’. Kelaart’s (1852–1854) conclusion was mainly repeated in the 1930s by Phillips (1980: 28): “Resident and plentiful over most of the cultivated and jungle areas of the whole Island, with the exception of the Highlands”. Such a generalisation prevailed until recently and was repeated in the faunal review by Bates and Harrison (1997), in a conservation compilation by Mickleburgh *et al.* (1992) and in a popular guide by Banks and Banks (1995). In contrast, Eisenberg and McKay (1970) claim that the species is widely distributed in the lowland wet rain forest and grassland zone but present only seasonally in the monsoon scrub jungle zone, monsoon forest and grassland zone and in the inter-monsoon forest zone (vegetation types are from Fernando, 1968). The basic discrepancy between Phillips (1980) on the one hand and Eisenberg and McKay (1970) on the other, concerns the region in which the bats occur only temporarily. While Phillips (1980) believes this is a high altitudinal zone, Eisenberg and McKay (1970) state it to be the dry region of Sri Lanka, which covers approximately two thirds of the island’s 65,525 km² surface area.

Actual knowledge of *P. giganteus* distribution in Sri Lanka is summarised in Fig. 1. Data are derived from published sources, the collections of the Forschungsinstitut und Natur-Museum Senckenberg, Frankfurt am Main (SMF) and the Field Museum of Natural History, Chicago (FMNH), and my own unpublished records, which were collected in 1995, 1999 and 2002. In total, 43 localities are available from the island and 25 of them are from the Wet Zone. Thus,

nearly 60% of the records are concentrated in approximately one third of the surface of Sri Lanka. In the Dry Zone, the localities are particularly scarce in its northern and eastern parts. Even worse, out of a mere six records which lie to the north of the line Negombo — Kandy, four are historical (points 1, 2, 4 and 6 — Fig. 1), dating back to the first quarter of the 20th century and even to the mid-19th century.

It is hardly possible to conclude from records in the Dry Zone whether the bat is a permanent or only a temporary visitor there. Dated records from the Hambantota district, however, allow further comment on the generalisation by Eisenberg and McKay (1970). This Dry Zone district is of interest for two reasons. As one of the three extra-dry zones of Sri Lanka, it receives annually around 1,000 mm of precipitation (Madduma Bandara, 2000*b*), as opposed to 1,840 mm around Kandy (Wet Zone), a region which abounds with food resources for frugivorous bats at all times of the year (Walton and Trowbridge, 1983) and is also densely populated by *P. giganteus*. Next, Phillips (1980) explicitly states that this species appears to be absent, during the greater part of the year, from the Hambantota district. Data collected in this district over the last decade confirm the species’ presence in January–February, March, August, and October. All reports, with the exception of those for March, relate to colonies. Evidence from this particular region is thus not supportive of the hypothesis on the seasonal occurrence of *P. giganteus* in dry regions of Sri Lanka.

Neither of the two generalisations on the distributional status of *P. giganteus* in Sri Lanka is supported by hard evidence. Only the statement of its abundant and broad occurrence in the Wet Zone, which is common to both, Phillips (1980) and Eisenberg and McKay (1979), accords with the available records. In addition, the

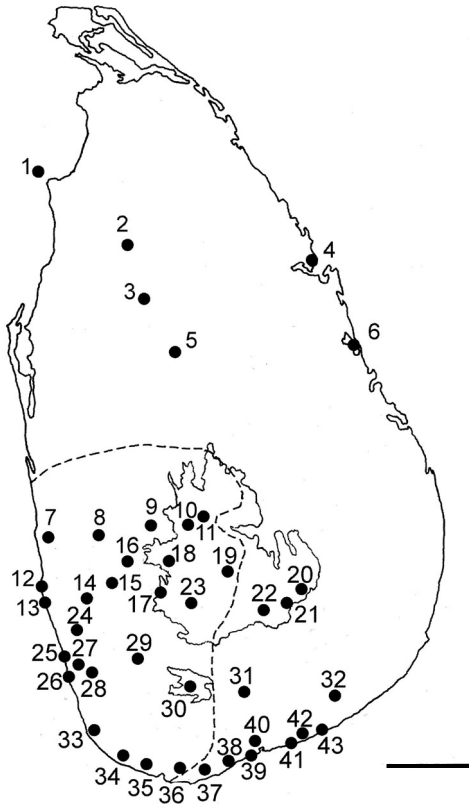


FIG. 1. Records of *P. giganteus* in Sri Lanka. The contour of 500 m a.s.l. (strait line) and the boundary of the effective dry period (broken line; according to Madduma Bandara, 2000a) are shown; the Wet Zone is to the south-west of the broken line. Records: 1 — Mannar; 2a — Cheddikulam; 2b — Cheddikulam (Feb. 1913); 3 — Anuradhapura; 4 — Trincomalee; 5 — Dikwewa (March 1999); 6 — Valaichchenai; 7 — Negombo, Colombo Airport (Oct. 2002); 8 — Warakapola; 9 — Mawanella; 10a — Peradeniya; 10b — Perydenya (Feb. 1912); 10c — Peradeniya (March 1974, April 1975, May 1975); 10d — Peradeniya (Sept.–Oct. 1981); 10e — Peradeniya (July 1995, March 1999, Sept. 2002); 10f — Peradeniya (Jan.–Feb. 1999); 11a — around Kandy, 11b — Katugastota; Undawattekele Forest Sanctuary (Sept.–Oct. 1981); 11c — Undawattekele Forest Sanctuary (March 1999, Sept. 2002); 12a — Colombo; 12b — Colombo (Jan.–Feb. 1999); 12c — Colombo (Oct. 2000); 12d — Colombo, Borella; Slave Island (Oct. 2002); 13a — Dehiwalla; 13b — Dehiwalla (Oct. 1960); 14 — Hanwella; 15 — south-west of Avissawella (March 1999); 16 — Ruwanwella (March 1999); 17 — Gonagama, Kitulgala (Sept. 1925); 18 — Nawalapitiya; 19 — Nuwara Eliya; 20 — Passara; 21 — Tonacombe, Namunukula, Uva Hills (Sept. 1952); 22 — Bandarawella district; 23 — Lower Dikoya valley; 24 — Horana; 25 — Kalutara (Jan.–Feb. 1999); 26a — Barbery Island; 26b — Barbery Island (Nov. 1907); 27a — Anasigalla; 27b — Anasigalla (Jan. 1922, Feb. 1923); 28 — Matugama; 29 — Bulathsinhala; 30 — Kolonne (March 1999); 31 — Embilipitiya (March 1999); 32a — Tissa tank (Jan.–Feb. 1999); 30b — Tissamaharama (March 1999); 33 — Hikkaduwa (Aug. 1995); 34 — Unawatuna (Aug. 1995); 35 — Habaraduwa (March 1999); 36 — Matara (Aug. 1995); 37 — Dondra, Devinuwara (Aug. 1995); 38 — Mawella (Aug. 1995); 39 — Tangalla (March 1999); 5 km south-west of Tangalla (Sept. 2002); 40 — west of Ranna (March 1999); 41a — Hambantota district; 41b — Hambantota (Aug. 1995); 42 — Weligatta (March 1999); 43 — Bundalla area (Oct. 2000). Corresponding references: Kelaart (1852–1854): 4, 19. Tennet (1861): 10a. Macmillan (1906): 10a. Andersen (1912): 26a. Wroughton (1915): 1, 2a, 6, 10a. Theodor (1967): 2b, 10b, 17, 21, 26b, 27b. Phillips (1924): 28. Phillips (1980): 11a, 19, 23, 26a, 41a. Walton and Trowbridge (1983): 10d, 11b. Bates and Harrison (1997): 3, 8, 9, 12a, 13a, 14, 18, 22, 24, 27a, 28, 29. Martin (1999): 10f, 12b, 25, 32a. Blincow (2000): 12c, 43. SMF: 10c. FMNH: 13b. Own data: 5, 7, 10e, 11c, 12d, 15, 16, 30, 31, 30b, 33, 34, 35, 36, 37, 38, 39, 40, 41b, 42. Scale bare = 50 km

temporary presence of bats in the Dry Zone, as advocated by Eisenberg and McKay (1970), is not valid for the southern part of that zone. Its status over two thirds of the island's Dry Zone is poorly documented and thus largely unknown.

Until the turn of the 19th century, Sri Lanka was almost entirely covered by natural forest. Since then, forest resources have been reduced to 70% of the island area by 1900 and to 31% by 1993 (Bandaratillake, 1997). Consequently, one might expect deforestation to affect the distribution of *P. giganteus*. However, the Wet Zone was more affected by habitat destruction than any other part of the island. Currently, the forest cover is most dense on the northern and the eastern parts of this country (Bandaratillake, 1997), i.e., in regions with hardly any *P. giganteus* records. In contrast to many other regions of south-eastern Asia where large fruit bats are molested and exploited for food (Mickleburgh *et al.*, 1992), this is evidently not the case with Sri Lanka (Walton and Trowbridge, 1983; own observations). Thus neither habitat change nor direct human impact can explain the distribution of *P. giganteus* in Sri Lanka.

The most plausible explanation is that the current perception of the distributional status reflects a sampling bias. The south-western corner of Sri Lanka is a densely populated and touristically highly developed region, with a dense network of roads. Of the remaining parts of the island, visitors mainly travel from Kandy (point 11 on Fig. 1) to the ancient capital of Anuradhapura (point 3), and along this road are the only two recent records from the northern half of the island. In the south-east, records stretch along the coast as far as Kataragama. This is the region in which Yala West (Ruhuna) National Park starts, another tourist destination.

It is frequently the case with tropical biodiversity that presumptions are only

loosely supported by hard evidence, e.g., the existence of broadcontinuous distributions of scaly-tailed squirrels (family Anomaluridae) are postulated throughout the African forest belt, although their ranges are actually highly fragmented (Schunke and Hutterer, 2000). The case with *P. giganteus*, however, seems to be just the opposite. I assume that this very common species is under-represented in museum collections and not adequately recorded in data files because its presumed wide occurrence lowered the interest of field workers, who preferred to focus on rare and little known species. Thus, although it is much easier to record *P. giganteus* than any other bat species, its commonness is not self-evident from the number of localities reported for Sri Lanka's bats by Bates and Harrison (1997). Namely, *P. giganteus* (18 localities) ranks in this respect only 5th among the island's 30 species.

ACKNOWLEDGEMENTS

Dr. Dieter Kock drew my attention to several sources of information and commented on the text, for which I am grateful.

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Received 13 October 2004, accepted 21 December 2004

Size-based fruit selection of *Calophyllum brasiliense* (Clusiaceae) by bats of the genus *Artibeus* (Phyllostomidae) in a Restinga area, southeastern Brazil

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Key words: frugivory, seed dispersal, seed size, optimal foraging, Atlantic Forest

INTRODUCTION

When feeding on fruits, frugivores face foraging decisions at least on three levels: choice among fruits of different species, among individual crops of a single species, and among fruits borne on the same plant (Sallabanks, 1993; Wheelwright, 1993). Specifically, selection based upon fruit size, or related otherwise to size constraints (e.g., seed size), has been repeatedly documented (Jordano, 1995b). However, we found little information about the details of this kind of fruit selection by bats, particularly in the case of individual fruits within the crop of an individual parental tree. In this study we investigated the influence of fruit size of *Calophyllum brasiliense* on fruit choice by large Neotropical bats of the genus *Artibeus* Leach, 1821 (family Phyllostomidae, subfamily Stenodermatinae). Specifically we evaluated the roles of overall fruit size and amount of pulp in determining fruit choice in the wild.

MATERIALS AND METHODS

Our study site was a 'Restinga' area (coastal sandy forest) at the 'Parque Estadual da Ilha do Cardoso' (PEIC), municipality of Cananéia, state of São Paulo, southeastern Brazil. *Calophyllum brasiliense* Camb. (Clusiaceae) is a large-seeded, canopy tree widely distributed over Neotropical America. Bats have been reported to be one of its seed dispersers (e.g., Fischer and Santos, 2001). In PEIC we observed bats from larger species of the genus *Artibeus*, probably *A. lituratus* (considering the species list given

by Fazollari-Corrêa [1995]), removing *C. brasiliense* fruits.

In order to investigate the influence of parental tree and seed mass on pulp mass/fruit, we measured the seed mass and total fruit mass of 79 intact fruits randomly sampled from the canopy of five individual *C. brasiliense* trees. Total fresh fruit mass was recorded with a precision balance (± 0.01 g) for each individual fruit and divided into seed mass and mass of other fruit matter; we assumed that the latter to be equal to pulp mass but also included the fruit's pericarp.

Our analysis was based on the comparison of morphological variation among bat-handled fruits sampled beneath fruiting *C. brasiliense* trees and intact fruits sampled from tree canopies before removal by frugivores. We assumed fruits to have been handled by bats, only when they presented clear marks of bat teeth. All handled fruits were partially eaten, and fruits with single bite marks were not included. Thus we could assume that bats selected and ate these fruits, and that they were not accidentally dropped by a bat. We must consider the possibility that some of the fruits collected beneath trees might have come from other trees of the same species, but this does not invalidate our analyses. Furthermore, we considered only ripe fruits, which could be recognized by their relative softness (when compared to unripe fruits), because *C. brasiliense* fruits do not change their color when they ripen. It is also important to consider that, sometimes, when visiting particular plant species, bats may eat fruits inside the canopy of the parent tree, especially when fruits are above a certain size or if they are difficult to remove, although they use to carry fruits away from the parent tree in many circumstances (Heithaus *et al.*, 1975; Handley *et al.*, 1991; Bizerril and Raw, 1998).

First, we characterized the morphological patterns of *C. brasiliense* fruits in order to assess the correlates of pulp mass variation for individual fruits. The influence of seed mass and parental tree on fleshy pulp mass was estimated by ANCOVA (Zar, 1999).

We estimated variation in pulp mass/fruit independent of seed mass and individual tree by using the residuals of this ANCOVA. To test for allometric variation of fleshy pulp mass and fruit mass, we correlated fruit mass with residuals of the previous analysis. This would reveal variation in the amount of fruit pulp/fruit with overall fruit size after controlling for the effects of seed mass and of individual differences among trees. Thus, if there is a relationship between residual pulp mass and fruit mass, there is variation in the proportion of fleshy pulp related to fruit mass. Furthermore, we can expect bats could use overall fruit size as a cue to select more pulpy fruits, as visual clues may also play a role in fruit selection by phyllostomids (Kalko and Condon, 1998). The relationship between residual pulp mass and fruit mass was assessed by the least-square linear regression (Zar, 1999).

In order to investigate if bats select fruits based on overall fruit size, we compared seed mass of intact fruits ($n = 79$) with those from 65 fruits with evidence of bat removal. We used seed mass rather than fruit mass, because fruits removed by bats were partially eaten and did not have their pulp mass complete (intact). Both traits show a strong relationship ($r^2 = 0.73$, $d.f. = 77$, $P < 0.001$, $n = 79$ intact fruits), and we can use seed mass as a good estimator of overall fruit size for fruits handled and partially consumed by the bats. Fruits with teeth marks or any other evidence of handling by bats were sampled on the forest floor, under the canopy of five fruiting trees, and we assumed them to be produced by those trees. It is important to note that almost all fruits included in the analyses were clearly eaten, because they did not present only a few teeth marks, but lacked some pieces (proportional to an *Artibeus* mouth), what made it possible for us to assume that they were really selected for consumption. We performed a nested ANOVA, in order to test the percent of variation in fruit size and pulp mass that is accounted for by among-tree variation and within-tree variation. A two-way ANOVA was also performed to test if mean seed mass varies among fruits (removed by bats or intact) and among crops of fruiting trees (Zar, 1999). Seed mass was log-transformed prior to analysis.

RESULTS

Seed mass for 79 intact fruits was 1.96 ± 0.89 g ($\bar{x} \pm SD$), varying from 0.20 to 4.30 g, while seed mass for the 65 removed fruits was 2.30 ± 0.79 g, varying from 0.6 to 4.20 g. Mass for all 213 seeds (including totally clean seeds) was 2.20 ± 0.86 g, varying from 0.20 to 5.30 g. Mean seed mass varied

significantly among five parent trees ($F = 61.60$, $d.f. = 4$, $P < 0.001$), ranging between 3.20 ± 0.80 g (tree 1) to 1.60 ± 0.55 g (tree 3). The mass of fleshy pulp/fruit was positively correlated with seed mass ($F = 17.09$, $d.f. = 4$, $P < 0.001$), and significantly affected by parental tree ($F = 7.62$, $d.f. = 1$, $P < 0.001$), and the interaction of both factors ($F = 11.37$, $d.f. = 4$, $P < 0.001$). The residual pulp mass was positively related with fruit mass in intact fruits ($F = 10.93$, $d.f. = 78$, $P < 0.001$), indicating that the proportion of fleshy pulp increases with fruit mass, despite the relatively low r^2 (0.113) that might be related to between-tree variation in other fruit traits (e.g., shape) influencing the amount of pulp/fruit. The nested ANOVA results ($F = 25.32$, $d.f. = 4$, $P < 0.001$) suggest that 44.3% of the total variation in fruit mass can be accounted for by variation between crops of the individual trees, although there is also substantial variation in fruit mass among the fruits within a given crop (residual = 55.7%). This suggests that bats might select among crops of individual trees based on fruit size, but also selection can operate between individual fruits within a single crop. After controlling for the effect of parental tree, fruits removed by bats are significantly larger than the available, intact fruits ($F = 3.94$, $d.f. = 1$, $P < 0.05$; Fig. 1). It is interesting to note that the only tree that did not follow the general trend (removed fruits larger than intact ones) was the one with highest mean seed mass. It is possible that the reward obtained by bats when feeding on fruits from this individual tree is so high on average that bats do not have to select among fruits. There was also another individual tree, whose difference between mean seed mass of intact and removed fruits was small, but followed the general trend.

DISCUSSION

Our results suggest that bats consistently select and handle the larger fruits of

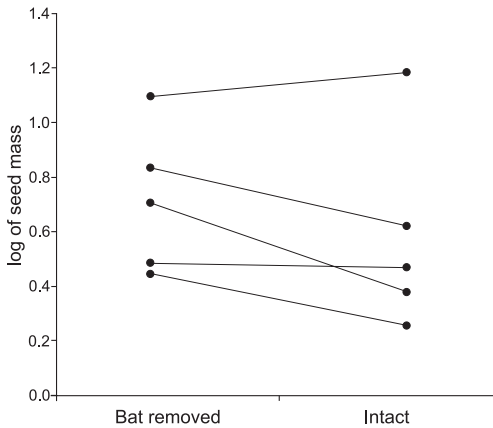


FIG. 1. Contrast between the mean seed mass of fruits removed by bats and of intact fruits collected from the canopies of five adult trees of *C. brasiliense* (Clusiaceae). Each line corresponds to the contrast for an individual tree

C. brasiliense, although this might not result in successful removal of larger seeds due to loading constraints imposed by fruit size or shape. This pattern is expected for foragers that maximize the difference between energy expenditure and intake while searching and handling food (Jordano, 1995a) according to the optimal foraging theory (originally proposed by MacArthur and Pianka, 1966). Foster (1990) suggested that fruit mass and size are key characteristics for frugivore foraging, because they influence reward and costs of handling for the frugivore. Nevertheless, Wheelwright (1993) pointed out that the selection pattern might differ among individual trees.

Some bat species have been reported to handle and successfully disperse extremely large fruits (Meehan *et al.*, 2002), and some studies suggest a positive relationship between the size of the bat species and of its preferred fruit (Fleming, 1991). Our results agree with the feeding preferences proposed for the larger *Artibeus* species (Bonaccorso and Gush, 1987). Most authors report that these bats tend to feed on species with relatively large fruits (when compared to other bat species), many of them with

large seeds, frequently involving long handling times (Marques, 1994).

By selecting larger fruits, *Artibeus* bats consume a large overall quantity of pulp per fruit. Moreover, as larger *C. brasiliense* fruits have a disproportionately higher amount of pulp than smaller fruits, our data suggest that bats select them on the basis of higher pulp-seed ratio, i.e., maximizing the pulp or juice ingested per unit fruit mass handled. Hence, as proposed by Howe and Vande Kerckhove (1981) for frugivorous birds, pulp-seed ratio can be a more important determinant on fruit choice by bats than fruit size, although overall fruit size is probably a proximate cue for more pulpy fruits, especially for drupaceous species.

Artibeus bats remove fruits and consume only the pulp, acting as legitimate seed dispersers. However, it is important to remember that *Artibeus* spp. do not ingest the whole pulp mass of the *Calophyllum* fruits they chew. They acquire nutrients by ingesting the fruit's juice, composed of water and many non-fibrous substances; after the chewing behaviour, they just expel fibrous pellets. See Nogueira and Peracchi (2003) for a detailed description of this kind of feeding behaviour in other Stenodermatinae bats of the genus *Chiroderma*.

Marques (1994) observed that even partial pulp removal by bats, may accelerate germination of *C. brasiliense* seeds. Moreover, Fischer and Santos (2001) observed that larger seeds of *C. brasiliense* germinated faster. In addition, large seeds are usually more resistant to seed predators (Mack, 1998) and have more nutritional reserves for the embryo (Westoby *et al.*, 1992). Although many fruits were dropped below the canopy of *Calophyllum* parent trees, some of them were away and were found below other tree species (a few per site). Hence, we suggest that *Artibeus* bats feeding on fruits of *C. brasiliense* may also increase the reproductive success of these trees by

contributing to selective removal of the largest seeds.

ACKNOWLEDGEMENTS

We would like to thank Mauro Galetti, Wesley Silva, and Marco A. Pizo for useful advice and help during the 'Curso Latino-Americano de Frugivoria e Dispersão de Sementes — 2003' (organized by UNICAMP and IBC), where this work took place. Environmental monitors at Parque Estadual da Ilha do Cardoso, especially Romeu, Carlinhos and Ari Caiçara, who helped to identify guanandí trees (*C. brasiliense*) in the forest and collect their fruits (even on tree canopies). Three anonymous referees and the editor for their detailed reviews of our manuscript. And especially our colleagues, who were very kind, making the course a very pleasant experience. MARM was supported by grants from CAPES and FAPESP; NOL and PRG were supported by grants FMB and FAPESP; PJ had funds from the Spanish MCyT (REN2003-00273) and a CSIC-CNPq agreement during the preparation of the manuscript.

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First resident population of *Pipistrellus nathusii* (Keyserling and Blasius, 1839) in the Iberian Peninsula

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Key words: *Pipistrellus nathusii*, Iberian Peninsula, bat boxes, rice paddies, mating

INTRODUCTION

Pipistrellus nathusii (Keyserling and Blasius, 1839) is found from the Iberian Peninsula and British Isles to Asia Minor and Transcaucasia (Bogdanowicz, 1999; Russ *et al.*, 2001). Although considered as a rare species in most European countries, it is thought that this could be merely the consequence of inappropriate sampling methods during bat surveys (Bogdanowicz, 1999).

To date, records of *P. nathusii* from the Iberian Peninsula are scarce: the first reliable data on this species in Spain were gathered in the early twentieth century in Mediterranean areas (Catalonia and Valencia), central Spain and along the Cantabrian coast in the north of the country (Cabrera, 1914; Aguilar-Amat, 1921, 1924; Ibáñez *et al.*, 1992). As no new data had been produced for several decades, the species was considered to be extinct (Gonzalez-Álvarez, 1991) until it was recorded in several new localities in the north of the peninsula during the 1990s (Rodríguez-Muñoz *et al.*, 1994; Aihartza *et al.*, 1997). Nevertheless, even during this period no more than seven individuals were captured (Rodríguez-Muñoz *et al.*, 1994; Woutersen and Bafaluy, 2001; Aihartza and Garin, 2002) and most records were of single individuals found in autumn or winter (Ibáñez *et al.*, 1992; Aihartza and Garin, 2002; Rodríguez-Muñoz, 2002). Consequently, some authors considered *P. nathusii* to be only an occasional wintering species in the Iberian

Peninsula, mainly occurring along the northern coastline (Ibáñez, 1998). A recent review of the status of the species in the Iberian Peninsula recognised that most observations of the species could be considered as doubtful (Rodríguez-Muñoz, 2002) and, according to Rodríguez-Muñoz *et al.* (1994), the species should be considered as insufficiently known.

In this paper we present the first records of mating groups of *P. nathusii* in the Iberian Peninsula, and provide the first evidence of residency in the region for the species. Also, we provide information on biometry and sexual size dimorphism.

MATERIALS AND METHODS

The study was carried out in the Ebro Delta (Catalonia, NE Iberian Peninsula; UTM: 0°50'E, 40°42'N), one of the largest deltas (320 km²) in the Mediterranean region of the Iberian Peninsula. The landscape is dominated by rice paddies, a few lines of trees (*Eucalyptus globulus* and *Washingtonia filifera*) and isolated buildings, in which roost sites for bats are lacking. The mean (\pm SE) annual temperature during 2000–2002 was 18.5°C (\pm 0.26) with a minimum absolute temperature during this period of 0.2°C. The mean humidity during the period 2000–2003 was high (75.3% \pm 2.08; Ebro Delta Natural Park office).

In 1999, 69 bat boxes were put up by the staff from the Ebro Delta Natural Park to provide more bat roosting sites (14.5% in trees, 42.0% in buildings and to 43.5% on poles). Boxes were fixed to trees with iron nails (Stebbing and Walsh, 1991) and to houses and posts with screws. Bat boxes were made from laminated wood (preserved with natural oil) with walls 20 mm thick, slit size of 15 mm, a rough surrounding landing area of 100 mm, and effective internal measurements: 140 mm long, 195 mm wide, and

250 mm high. All bat boxes are side opening. Two bat box models were used: 44 (63.8%) of model A (one compartment) and 25 (36.2%) of model B, with two communicating compartments divided by laminated wood and with two landing areas, one for each compartment.

Bat boxes were checked on nine occasions between April 2002 and November 2003. Every bat captured was sexed and the following measurements taken: body mass, length of forearm, length of fifth digit finger, and wingspan. The reproductive status of males and females and the occurrence of secondary sexual characters such as the development of buccal pads (Harrison and Davies, 1949) were also checked. The ratio of forearm length to fifth finger was used for determining the species (Speakman *et al.*, 1991; Russ *et al.*, 1998; Martinoli *et al.*, 2000). All measurements were made with a precision calliper and bats were weighed on a professional digital balance (accuracy to 0.1 g). All animals were released after data had been obtained. As well, some bats were ringed following the procedures established by the Spanish Ministry of the Environment (Ministerio de Medio Ambiente).

For captured individuals, field identification was carried out on the basis of dental criteria (Menu and Popelard, 1987; Helversen, 1989). Additionally, we used a D240x bat detector (Pettersson Elektronik AB, Uppsala) with heterodyne and time expansion ($\times 10$) systems, as well as a DAT recorder (SONY TCD-D8) and a laptop computer with a professional sound card (Digigram Vx pocket v2) to record echolocation and social calls (Ahlén, 1990; Barataud, 1996; Russ, 1999). Call samples were recorded close to the boxes during spring, summer and autumn. Sounds were analysed by Bat Sound (Pettersson Elektronik AB, Uppsala). A sample frequency of 44,100 samples/second, 16 bits/sample and automatic FFT with a Hanning window were used. Recordings were screened for the presence of the characteristic social calls, which *P. nathusii* emits during the mating period (Russ, 1999; Russo and Jones, 1999). For molecular analysis one individual wing membrane was punched and samples preserved in ethanol 70% (Worthington Willmer and Barratt, 1996). The correct identification of the species was confirmed on one individual by sequencing a DNA mitochondrial fragment of 802 bp from the cytochrome b gene (C. Ibañez, pers. comm.).

Variation in body mass and skeletal measurements according to sex and season were examined by means of two-way ANOVA. Skeletal measures were compared to other European populations of *P. nathusii*. Before the analysis variables were transformed to reach normality and homoscedasticity (Zar, 1996).

RESULTS

We captured 64 *P. nathusii* (44 ♂♂ and 20 ♀♀) in bat boxes, of which 24 were ringed (15 ♂♂ and 9 ♀♀). During the study period bat boxes were mainly used by *P. pygmaeus*, which established maternal colonies during the breeding season and also occupied boxes during the non-breeding season. Both species were sharing the same roosts during the study period, although the large size and reddish colour of *P. nathusii* allowed us to separate the two species; identification was confirmed in hand by the use of measurements and dental criteria. We observed two well-developed cusps: one on the first upper incisor and another on the second upper incisor, higher than the secondary cusp of the first. Dorsal fur coloration was reddish during summer season and changed to brown/grey in winter. Additionally, the characteristic social calls, with a rising trill at the end, were recorded in April and August from flying bats and from bats located inside bat boxes.

The body mass of resident males *P. nathusii* (Table 1) showed a significant increase from spring ($6.28 \text{ g} \pm 0.18$, $n = 12$) to autumn ($7.78 \text{ g} \pm 0.25$, $n = 6$), with intermediate values in summer ($7.02 \text{ g} \pm 0.14$, $n = 18$; one-way ANOVA: $F_{2, 33} = 12.12$, $P < 0.001$). From autumn to spring hibernating individuals experienced body mass loss, while from spring to autumn they gained body mass. In spring and autumn, seasons in which both males and females were found together in bat boxes, the body mass of females was significantly greater than that of males (sex: $F_{1, 42} = 14.19$, $P < 0.001$); body mass was higher in autumn than in spring (season: $F_{1, 42} = 37.32$, $P < 0.001$). The two-way ANOVA also revealed that the interaction between body mass and season was not significant ($F_{1, 42} = 0.81$, $P = 0.37$), indicating that body mass of both males and females showed the same

TABLE 1. Some biometric measurements from 64 *P. nathusii* individuals captured from April 2002 to November 2003 in the Ebro Delta, NE Spain. Differences between groups were tested by one-way ANOVA on transformed means

Variable	♂ ♂				♀ ♀				F-value
	n	min-max	\bar{x}	SE	n	min-max	\bar{x}	SE	
Body mass (g)	41	5.90-9.70	6.94	0.12	21	5.60-9.60	8.01	0.24	17.67***
Forearm length (FAL, cm)	39	31.75-35.35	33.62	0.14	22	32.90-35.10	34.20	0.14	7.00**
Length of fifth finger (FFL, cm)	37	40.95-47.05	43.34	0.25	20	41.10-50.00	44.31	0.43	3.50
FFL/FAL	34	1.23-1.38	1.29	0.005	20	1.19-1.42	1.29	0.011	0.01

** — $P < 0.01$; *** — $P < 0.001$

seasonal pattern of increase between spring and autumn. Forearm length measured during spring and autumn showed sexual dimorphism (season: $F_{1,41} = 1.70$, $P = 0.19$; sex: $F_{1,41} = 4.20$, $P < 0.05$). Sexual size dimorphism was more evident when all the individuals in the sample were considered (Table 1).

Pipistrellus nathusii was detected in bat boxes for the first time in spring 2002, whereas *P. pygmaeus* colonies were already established in these boxes in summer 2000. During the study period the occupancy rate of bat boxes by *P. nathusii* varied from zero in June 2002 to a maximum of 33.3% in November 2002. In November 2002, three boxes were occupied by a male together with 1-4 ♀♀, while five boxes were occupied by a male with 1-2 ♀♀ in November 2003. Furthermore, solitary males were found in three other boxes. Distended epididymes and enlarged buccal pads were observed in six males captured from August to November. Males remained in the study area throughout the year and individuals were trapped in autumn, winter, spring and summer. Nevertheless, females present in early spring disappeared from bat boxes in summer and only returned in autumn (Fig. 1). Male to female proportions changed seasonally throughout the study period (interaction season \times sex: $G = 12.50$, $d.f. = 2$, $P < 0.001$) but did not change between years (year \times sex: $G = 0.31$, $d.f. = 2$, $P = 0.57$; Fig. 1).

DISCUSSION

Although some authors have suggested that *P. nathusii* may be resident in the Iberian Peninsula (ICONA, 1986; Rodríguez-Muñoz *et al.*, 1994), to date no evidence has ever been provided to support this hypothesis. This paper proves for the first time that the species can be considered as resident in the Iberian Peninsula, since

individuals were observed in the study area throughout the year (including summer). The records of Rodríguez-Muñoz *et al.* (1994) appear doubtful since identification was obtained by examining only echolocation calls, a parameter which may well overlap with that of other species (e.g., Russ, 1999). We know now that male *P. nathusii* remain throughout the year in the study region and that females are present during winter, spring and autumn. Furthermore, our study provides the first proof that the species mates in the region.

Two hypotheses may explain the seasonal absence of females in the study area. The first one assumes that females, like other migratory bats such as *Nyctalus noctula*, return to traditional breeding areas in eastern Europe during late spring (Aellen 1983; Gerell-Lundberg and Gerell, 1994; Kapteyn and Lina, 1994; Limpens and Feenstra, 1997). Agreeing with Kapteyn and Lina (1994) we found less tendencies for philopatry in males, which probably do not return to their birth places and spend summer beyond the southern boundary of the nursing area. The second hypothesis presumes that there is a breeding roost near the study area that has yet to be found. Strengthening

this hypothesis, Schober and Grimmberger (1996) indicate that mating *P. nathusii* roosts can be around 15 km from breeding sites. Furthermore, Martinoli *et al.* (2000) suggest that the characteristic social calls emitted by males in August are a possible sign that *P. nathusii* breeds in the area. If this is the case, we are probably dealing with an isolated breeding colony (see Strelkov, 2000), which could represent one of the southernmost breeding colonies of this species in Europe. Whatever the true situation, future research is necessary to determine whether females are breeding in the area or are migrating to eastern Europe to breed. We are currently undertaking radio-tracking studies with tagged females in order to obtain an answer to this fascinating question.

An alternative explanation to the disappearance of females from bat boxes in summer could be the high occupancy rate of these shelters by *P. pygmaeus* (C. Flaquer, I. Torre, and R. Ruiz-Jarillo, unpubl. data). The sunniest bat boxes placed on poles and walls (required for breeding) are intensively occupied by colonies of *P. pygmaeus* during the breeding season (C. Flaquer, I. Torre, and R. Ruiz-Jarillo, unpubl. data). Male

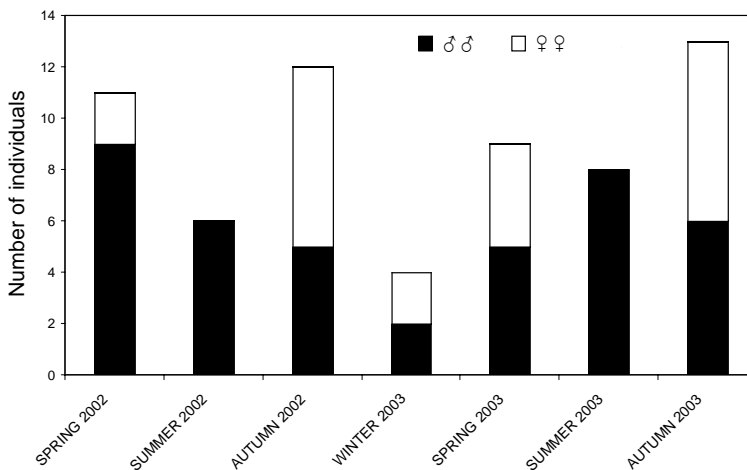


FIG. 1. Seasonal distribution of occurrences of *P. nathusii* throughout the study period in bat boxes located in the Buda Island (Ebro Delta, Spain)

P. nathusii seem to prefer shaded boxes located on trees which are not used by *P. pygmaeus* during breeding.

The analysis of morphological data from *P. nathusii* indicated that there is sexual dimorphism in body mass and forearm length, and that females are bigger than males irrespective of season (spring and autumn). However, morphometric data were within the range of other European populations (Russ *et al.*, 1998; Martinoli *et al.*, 2000; Rodríguez-Muñoz, 2002; Vierhaus, 2004). Year body mass changes observed are related to a common overwintering strategy for temperate-zone species, where bats begin hibernation with fat reserves at their maximum (Schober and Grimmberger, 1996).

Finally, we would like to add that the methodology used in this study, namely the regular checking of bat boxes, may improve knowledge of the status of cryptic taxa such as *P. nathusii*. As Bogdanowicz (1999) has pointed out, knowledge of *P. nathusii* may be a consequence of the use of bat detectors, a limited sampling method that could well underestimate the presence of this species in the Iberian Peninsula.

ACKNOWLEDGEMENTS

This study received financial and technical support from the Ebro Delta Natural Park, dependent on the Catalan Ministry of the Environment (Departament de Medi Ambient, Generalitat de Catalunya). We would like to thank the park staff, above all Jordi Roig, Francesc Vidal, Miquel Àngel Franch, Iolanda Bel, Vicente Fouces, Xavi Porres and Ramon Bartomeu, for their help. The comments of two anonymous referees improved the final version of this article.

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Received 05 August 2004, accepted 09 February 2005