The Iberian contribution to cryptic diversity in European bats

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We investigate the contribution of the Iberian bat fauna to the cryptic diversity in Europe using mitochondrial (cyt b and ND1) and nuclear (RAG2) DNA sequences. For each of the 28 bat species known for Iberia, samples covering a wide geographic range within Spain were compared to samples from the rest of Europe. In this general screening, almost 20% of the Iberian species showed important mitochondrial discontinuities (K2P distance values > 5%) either within the Iberian or between Iberian and other European samples. Within Eptesicus serotinus and Myotis nattereri, levels of genetic divergence between lineages exceeded 16%, indicating that these taxa represent a complex of several biological species. Other well-differentiated lineages (K2P distances between 5–10%) appeared within Hypsugo savii, Pipistrellus kuhlii and Plecotus auritus, suggesting the existence of further cryptic diversity. Most unsuspected lineages seem restricted to Iberia, although two have crossed the Pyrenees to reach, at least, Switzerland.

Key words: Chiroptera, cryptic species, refugia, Europe, Iberia, mitochondrial DNA

INTRODUCTION

Species have periodically expanded and contracted their range since at least the Tertiary in response to repeated changes in environmental conditions. Animals and plants experienced long periods of isolation in refugia during glacial episodes, before expanding during inter-glacials. These periodic pulses have had strong consequences on the evolution of organisms’ life histories (Dynesius and Jansson, 2000). Because the Gibraltar and Messinian straits remained active as geographic barriers during cold periods, the Iberian, Italian and Balkan Peninsulas in the Mediterranean basin acted as southernmost refugia for many western European species that now have much wider distribution ranges. These areas harbour high levels of biodiversity (Myers et al., 2000), as evidenced by molecular techniques (see e.g., Hewitt, 1996; Taberlet et al., 1998; Ruedi and Castella, 2003). Particularly, the Iberian Peninsula shows a remarkably high level of endemism in both plants and animals (summarized in García-Barros et al., 2002). Temperate habitats and species seem to have persisted in the Iberian Peninsula during the cold periods (Bennet et al., 1991; Olalde et al., 2002), allowing this area to act as an important repository reservoir (Gómez and Lunt, 2006). Molecular techniques also helped to uncover cryptic diversity in many groups of animals and
A description of a new species of *Pipistrellus* (Chiroptera: Vespertilionidae) from Madagascar with a review of related Vespertilioninae from the island

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Six species of small vespertilionid bat were recently collected in Madagascar. *Neoromicia matroka* (included by some in *Eptesicus*) and *N. malagasyensis* were already recorded from the island. *Pipistrellus hesperidus* was known but under a different name, *P. kuhlii*. *Neoromicia melckorum* is a new species record for the island. *Hypsugo anchietae* represents a new species and genus record. The last taxon is a previously undescribed species of *Pipistrellus*, which shows affinities to three South-east and East Asian pipistrelle taxa. In this paper, the new species is described and further information on the taxonomy, distribution, ecology, and behaviour of all six taxa are provided.

Key words: Vespertilioninae, *Pipistrellus* sp. nov., *Hypsugo anchietae*, *Neoromicia melckorum*, taxonomy, distribution, Madagascar

INTRODUCTION

Small vespertilionid bats of the genera *Pipistrellus* Kaup, 1829, *Hypsugo* Kolenati, 1856, *Neoromicia* Roberts, 1926 and *Eptesicus* Rafinesque, 1820 are widely distributed in the Old and New World and are common in many areas. However, in some cases, their taxonomy remains problematical with a series of reviews coming to different conclusions concerning the generic status of a range of well-defined species, for example Heller and Volleth (1984), Horáček and Hanák (1986), Hill and Harrison (1987), Volleth and Heller (1994), Volleth et al. (2001) and Kearney et al. (2002).

In Madagascar, to date, little has been published on the small, pipistrelle-like, vespertilionid bats. The first record was by Thomas and Schwann (1905), who described a new species *Vespertilio matroka* (= *Neoromicia matroka*: a discussion of the generic status of each taxon is included in ‘Taxonomic notes’ below). Subsequently, Dorst (1947a, 1947b) recorded *V. nanus* (Peters, 1852) (= *N. nanus*) based on unspecified specimen material. In their monograph on the bat fauna of Madagascar,
A review of bat research in Thailand with eight new species records for the country

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A review of the literature relating to the history of bat research in Thailand (1821–2006) is included, together with lists of the 119 bat species currently recorded from the country and the 16 that are omitted for lack of supporting data. The geographical distribution within Thailand of the some of the more significant bat field studies (1896–2004) is mapped and briefly discussed. Based on field work conducted in peninsular Thailand in 1993 and 2003–2004, eight bat species (Hipposideros ridleyi, Myotis hermani, Pipistrellus stenopterus, Hesperoptenus tomesi, Murina suilla, Murina aenea, Kerivoula pellucida, and Mops mops) are recorded from the country for the first time; information is provided on their taxonomy, distribution, and ecology. Recommendations are made for further bat studies in Thailand, with emphasis placed on selecting less well known species groups, such as forest bats, in under-researched habitats in neglected geographical areas (for example, the deciduous dipterocarp forests of eastern Thailand and the semi-evergreen forests of peninsular Thailand). A need to develop in-country skills in bat acoustics and taxonomy is also highlighted.

Key words: Chiroptera, Thailand, systematics, literature review, faunal list, new records

INTRODUCTION

Although Thonglongya (1974) wrote a detailed review of the history of mammal studies in Thailand, to date, there has been no comprehensive summary of bat research. This contrasts with other Southeast Asian mainland countries such as Myanmar (Bates et al., 2000), Vietnam (Hendrichsen et al., 2001a) and Cambodia (Kock, 2000; Hendrichsen et al., 2001b). It is more comparable to the situation for Lao PDR, where some data for recent surveys are included in Francis et al. (1999a) but there has been no synthesis of the historical literature.

In order to put previous studies of Thai bats in context and to provide a benchmark for future research, this paper gives a review of the literature; a list of currently recognised extant bat species with supporting references (Table 1); and taxonomic and ecological information on eight species, that are new records for the country. This latter material was collected by the senior author and others during a series of recent surveys, primarily in southern, peninsular Thailand. The paper also includes a list of bat species previously recorded from Thailand but now omitted for lack of supporting data (Table 2) and
The type locality of *Natalus stramineus* (Chiroptera: Natalidae): implications for the taxonomy and biogeography of the genus *Natalus*

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The name *Natalus stramineus* has been historically applied to populations of the genus *Natalus* from virtually the entire Neotropics. The geographic origin of the holotype of *N. stramineus*, however, has never been known with certainty, confounding discussions concerning the species limits, nomenclature, and biogeography of this genus. The type locality of *N. stramineus* was assumed to be Brazil for about 80 years, but was later transferred to the Lesser Antilles. Although the later view has dominated the taxonomy of *Natalus* for the past four decades, there have been recent claims that the type locality might indeed be in Brazil. In this study, I provide morphological evidence that corroborates the Lesser Antillean origin of the holotype of *N. stramineus*. In addition, I argue that *N. stramineus*-like populations do not occur in northern South America implying that the genus *Natalus* is distributed throughout Central and South America as three allopatric taxa. The findings presented here prompt the recognition of two additional species for the continental Neotropics and put end to lingering confusion about the degree of sympatry, or lack thereof, among these species. Finally, I summarize the available information about the natural history of *N. stramineus*, as herein restricted, and argue that the current distribution of the species is likely the result of ancestral dispersal from northern South America.

**Key words:** *Natalus*, Natalidae, Lesser Antilles, Caribbean biogeography

INTRODUCTION

The genus *Natalus* comprises a small assemblage of bats characterized by funnel-shaped ears and very long legs and tail (Koopman, 1994). Traditionally, it was treated as the only genus in the new world endemic family Natalidae and thought to contain three subgenera: *Nyctiellus*, *Chilonatalus*, and *Natalus* (Dalquest, 1950; Varona, 1974; Silva-Taboada, 1979; Koopman, 1994). Recently, the three subgenera have been elevated to generic level on the basis of their distinctive morphology (Morgan and Czaplewski, 2003). Natalidae, thus, is currently understood as comprising three genera and nine species: *Natalus jamaicensis*, *N. major*, *N. lanatus*, *N. primus*, *N. stramineus*, *N. tumidirostris*, *Chilonatalus micropus*, *C. tumidifrons*, and *Nyctiellus lepidus* (Simmons, 2005; Tejedor, 2005). *Natalus stramineus* is the type species of the genus *Natalus*.

The identity and geographic origin of the holotype of *N. stramineus* have been uncertain. Gray’s (1838) original description of this taxon as a new genus and species indicated neither collection locality nor specimen number of the material on which he based his description. Although two studies, a revision of the genus *Natalus* sensu stricto by Goodwin (1959) and a review of
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During the reproductive period, females of many bat species gather together in roosts to form maternity colonies, where the young are born and raised to independence. These colonies vary in size from less than ten to several thousand individuals, depending on the species involved. Each evening, bats emerge from their roost to forage and drink and typically they return before dawn (Kunz, 1982). In this paper, we use the terms ‘emergence’ for the collective departure from the roost at dusk and ‘return’ for the collective re-entry to the roost at dawn.

Factors regulating the timing of nocturnal activity are of endogenous as well as exogenous origin. Return behaviour of bats at maternity colonies has been relatively little studied in comparison with emergence behaviour (Voûte et al., 1974; Erkert, 1978; Marimuthu, 1984; Isaac and Marimuthu, 1993; Lee and McCracken, 2001). Emergence time of a bat colony changes in parallel with that of sunset and the return parallels sunrise (e.g., Erkert, 1978), but cloud cover can affect emergence (Erkert, 1978; McAney and Fairley, 1988; Kunz and Anthony, 1996) and return behaviour (Erkert, 1978). Thus light levels influence the initiation and cessation of flight activities.
INTRODUCTION

The pipistrelles, like all temperate-zone bats, have an annual rhythm that includes hibernation for several winter months. The cycle is thus essentially triphasic: after hibernation, which usually occurs in roosts occupied by large numbers of bats, the males and females separate; while the females gather in nursery roosts to bear and raise their young (e.g., Swift, 1980; Feyera-bend and Simon, 2000), the males generally lead basically solitary lives in summer (e.g., Park et al., 1996). When the young no longer need their mothers’ care, the females leave the nursery roosts and migrate toward the winter roosts. It is in this phase that mating occurs, as well the remarkable ‘invasion behaviour’ of the pipistrelle bat. During ‘invasions’ many bats, mainly young bats born the same year, gather at certain places, a behavior comparable with the swarming behaviour of other bats, the biological significance of which is still unclear (see, e.g., Grummt and Haensel, 1966; Grimmberger and Bork, 1978; von Helversen et al., 1987; Sachteleben, 1991; Smit-Viergutz and Simon, 2000).

Due to Gerell and Lundberg’s studies in Sweden, the mating system of the common
Small scale distribution patterns of female and male Daubenton’s bats (*Myotis daubentonii*)

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We analysed the distribution and relative abundance of *Myotis daubentonii* in the lowlands and uplands around the Lahn river near the city of Giessen (Hessen, Central Germany). We assumed a positive correlation between distribution and relative abundance of the trawling *M. daubentonii* with the amount of water surface in our study area. We further expected an unequal distribution of male and female *M. daubentonii* especially during the energy demanding pregnancy and lactation period of females. Daubenton’s bats were found at 75% of the 64 ponds and lakes we surveyed by standardized nightly spotlight counts. The number of Daubenton’s bats correlated positively with the area of the water surface and negatively with the distance to the nursery colonies. Nursery colonies were located with radio-tracking and existed predominantly in the lowlands close to the Lahn river. Mean flight distance between nursery colonies and foraging areas was 2.3 km (mean ± 1.4 km, range: 0.6–6.3 km). Sex ratio was determined at three sites studied in detail from 1992–2003 by mist-netting along regular used flight paths (n = 1,847 caught individuals). The number of female per male *M. daubentonii* was unequal and differed significantly between the three sites. In the lowland we found one site clearly dominated by females (median = 4.3 females per male, percentages of females 79.3%, n = 169 individuals) and a second site with an almost balanced sex ratio (median = 1.1 females per male, percentages of females 50.3%, n = 939 individuals). At the third site in the uplands males outnumbered females (median = 0.2 females per male, percentages of females 13.5%, n = 739 individuals). The percentages of females remained largely constant from spring to mid summer and changed at the beginning of September. The study revealed that a detailed knowledge of the spatial distribution of gender specific roost sites and key foraging habitats is necessary for the establishment of meaningful monitoring and conservation measures for bats.

*Key words*: *Myotis daubentonii*, sex ratio, abundance, distribution, conservation

**INTRODUCTION**

Daubenton’s bat (*Myotis daubentonii*) is one of three European trawling bats besides *M. dasycneme* and *M. capaccini*. It is mainly adapted to hunt for insects above water surfaces (Jones and Rayner, 1988; Kalko and Schnitzler, 1989; Siemers *et al.*, 2001). Daubenton’s bats feed mostly on Chironomidae (Swift and Racey, 1983; Beck, 1995) that are caught when they emerge or swarm just above the water surface. Because of their feeding habits, riverine areas with smooth water surface and trees on both banks (Warren *et al.*, 2000) and extensive still water surfaces represent key foraging...
Occurrence and morphometric variability in the frugivorous bat species, \textit{Cynopterus sphinx} and \textit{Rousettus leschenaulti}, from a tropical rainforest, Xishuangbanna, SW-China

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Occurrence and morphometric variation were recorded over one and a half years for two species of frugivorous bats, \textit{Cynopterus sphinx} and \textit{Rousettus leschenaulti}, from six localities in and around a tropical rainforest in Xishuangbanna, SW-China. Occurrence of both species was simultaneous. The two species breed all throughout the year, but we found one distinct peak in breeding season for each species. Although the overall morphology between the two species did not differ significantly, statistical analysis of morphological characters revealed consistent spatial correlations for both taxa. Body size and forearm length for both univariate and multivariate analyses (as derived from principal component analysis) was strongly and positively correlated with morphometric variations across the locations for \textit{C. sphinx} and \textit{R. leschenaulti}. Both, the different peaks in breeding season and the consistent spatial correlations suggest mechanisms to help resource partitioning. The study represents the first species documentation from this area.

\textit{Key words:} frugivorous bats, tropical rainforest, morphometric variation, SW-China

\section*{INTRODUCTION}

Morphometric studies of bats allow inferences of biomechanical and energetic properties, as well as ecological and behavioural aspects (Mauricio \textit{et al.}, 2001). Within bat biometrics, the characters body mass, wing morphology, and forearm length may be regarded as the focal parameters for many autecological considerations.

Variation in animal body size has functional consequences for a diverse array of life history attributes, and is therefore subject to an equally diverse array of selection pressures (Clutton-Brock and Harvey, 1983; Lindstedt and Swain, 1988; Aldrich and James, 1991; Baumgardener and Kennedy, 1993). The multifaceted nature of adaptive variation in body size suggests that consistent spatial correlations with particular ecological variables are generally not to be expected. However, geographic variation in body size for many species of mammals conform to Bergmann’s rule (1847). Species in cold climatic zones have comparatively larger body size than their tropical counterparts; to maintain body temperature, their surface to volume ratios are smaller (McNab, 1971, 1999). Additionally, metabolic rate is negatively correlated with body mass, and thus the empirical assessment of Bergmann’s rule holds (Zink and Remsen, 1986; Zeveloff and Boyce, 1988). On the other hand, suggestions vary with respect to
Habitat use and conservation of bats in rainforest and adjacent human-modified habitats in eastern Madagascar

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We used roost searches, mist netting and acoustic sampling to investigate the habitats used by bats in Parc National de Mantadia and the Réserve Spéciale d’Analamazaotra, eastern Madagascar. Four species were caught in relatively intact humid forest (Myotis goudoti, Miniopterus manavi, Miniopterus majori and Emballonura atrata) two in agricultural land, Neoromicia matroka and Neoromicia melckorum, and one, Rousettus madagascariensis, in Eucalyptus plantations. Mormopterus jugularis, Chaerephon pumilus and Mops leucostigma were found roosting in buildings ca. three km from the humid forest. Acoustic sampling revealed that Neoromicia spp. and molossids were ubiquitous and were recorded from intact and degraded humid forest, Eucalyptus plantations and agricultural land. Myotis goudoti showed the strongest association with intact humid forest. Taxon richness, determined by acoustic sampling, was highest in humid forest but activity was highest in plantations and agricultural land. Mixed-habitat landscapes that surround protected forests and consist of a mosaic of regenerating forest, agriculture, wetlands, villages and plantations are important for bats and promote chiropteran diversity because they provide roosting and foraging sites for species that rarely use intact forest. The humid forests of eastern Madagascar have lower bat diversity than the island’s western deciduous karst forests.

Key words: acoustic, roosts, habitat, landscape, conservation, Madagascar

INTRODUCTION

Comprehensive species inventories have been made of rainforest amphibians, reptiles, small land mammals and primates in Madagascar and this information has been used to assess their conservation status (e.g., Raxworthy and Nussbaum, 2000), levels of forest dependency (e.g., Ganzhorn et al., 2003), biogeography (e.g., Goodman and Ganzhorn, 2004) and have contributed to macro-analyses to prioritise conservation efforts (e.g., Brooks et al., 2002). However as noted recently (Goodman and Benstead, 2005), many gaps remain in our knowledge of Madagascar’s endemic species and there have been surprisingly few studies on the island’s chiropteran fauna.
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Most molossid species known from Madagascar are known to live synanthropically and four, Mormopterus jugularis, Chaerephon pumilus, Chaerephon leucogaster, and Mops leucostigma are relatively widespread (Goodman and Cardiff, 2004). There is no information available on the feeding ecology and diet of molossids in Madagascar and this reflects a general paucity of ecological study on Malagasy microchiropterans (Goodman and Benstead, 2005), although advances have recently been made in their taxonomy (e.g., Goodman and Ranivo, 2004; Goodman et al., 2005), diet (Razakarivony et al., 2005) and biogeography (e.g., Yoder et al., 2005).

There is growing appreciation of the potential role that molossid bats play in predation on crop pests (e.g., Whitaker et al., 1996; Lee and McCracken, 2005). Molossids in Madagascar frequently roost in large colonies in municipal buildings or houses, and often close to agricultural land. Therefore, in addition to the objective of describing the diet of Madagascar’s endemic mammals, a better understanding of the dietary...
The trophic niche of the Geoffroy’s bat (*Myotis emarginatus*) in south-western Germany

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In Germany, the Geoffroy’s bat (*Myotis emarginatus*) is one of the rarest bat species. In south-western Germany (federal state of Baden-Württemberg), only four nursery roosts of *M. emarginatus* are known. Referring to the trophic niche of this species and to own observations, we hypothesized that cowsheds are important foraging areas for *M. emarginatus* in Central Europe. This would have important implications for the conservation of this species. To test this hypothesis we conducted a diet analysis aiming at three major aspects: the trophic niche, indications for foraging habitats used, and the importance of these foraging habitats throughout the nursery season. Flies (Brachycera) made up the largest volume in the diet of *M. emarginatus* throughout the season, followed by spiders (Araneida) and butterflies (Lepidoptera). Among the flies, the genus *Musca* and the species *Stomoxys calcitrans* were found in more than half of the investigated faecal pellets. Both of these fly-taxa are strongly related to cattle farming. Therefore we conclude that the individuals of the investigated colony of *M. emarginatus* were mainly hunting in the vicinity of cattle farms during the whole nursery season. Consequently, the preservation of traditional cattle farming is likely to play a key role for the conservation of *M. emarginatus* in Central Europe.

**Key words:** *Myotis emarginatus*, faecal analysis, Brachycera, foraging habitats, cowsheds

**INTRODUCTION**

As in all of Europe, the Geoffroy’s bat (*Myotis emarginatus*) is endangered in Germany where it is at the northern border of its distribution (Boye *et al.*, 1999). Preferring warm climates, *M. emarginatus* populates mainly the southern parts of Germany (federal states of Rheinland-Pfalz, Bayern and Baden-Württemberg — Brinkmann *et al.*, 2004). In Baden-Württemberg, for example, there are only four nursery colonies known; all of them are located in the Rhine River valley.

For the effective conservation of this endangered species, accurate knowledge of the species’ ecology is essential. It is well known that *M. emarginatus* has an outstanding ability to locate prey very close to echo-cluttering background (Schumm *et al.*, 1991; Siemers and Schnitzler, 2004). This is reflected in this species’ diet that consists mainly of flightless taxa and of taxa that are sessile at night.
Echolocation calls, wing shape, diet and phylogenetic diagnosis of the endemic Chinese bat *Myotis pequinius*

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We describe the echolocation calls, flight morphology and diet of the endemic Chinese bat *Myotis pequinius* Thomas, 1908. Orientation calls are broadband, and reach low terminal frequencies. Diet comprised 80% beetles by volume. Wing shape and call design suggest that the bats fly in cluttered habitats, and the possession of moderately long ears and the dietary composition imply they forage at least sometimes by gleaning. *Myotis pequinius* resembles a larger Oriental version of the western Palaearctic species *M. nattereri*. Phylogenetic analysis based on sequences of the cytochrome *b* gene of mitochondrial DNA (1,140 base pairs) from a range of Palaearctic *Myotis* species confirmed that *M. pequinius* is close to the *nattereri* group, and is a sister-species to the eastern Palaearctic *M. bombinus*. One bat sequenced from China could not be identified from available species descriptions. It was smaller than *M. pequinius*, and also differed from it in sequence divergence by 6.7%, suggesting the existence of additional, cryptic taxonomic diversity in this group. Our phylogenetic analysis also supports the recognition of *M. schaubi* as a species distinct from *M. nattereri* in Transcaucasia and south-western Asia. *Myotis nattereri tschuliensis* is more closely related to *M. schaubi* than to *M. nattereri*, and is best considered either as a subspecies of *M. schaubi*, or possibly as a distinct species.

**Key words:** cytochrome *b*, echolocation calls, diet, wing shape, *Myotis*

**INTRODUCTION**

The Peking myotis, *Myotis pequinius* Thomas, 1908 is endemic to China, and has been recorded from the provinces of Hebei, Beijing, Shandong, Jiangsu, Henan and Sichuan (Wang, 2003). The species was first described by Thomas (1908). Allen (1938: 212) stated “except for the two original specimens taken in a cave thirty miles west of Peiping, nothing further seems to be known of this bat”. Despite this poor knowledge, this endemic species is classified as Lower Risk, Near Threatened in the IUCN Red List for microchiropteran bats (Hutson *et al.*, 2001). To our knowledge, nothing has
Echolocation signals of the plecotine bat, *Plecotus macrobullaris*

Kuyzakin, 1965

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*Plecutus macrobullaris* was recorded in an alpine region in Switzerland. Like other species of the genus *Plecutus*, *P. macrobullaris* emitted multiharmonic, downward frequency-modulated signals consisting mostly of the 1st and the lower part of the 2nd harmonic. Signal structure depended on the distance to the background. The shortest signals (0.8 ms) were recorded close to the background. The first harmonic began at about 46 kHz and ended around 23 kHz. Signals were emitted in groups. The longest signals (up to 7.3 ms) were recorded above a meadow, far from background targets. These signals, which were more shallowly modulated, started at about 42 kHz and ended around 15 kHz. They occasionally lacked the 2nd harmonic and were often emitted only every 2nd or 3rd wing beat cycle. In short signals of up to 4 ms, the 1st and 2nd harmonic did not overlap, whereas overlap was prominent in longer signals. Although *P. macrobullaris* is genetically more closely related to *P. auritus*, its signal structure is closer to that of *P. austriacus*. Taking further evidence from morphological data, signal structure, and flight behaviour into account, we conclude that *P. macrobullaris* occupies a similar niche in mountainous areas as *P. austriacus* does in the lowland.

**Key words:** *Plecutus macrobullaris*, echolocation, signal structure, foraging behaviour

**INTRODUCTION**

Bats of the genus *Plecutus* are widely distributed throughout the northern hemisphere. With the advent of molecular techniques, species designation within the genus has changed frequently, in recent years (for a review see Spitzenberger *et al.*, 2006). Up to now, five species have been described in Europe: *Plecutus auritus* (Linnaeus, 1758), *P. austriacus* (Fischer, 1829), *P. kolombatovici* Dulic, 1980, *P. macrobullaris* Kuyzakin, 1965 [also described as *P. alpinus* by Kiefer and Veith (2002) and as *P. microdontus* by Spitzenberger *et al.* (2002) — see Spitzenberger *et al.* (2003)], and, most recently, *P. sardus* Mucedda, Kiefer, Pidinchedda and Veith, 2002 from Sardinia (Mucedda *et al.*, 2002; Kiefer, 2004; Kiefer and Helversen, 2004a). Mitochondrial DNA analysis revealed the existence of two major clades, the ‘auritus group’, including *P. auritus* and *P. macrobullaris* and the ‘austriacus group’, including *P. austriacus* and *P. kolombatovici* in Europe (Juste *et al.*, 2004).

The distribution area of *P. macrobullaris* includes the Pyrenees, the Alps, Crete,
Vocalizations emitted during mother-young interactions by captive eastern red bats *Lasiurus borealis* (Chiroptera: Vespertilionidae)

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We recorded acoustic signals during interactions between mother eastern red bats and their nursing young. Mothers and young produced tonal (structured change in frequency over time) frequency-modulated (FM) signals with varying harmonic components in situations ranging from reunion to just before nursing. Pups left by their mothers were usually silent, only occasionally producing tonal isolation calls. Adult females used FM signals in stressful situations, times when young usually produced clicks. Vibrational signals (‘hums’) composed of clicks (broadband, no structured change in frequency over time) characterized pup-pup and mother-pup interactions but pups also used other clicks that differed in frequency components from clicks comprising the hums. In stressful situations, adults produced FM signals, the pups, clicks. FM signals of pups decreased in frequencies with increasing age (size). Echolocation calls of adults and subadults hunting flying prey differed in frequency components. Differences in duration of echolocation calls coincided with setting (short calls in flight cages, open calls in the open). FM signals produced by pups searching for their mothers’ nipples showed little potential for individual signatures. Calls and calling behaviour of eastern red bats that are solitary and foliage-roosting, differed from those of more gregarious species roosting in more sheltered situations.

*Key words*: clicks, frequency modulated signals, echolocation, harmonics, signatures, *Lasiurus*

INTRODUCTION

Most reports (e.g., Brown, 1976; Porter, 1979; Thomson *et al*., 1985; McCracken and Gustin, 1991; Balcombe and McCracken, 1992; Zhang *et al*., 2005) about the acoustic signals produced by mother bats and their dependent young come from colonial species, usually those roosting in protected situations (in hollows or crevices). To locate and identify their dependent young, mother bats use a combination of spatial memory, acoustic, and olfactory cues (Gustin and McCracken, 1987; Balcombe, 1990; Loughrey and McCracken, 1991; McCracken and Gustin, 1991; Balcombe and McCracken, 1992). For bats, precision in maternal recognition of young is the rule rather than the exception (McCracken and Bradbury, 1984; Thomson *et al*., 1985; Scherrer and Wilkinson, 1993), even for species living in very large groups. From an early age, developing young produce frequency-modulated (FM) signals, which...
Female interactions in harem groups of the Jamaican fruit-eating bat, *Artibeus jamaicensis* (Chiroptera: Phyllostomidae)

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Harem groups of the Jamaican fruit-eating bat (*Artibeus jamaicensis*) are well-defined units that occupy different crevices in caves. For two consecutive years, we analyzed the non-random associations among female bats and their interactions with other members of the harem. Female members occupying the edges of the harems came from different parts of the cave and were more frequently expelled from the roosting site. Females from the central core of the harem were attacked less often and received more affiliative interactions. Females occupying areas between the central core and the edges were the most active in repelling arriving females and were responsible for grooming the central core females. During the breeding season, aggressive activities decreased and females became more tolerant, which suggests that a potential benefit of roosting together is that it provides for a more suitable place to nurse newborns, because all females produce a better environment, in thermoregulatory ways.

Key words: aggressive interactions, affiliative interactions, *Artibeus jamaicensis*, harem groups

INTRODUCTION

Bats colonies frequently split into well-structured social units such as single male and multi-female groups, multiple male and multiple female groups, and single male and single female monogamous groups (McCracken and Wilkinson, 2000). This formation of social units may be associated with factors such as resource availability, protection against predation, and social relationships including mating systems. Recording group composition and individual relationships is important because we can study the degree of association among individuals and their influences in the group, providing ideas about the importance of group living (Kerth and König, 1999). This information is important because knowing relationships between bats; we can address questions about membership in groups, social structure of the groups, and type of relationships between them.

Bats provide an opportunity to study social units because sociality is widespread in this order of mammals. Temperate species form maternity colonies where young are raised (Bradbury, 1977) and tropical species have a rich diversity of social systems that may be related to changes in season and/or...
INTRODUCTION

This is a study of the annual reproductive pattern of the male Lesser Antillean bat (Brachyphylla cavernarum Gray). This phyllostomid is a New World, tropical, colonial, primarily frugivorous bat which also utilizes pollen, nectar and insects (Bond and Seamon, 1958; Nellis, 1971; Gardner, 1977; Nellis and Ehle, 1977). Brachyphylla colonies vary in number from less than a hundred (Beatty, 1944; Buden, 1977; Nellis and Ehle, 1977) to gatherings of thousands of individuals (Bond and Seaman, 1958; Koopman, 1975; Nellis and Ehle, 1977). Diurnal roosting sites varied from natural caves or crevices (Anthony, 1925; Silva Taboada and Pine, 1969; Koopman, 1975) to man-made structures (i.e., buildings, wells etc. — Beatty, 1944; Koopman, 1975; Nellis and Ehle, 1977).

A review of the literature concerning the systematics, general biology, and natural history of B. cavernarum (Silva Taboada, 1979; Swanepoel and Genoways, 1983; Gannon et al., 2005; Genoways et al., 2005) further characterized this species. Many genera of the family Phyllostomidae are believed to be polyestrous reproducing twice each year. The St. Croix population of Brachyphylla appeared to be monestrous as do Brachyphylla in other parts of its geographic range. Wilson (1979) suggested a second parturition occurs annually in at least some populations. Our study does not verify this suggestion. We describe the anatomy and
Age related variation in the energy costs of torpor in Daubenton’s bat: effects on fat accumulation prior to hibernation

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Insectivorous bats in their first year of life generally deposit less fat prior to hibernation than older bats of the same species. In the present study we explored the energy expenditures of first-year (sub-adult) and older than one year (adult) Daubenton’s bats (Myotis daubentonii) during torpor and their patterns of roost site selection and fat accumulation in an artificial roost site, removing from the equation the effects of differences in aerial foraging behaviour by feeding them on non-aerial prey (mealworms). Sub-adult bats had oxygen consumption during torpor that averaged 2.75 × greater than adult individuals. In an artificial enclosure in which bats could fly freely and choose whether to roost inside or outside of a hollow brick, sub-adults gained body mass at a significantly lower rate (67.8 mg × day⁻¹) than adults (100.3 mg × day⁻¹), despite being fed non-aerial prey (mealworms). The difference in rates of mass accumulation (32.5 mg per day) far exceeded the theoretical influence of different metabolic rates (7 mg × day⁻¹) in torpor. Despite lower rates of mass gain in this artificial situation, sub-adults ultimately achieved the same mass accumulation as adults because they continued to accumulate fat for a longer period, an option that might be unavailable to them in the wild as feeding conditions deteriorate. The rate of body mass accumulation was positively correlated with the time spent utilising the brick roost site, but utilisation of this site did not differ significantly between age classes. These data support the hypothesis that differences in the accumulation of fat between age classes may reflect in part differences in expenditure as well as differences in food intake, but the contribution of differences in metabolism during torpor are relatively small.

Key words: Myotis daubentonii, oxygen consumption, hibernation torpor, fat accumulation

INTRODUCTION

During winter in the temperate and arctic zones ambient temperatures decline on average by 20–40°C below the peak levels observed in summer (Oliver and Fairchild, 1984). This reduction in temperature results in a large increase in the energy demands that are experienced by small endothermic mammals (Speakman, 2000; Speakman and Thomas, 2003) and birds (Bryant, 1997). At the same time as they face increased energy demands, however, insectivorous species often experience a reduction in food supply because their insect prey become less active at lower temperatures. In response to the potential imbalance of energy intake and energy expenditure, small insectivorous mammals, such as bats, have evolved a number of strategies which
INTRODUCTION

To address research questions such as spatial movement, dispersal, longevity, social structure and mating system, reliable marking techniques are necessary to ensure the recognition of individuals over extended periods of time. In birds and bats the use of individually numbered rings is the most widespread method when it comes to the study of large-scale movements and migration (Calvo and Furness, 1992). Dating back to the studies of Eisentraut and Griffin in the beginning of the 20th century (Eisentraut, 1934, 1960; Griffin, 1934), marking bats with aluminium bands at the forearm is a standard method for studying bat migration (Barclay and Bell, 1988). In the United States, bird bands were initially placed around the bats’ legs (Allen, 1921), but since the studies of Trapido and Crowe (1946) bats have been banded there around the forearm like in Europe (Eisentraut, 1934). However, bird rings have subsequently been found to cause severe injuries (Hooper and Hooper, 1956; Hitchcock, 1957; Davis, 1960, 1961; Herreid et al., 1960), so special bat rings have been developed (Issel, 1951; Bels, 1952; Casteret cited in Hooper and Hooper, 1956; Herreid...
INTRODUCTION

The problem of cryptic diversity has grown into a hot topic in bat taxonomy during recent years. This is especially so for the region of western Palearctic. The list of bat fauna has expanded from 31 to 46 species due to discoveries of cryptic species alone (cf. e.g., Corbet, 1978 or Horáček et al., 2000 versus Mayer and Helversen, 2001; Helversen et al., 2001; Kiefer et al., 2002; Spitzenberger et al., 2001; Mucedda et al., 2002; Hulva et al., 2004; Simmons, 2005 and/or Spitzenberger et al., 2006) since the first cases of sympatric sibling species were reported there in sixties and seventies. Most of these discoveries appeared recently through the application of molecular methods. Although a significant degree of population substructures was not expected in volant mammals, molecular tools revealed a surprising amount of phylogenetic gaps in a variety of phylogeographic patterns. This calls not only for rearrangements in taxonomy of the respective clades but also for reconsideration of the speciation mechanisms producing the cryptic species diversity.

The discovery of these cryptic species questioned the universality of a standard model of allopatric speciation explaining the sympatric situations by secondary range extension of the respective allopatric species. This resulted in a lively discussion on speciation under parapatric or sympatric conditions and on the ecological and behavioral mechanisms that may affect it (see e.g., Losos and Glor, 2003 for a review). A detailed model of sympatric speciation in bats was first proposed by Jones (1997) and Barratt et al. (1997) who stressed the possible role of divergence in echolocation call frequency for niche partitioning and social recognition in the speciation process of the western Palearctic cryptic species group, Pipistrellus pipistrellus. An example of such a model of speciation has recently been provided in the case of the SE Asiatic large-eared horseshoe bats (Rhinolophus phillipinensis) where switching of frequencies to different harmonics of the same fundamental frequency was shown to be major factor that promoted reproductive isolation of three sympatric size morphs of this bat (Kingston and Rossiter, 2004). Correspondingly, multiple
Further range extension of *Pipistrellus kuhlii* (Kuhl, 1817) in central and eastern Europe

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Key words: *Pipistrellus kuhlii*, distribution, expansion, Europe

INTRODUCTION

Kuhl’s pipistrelle *Pipistrellus kuhlii* (Kuhl, 1817) is distributed mainly in southern and central Europe with the northern border of its range rapidly shifting northwards and therefore insufficiently known. Recently, its northermmost localities have been reported along the line from north-western France through Switzerland, southern Germany, Austria, southern Hungary, Serbia and southern Bulgaria to north-eastern Ukraine and south-western Russia (e.g., Iljin, 2000; Gavrys’ and Kotserzhynska, 2002; Benda *et al.*, 2003; Bogdanowicz, 2004); few vagrants were also reported from southern coast of Britain (reviewed by Bogdanowicz, 2004).

*Pipistrellus kuhlii* is a bat characteristic of urban areas, roosting mainly in crevices of various buildings and hunting typically over water and near street lights. Winter roosts are still poorly known but seem to be located in fissures of buildings and ventilation shafts (Vernier and Bogdanowicz, 1999; Bogdanowicz, 2004). *Pipistrellus kuhlii* appears to be mostly a sedentary species; winter records are known from the northernmost part of its range in Tolyatti, Samara, and Izhevsk cities of Russia (Iljin *et al.*, 2003; D. Smirnov and V. Viekhnik, in litt.). Its conspicuous range expansion is exceptional among European bats; in the last two decades approximately the species has colonised new territories northwards, particularly rapidly in Hungary and in Ukraine (Zagorodniuk and Negoda, 2001; Szatyor *et al.*, 2003; Estók, In press). Herein, we report the first records of *P. kuhlii* from Poland and western Ukraine with review of the new localities for the species in central and eastern Europe.

MATERIALS AND METHODS

For the species identification we used characters given by Dietz and von Helversen (2004). The specimen from Poland is held in the first author’s collection. Bats from Ukraine were released after examination. Dental characters were examined with a magnifying lens (6×).

RESULTS

The new localities of *P. kuhlii* were recorded in the following sites:

1) Zawiercie (50°30’N, 19°25’E), 357 m a.s.l., Śląsk district (southern Poland). A juvenile male (partial ossification of the epiphyses of wing bones) captured on 1 December 2005 in the office, on the first floor of two-story building (Będzin Power Distribution Plant), in the center of the town, near the railway station. The bat was hiding on the window-sill between the files and window frame. The bat was in poor condition and died after a month. The forearm length was 34.5 mm and the 5th finger measured 44.9 mm. Dorsal pelage was two-coloured
INTRODUCTION

There has been considerable debate regarding the significance of insects in the diets of frugivorous bats, the manner in which such bats obtain insects, and the nutritional role insects play (e.g., Gardiner, 1977; Marshall, 1983; Thomas, 1984b; Courts, 1998; Herrera et al., 2001). Initially it was believed that most insects were ingested accidentally with the flowers or fruit on which they were resting (e.g., Marshall, 1983; Thomas, 1984b), but they are now considered to be an important component of the diet of fruit-eating bats, especially those in the family Phyllostomatidae (e.g., Willig et al., 1993). These bats use echolocation and may be able to detect insects using this sensory system.

It is less clear how fruit-eating Megachiroptera (Pteropodidae) obtain insects, whether it is deliberate or accidental, and whether insects are important sources of protein or other nutrients for these bats (Courts, 1998). Almost all observations of insect eating have involved captive individuals (e.g., Funakoshi et al., 1993; Courts, 1997). Observations in the wild typically involve finding insect remains in faeces or rejected material (‘spats’) (Parry-Jones and Augee, 1992; Funakoshi et al., 1993). A single observation of a Pteropus poliocephalus catching a flying cicada has been reported (Parry-Jones and Augee, 1991), and Allen (1939) reported that Rousettus spp. occasionally snap insects off flowers.

Here we report observations of the Egyptian fruit bat (Rousettus aegyptiacus; Pteropodidae) deliberately feeding on garden fruit chaffer beetles (Pachnoda sinuata; Scarabidae) in the wild. Egyptian fruit bats occur in eastern and western Africa and are relatively common in the Western Cape Province of South Africa (Kwiecinski and Griffiths, 1999). Adult bats weigh approximately 130 g and feed on a variety of fruits as well as flowers and leaves (Kwiecinski and Griffiths, 1999; Taylor, 2000). Garden fruit chaffers (0.85 g, 22 mm body length) are common in southern Africa and are present as adults from October through April. Adult beetles feed during the day on ripe fruits and flowers. They are inactive at night and can be found in groups in ‘sleeping trees’ (Scholtz and Holm, 1985).

MATERIALS AND METHODS

We studied the feeding behaviour of Rousettus aegyptiacus in Cape Town, South Africa from September 2004 to May 2005. We observed free-flying individuals as they fed at three native fig trees (Ficus sur) on the grounds of the Baxter Theatre near the University of Cape Town campus. While ingesting food, the bats roosted in a nearby palm tree (Phoenix dactylifera) where we could observe their behaviour in the light provided by street lamps. We collected spats, the rejected portions of masticated food items, on a plastic sheet placed under the roost tree. We also searched regularly for insect remains among the accumulated spats under this tree and occasionally at two other trees at which R. aegyptiacus fed, one on the grounds of the Baxter Theatre and one at Kirstenbosch Botanical Gardens.


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**A case of exceptionally high predation levels of *Rousettus madagascariensis* by *Tyto alba* (Aves: Tytonidae) in western Madagascar**

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**Key words**: *Tyto alba*, predation, *Rousettus madagascariensis*, western Madagascar

**INTRODUCTION**

Previous research conducted on the diet of barn owls (*Tyto alba*) occurring on Madagascar, based on regurgitated pellets, found that bats comprise a very small proportion of this predator’s prey spectrum (Goodman *et al.*, 1993b). Further, when bats are present in the food remains of this owl species, relatively small-bodied chiropteran species are the most commonly taken. Introduced terrestrial mammals (*Rattus*...
INTRODUCTION

Twenty-one species of bats around the world have been recorded using modified leaves as roosts, usually called ‘tents’ (Timm, 1987; Kunz and Lumsden, 2003; Rodríguez-Herrera and Tschapka, 2005). Most tent roosting bats are members of the family of New World leaf-nosed bats (Phyllostomidae) except three pteropodids (Balionycteris maculata, Cynopterus brachyotis, and C. sphinx) and one vesper-tilionid bat (Scotophilus kuhlii). Similarities in tent architecture among the Old World pteropodids and the New World phyllostomids support an interpretation of convergence in tent-making and tent-roosting behavior (Kunz et al., 1994; Kunz and Lumsden, 2003).

It has been suggested that the mating system associated with tent use is polygamy, based on the defense of a resource — tents (Brooke, 1990; Balasingh et al., 1995; Kunz and McCracken, 1996; Storz et al., 2000; Kunz and Lumsden, 2003; Chaverri and Kunz, 2006). The main idea is that males modify leaves to create a refuge, so that females would select a male based upon some characteristics of a tent that potentially can be defended against other males (Balasingh et al., 1995; Kunz and McCracken, 1996; Kunz and Lumsden, 2003).

To date, the construction of tents has only been observed in the flying fox, C. sphinx (Balasingh et al., 1995) where males modified palm fronds. However, little information is available for other tent-making or tent-roosting species. Using telemetry, Chaverri and Kunz (2006) observed that a male Artibeus watsoni remained motionless at a site for 30 min; the following day they found the bat in a new tent where it had stayed throughout the previous night. Hence, it remains an open question which sex constructs tents and how they are constructed. This information, however, is crucial to better understand the evolution of this complex behavior, in particular with regard to the social organization in tent-making bats.

The Honduran white bat, Ectophylla alba, is a small phyllostomid (forearm length 27–31 mm) with distinctively white fur, and yellow ears and noseleaf. Its distribution is restricted to the lowlands of the Caribbean slopes of Honduras, Nicaragua, Costa Rica, and northwestern Panama (Timm, 1982; LaVal and Rodríguez-H., 2002). This species apparently roosts only in tents; it has never been recorded in other types of refuges like hollow tree trunks or caves. Although there are at least 10 species of plants used for tents, most have been located in Heliconia imbricata and H. pogonantha (Timm and Mortimer, 1976; Brooke, 1990; Kunz et al., 1994).

As part of a long-term study on the mating system and social organization of E. alba in Costa Rica, we are investigating tent construction, and herein present for the first time information on tent construction by a phyllostomid bat in the field. We observed a female Ectophylla modifying Heliconia leaves into a tent. This is the first direct
Notably range extension of *Sturnira aratathomasi* Peterson and Tamsitt 1969 in Perú

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**Key words:** *Sturnira aratathomasi*, distribution, Perú, Apurímac, the Andes, dry forests

**INTRODUCTION**

The genus *Sturnira* is one of the most speciose genus of Neotropical bats. Currently, no less than 15 species are recognized (Pacheco and Patterson, 1991, 1992; Koopman, 1993; Iudica, 2000; Sánchez-Hernández *et al.*, 2005; Simmons, 2005). Among them, the Aratathomas’s yellow-shouldered bat *Sturnira aratathomasi* and the greater yellow-shouldered bat, *Sturnira magna*, are the two largest species of the genus; however, the former is one of the less known species in the genus. Most of the specimens of *S. aratathomasi* come from the Northern Andes, where as few as 18 specimens are known from Mérida state, Venezuela (Soriano and Molinar, 1984), the departments of Cauca, Caldas, Huila and Valle del Cauca, Colombia (Tamsitt *et al.*, 1986; Soriano and Molinar, 1987; Alberico 1987, Alberico *et al.*, 2000; Castaño *et al.*, 2003), and from Ecuador (Peterson and Tamsitt, 1968). The presence of *S. aratathomasi* in Ecuador is based on two specimens collected from an unknown locality before 1874; since then, no other specimen has been recorded for that country (Albuja, 1999; Tirira, 1999).

McCarthy *et al.* (1991) reported the first specimen of *S. aratathomasi* from Perú based on a juvenile male specimen (LSUMZ 21484) mist-netted on 29 August 1978, east of La Peca, at 3,165 m in the Cordillera Colán, Department of Amazonas. Later, the species was also reported from Río Abiseo, Department of San Martín (Solari *et al.*, 2001). The reported specimens of *S. aratathomasi* indicate it inhabits the premontane and montane life zone from 1,650 to 3,165 m a.s.l. (Soriano and Molinari, 1987; McCarthy *et al.*, 1991; Alberico *et al.*, 2000).

Here, we provide information on the specimens from San Martín and report on three additional specimens from the Department of Apurímac, extending the southern range of the species more than 840 km.

**MATERIALS AND METHODS**


The report of Solari *et al.* (2001) was based on two specimens (MUSM 7305, 7306) captured at Las Palmas, ca. 32 km NE de Pataz, Department San Martín, at 2,000 and 2,100 m a.s.l. (ca. 07°34'12.65"S, 77°17'50.64"W). The specimen MUSM 7305 was captured on 19 July 1990 in montane forest, and it is a male with testes 4 × 3 mm; whereas the specimen MUSM 7306, sex undetermined, was captured on 21 August 1990 at riverine vegetation, near the river. Other species captured at the lower montane forest of Las Palmas were: *Anoura caudifer*, *A. geoffroyi*, *Carollia brevicauda*, *Platyrrhinus ismaeli*, *P. nigellus*, *Sturnira bidens*, and *S. erythromos* (Velazco, 2005; M. Romo, personal comm.). The lower montane forest of Río Abiseo is characterized by the appearance of palms (*Chamaesorea poepigiana* and *Prestoea acuminata*), cyclanths (*Asplundia moritziana*, and *Sphaeradenia steyermarkii*), other trees (e.g., *Casearia nigricolor*, *Cecropia* sp., *Cestrum* spp., *Clusia* spp., *Ficus* spp., *Oreopanax* spp.), and by the absence of tree ferns and the bamboo *Chusquea scandens* (Young and León, 1988, 1991).
Aggressive behaviour of greater mouse-eared bat (*Myotis myotis*) towards lesser horseshoe bats (*Rhinolophus hipposideros*) in a hibernaculum

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**Key words:** *Myotis myotis*, *Rhinolophus hipposideros*, aggressive behaviour, hibernation

**INTRODUCTION**

Aggression occurs in many forms and can be an important adaptive behaviour (Ramirez, 1998). Also among bats, aggressive behaviour is observed in different situations, and can take on different forms, as occurs in other mammals. Aggression in bats has been observed during feeding. This behaviour is expressed through chasing and pursuing fight patterns as well as through scaring away a newcomer of the same or different species from the feeding area (Ransome, 1990). Many times this type of behaviour is accompanied by agonistic and aggressive calls generated and emitted by the aggressive bat (Racey and Swift, 1985; Ransome, 1990; Barlow and Jones, 1997). Aggressive behaviour is also often observed during the mating season (McCracken and Wilkinson, 2000). In this case, it concerns the males, which defend their roost sites (Davidson and Wilkinson, 2004) or female groups (McCracken and Bradbury, 1981; Gerell-Lundberg and Gerell, 1994). Such behaviour is also observed in mating colonies and consists of utilizing and defending the traditional roosting and foraging sites by females (McCracken and Bradbury, 1981; Rydell 1989; Kerth et al., 2002). In most cases, the aggression is usually reduced to agonistic behaviour, that is, to confrontational behaviour without fighting. However, there are rare incidents of direct fights (physical contact) between bats (Rydell, 1986), which very rarely lead to the...