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# Bats (Mammalia: Chiroptera) of the Eastern Mediterranean and Middle East. Part 6. Bats of Sinai (Egypt) with some taxonomic, ecological and echolocation data on that fauna

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**Abstract**. A complete list of bat records from Sinai was compiled, composed mostly of new findings from the field (85%). From the territory of Sinaitic peninsula, 106–111 records of up to 15 bat species are reported; viz. *Rousettus aegyptiacus* (Geoffroy, 1810) (10 records), *Rhinopoma cystops* Thomas, 1903 (1), *Taphozous perforatus* Geoffroy, 1818 (1), *Nycteris thebaica* Geoffroy, 1813 (2), *Rhinolophus clivosus* Cretzschmar, 1830 (9), *R. hipposideros* (Borkhausen, 1797) (8), *R. mehelyi* Matschie, 1901 (1 [uncertain]), *Asellia tridens* (Geoffroy, 1813) (4–5), *Eptesicus bottae* (Peters, 1869) (6), *Hypsugo ariel* (Thomas, 1904) (24), *Pipistrellus kuhlii* (Kuhl, 1817) (3–5), *Otonycteris hemprichii* Peters, 1859 (5), *Barbastella leucomelas* (Cretzschmar, 1830) (6), *Plecotus christii* Gray, 1838 (19–20), and *Tadarida teniotis* (Rafinesque, 1814) (8). Six species (*R. aegyptiacus*, *R. cystops*, *T. perforatus*, *R. mehelyi*, *E. bottae*, and *T. teniotis*) are here reported from Sinai for the first time. The taxonomic status of *Rousettus aegyptiacus* and *Tadarida teniotis* from Sinai is discussed. According to a profound taxonomic revision, *Hypsugo bodenheimeri* (Harrison, 1960) has been found to be a junior synonym of *Hypsugo ariel* (Thomas, 1904). The species status of *Barbastella leucomelas* from Sinai and southern Israel has been confirmed and hence, a separate species position for Central Asian *Barbastella* populations suggested. Representatives of *Plecotus christii* from the Sinaitic and southern Holy Land populations have been found to be significantly larger than the nominotypical ones from Upper Egypt and therefore described as a separate subspecies, *P. christii petraeus* subsp. nov. Basic descriptive echolocation parameters for 12 Sinaitic bat species are given and discussed. Echolocation calls of *Rhinolophus clivosus*, *Hypsugo ariel*, *Otonycteris hemprichii*, *Barbastella leucomelas*, and *Plecotus christii* are described in detail for the first time. Diet composition of six bat species (*Rhinolophus clivosus*, *Hypsugo ariel*, *Otonycteris hemprichii*, *Barbastella leucomelas*, *Plecotus christii*, and *Tadarida teniotis*) from Sinai was studied and their feeding ecology discussed.

**Distribution, taxonomy, ecology, echolocation, Chiroptera, Arabia, Middle East, Palaearctic Region**

Although a part of the African state of Egypt, the area of Sinai represents the westernmost promontory of the Arabian Peninsula of Asia, creating a land bridge between the two continents. In its historic sense, the name Sinai denotes mainly the mountainous territory of the true peninsula between two northern gulfs of the Red Sea, the Gulf of Suez and the Gulf of Aqaba. In the modern geographical and political sense, the area of Sinai (about 61.000 km$^2$; Haim & Tchernov 1974) covers the Egyptian part of Arabian peninsula between the Isthmus of Suez or the Suez Canal, respectively, and the Gulf of Suez in the west and the southwestern borders of the Gaza Strip (Palestine) and Israel, and the Gulf of Aqaba in the east (Fig. 1). However, the topography and geomorphology of southwestern Israel and Sinai is continuous; the only difference is in the vegetation cover of the arid areas, due to different types of agricultural practices on both sides of the border (Danin 1988). While the northern portion of Sinai is covered mainly by rather flat or even lowland deserts and semi-deserts, its southern part features high rocky mountains reaching altitudes over 2000 m a. s. l. (with the highest point, Gebel Katarina, reaching 2642 m), thus forming the highest mountain range in Egypt. Geographically, these mountains are part of a continuous mountain belt from the Hijaz Range of Saudi Arabia to the Red Sea Mts of eastern Egypt, and the mountain ridges along the Rift Valley of the Holy Land.

The southern mountainous region of Sinai represents the most arid part of the peninsula, with annual precipitation of less than 25 mm, while the northern semi-desert areas along the Mediterranean coast receive precipitation of 50–100 mm *per annum* (Zohary 1973, Osborn & Helmy 1980). The vegetation in Sinai is primarily a mixture of Saharo-Arabian and Sudanian desert floral types, with components of Mediterranean flora along the northern coast and patches of Irano-Turanian steppe flora in the southern rocky mountains (Danin & Plitmann 1986).

Based on fauna, flora and vegetation distributions, Haim & Tchernov (1974: 205) and Werner (1988: 374) divided the territory of Sinai into three main biogeographical regions; (1) the large northern part of the peninsula to north of ca. 29° 30’ N as well as the central part of the southern triangular area belong to the Saharo-Arabian region; (2) the smaller area of the Irano-Turanian region lies in the centre of high mountains, at altitudes of above 1500 m a. s. l.; and (3) the ‘Sudanian penetration zone’ stretches in a broad belt along the coast of the Red Sea. Such division roughly corresponds with the partition of Sinai by Zohary (1973) done in accordance with the vegetation zones. Haim & Tchernov (1974) characterised these regions by their typical floral elements; (1) desert with *Anabasis articulata*, *Gymnocarpus decandrum* and *Zygophyllum dumosum*; (2) dwarf-shrub steppe of *Artemisia herba-alba*; and (3) sparse desert vegetation composed of tropical elements incl. *Acacia radiana*.

The mammalian fauna of Egypt has been studied since the Linnaean era, including Hasselquist’s (1757) description of a bat species from Lower Egypt that he named ‘*Vespertilio ægyptiacus*’ (unfortunately, of unknown assignation within modern taxonomy; see Benda et al. 2006). Many mammals, including some bats, were studied and described from Egypt in the late 1700s and early 1800s (Bruce 1790, Geoffroy Saint-Hilaire 1818, 1828, Cretzschmar 1826–1830, Ehrenberg 1828–1833, Audouin 1829, Rüppell 1829, 1842), most of them representing first records of those species for the African continent. Rüppell’s collection, published first by Cretzschmar (1826–1830) and later by Rüppell himself (Rüppell 1842), also indicate some records of mammals from Sinai, including at least one bat species. Hence, the first published bat record from Sinai is that of *Vespertilio leucomelas* (= *Barbastella leucomelas*), based on specimens collected by E. Rüppell in 1822 and/or 1826 (cf. Cretzschmar 1830, Rüppell 1829, 1842, see below). Until now, this record has represented the only evidence of this species from Egypt. Probably the second known bat record from Sinai is that of *Asellia tridens* made in El Tur by F. Hemprich and C. Ehrenberg in

1823, although it was only published one hundred years later (Stresemann 1954). Anderson & De Winton (in Anderson 1902) summarised the mammalian fauna of Egypt, including that from Nubia and Sinai. They reported three bat species from Sinai, *Nycteris thebaica*, *Asellia tridens* and *Plecotus auritus* (= *P. christii*), and mentioned other two species known from areas possibly denoting Sinai (Table 13); 'Arabia Petraea' and 'Suez and its neighbourhood'. In the next few decades few mammal sampling from Sinai appeared (e.g. Bonhote 1912, Flower 1932), but they did not mention any bat specimens.

The first systematic mammalogical research of Sinai was carried out by K. Wassif and H. Hoogstraal (both from Cairo) in 1940s and 1950s. Their surveys recorded 22 species of mammals

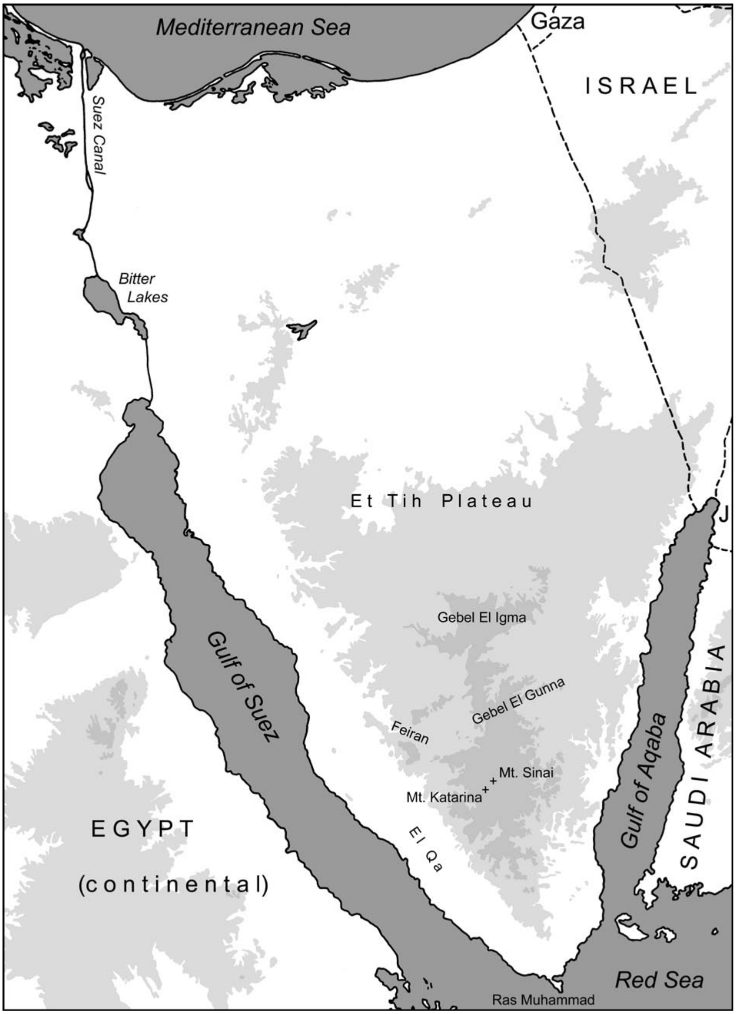



Fig. 1. General map of Sinai with main geographical features (pale shaded – area above 600 m a. s. l., dark shaded – area above 1200 m a. s. l.). J = Jordan.

including four bats, *Rhinolophus clivosus*, *R. hipposideros*, *Pipistrellus kuhlii* and *Otonycteris hemprichii* (Wassif 1953, Wassif & Hoogstraal 1954, Wassif et al. 1984). Since then, only a few occasional bat records were made in Sinai, mainly by Israeli collectors, that included the addition of one bat species to Sinaitic fauna, *Pipistrellus bodenheimeri* (= *Hypsugo ariel*) (Qumsiyeh 1985).

The first reviews of bats of the modern Egypt including Sinai were compiled by Sanborn & Hoogstraal (1955), Zein Ad Din & Hafiz (1959), and Hoogstraal (1962). The most complete summary of the knowledge of bat fauna of Egypt was written by Qumsiyeh (1985); he reported 22 bat species from the country (incl. rather uncertain taxa like *Pipistrellus deserti* and *Pipistrellus* [= *Hypsugo*] *bodenheimeri*) and nine from Sinai. Qumsiyeh's (1985) review is the most up-to-date and reliable summary of bat records of Egypt; the Sinaitic data compiled by him were corroborated by Harrison & Bates (1991). The only more recent paper concerning bats (and other mammals) of Egypt reported just 13 bat species from the country and only four from Sinai (Wassif 1995).

Although the terrestrial mammal fauna of Sinai had been studied in recent years, the number of bat records had not increased. Saleh & Basuony (1998) reported records of 21 species of mammals from the peninsula (including two species new for the fauna of Egypt), but none were of bats. The field guide to Egyptian mammals compiled by Hoath (2003) repeated the summary of bat records previously reviewed by Qumsiyeh (1985).

Since 2005 the British research and expedition company Operation Wallacea has formed a partnership with BioMap Egypt, the biodiversity recording centre for Egypt (run by the Egyptian Environmental Affairs Agency) and with the British Council in Cairo. The aim of this cooperation project is to increase the knowledge of the desert flora and fauna of Sinaitic peninsula with the surveys run by scientists accompanied by Egyptian and foreign students. The project has significantly increased the knowledge of the distribution and abundance of many plants (e.g. Guenther 2005, Zalat & Gilbert 2006), birds, reptiles and butterflies (Meakin et al. 2005) and has also revealed some new data on bats (Dietz 2005a, Dietz & Maltby 2006).

Here, we present results of bat research conducted in 2005–2007 in southern Sinai in the scope of the activities of Operation Wallacea as well as complete review of data available from that peninsula along with some taxonomic, ecological and echolocation observations.

## MATERIAL AND METHODS

### Geographical terms used

Egyptian (Arabic) geographical names are mentioned according to Osborn & Helmy (1980) and Qumsiyeh (1985), respectively, or were adopted to their mode used. The names quoted from literature were not changed in the record lists. Geographical names on a regional scale are used in the sense by Benda et al. (2006: 9) with exceptions of the term Palestine (previously used for the present territories of Israel and the Palestinian Territories to simplify such a long expression and to avoid confusion in historic terms; it is not used here as we do not feel it is necessary to simplify the name to one word), and the term Syria, which is used in its contemporary geographical extent (i.e. the 'Syria *sensu stricto*' by Benda et al. 2006). The term Holy Land covers the areas of Israel, Palestinian Territories and Jordan (*sensu* Qumsiyeh 1996). Under the Cairo region we consider the populated agglomerations of the Cairo and Giza Governorates and their broader environs.

### Records

The lists of records (arranged in alphabetical and/or chronological orders) include, for each item, the following information: name of the locality (each record is primarily listed by a name of nearest settlement or notable physical feature) [in brackets, number of locality as indicated in the map], and/or description of record site, date, number of recorded bats with indication of their sex, age and physiological condition (for details see Abbreviations below). All the original records come from the Governorate of Janub Sina (South Sinai).

### Morphological analysis

For morphological comparisons, we used museum specimens which were examined as described in previous studies (see Benda et al. 2004, 2006). Specimens were measured in a standard way with the use of mechanical or optical callipers.

Horizontal dental dimensions were taken on cingulum margins, tooth crown heights from cingulum to the cusp tip. Bacula were extracted in 4% solution of NaOH and coloured with alizarin red. The examined museum material is mentioned in the respective species chapters, the list of comparative material is given in Appendix II. For the evaluated external and cranial measurements see Abbreviations. Statistical analyses were performed using the Statistica 6.0 software. Other methodological details or aspects are described in the chapters concerning taxonomic notes on the respective species.

**Genetic analysis**

For the genetic part of the study applied on several species, we used the analysis of mitochondrial DNA. Genetic material was obtained from pectoral muscles or wing punches preserved in alcohol. Partial sequences of the mitochondrial gene for cytochrome *b* (609 bp or 522 bp, respectively) were obtained according to the protocol described by Benda & Vallo (2008). For comparisons, sequences from previous studies stored in GenBank were used, as described in the respective species chapters. Genetic distances and phylogenetic reconstructions were obtained using PAUP 4.0b10 software.

**Diet analysis**

We collected a set of faecal pellets within our field studies for further examination. From museum specimens the digestive tract content was analysed. Pellets were disassembled in a Petri dish filled with water under a binocular microscope. Particular pieces of prey were identified to the order or family level and the percentage volume of prey categories was estimated for each pellet. The total volume of each diet item in a sample was counted as an average. Digestive tracts were dissected in a Petri dish filled with water and percentage of volume of particular prey categories was estimated for each one. The number of analysed pellets or digestive tracts regarding particular species is mentioned in the text of corresponding chapter and in the legend of Fig. 16.

**Field recordings and sound analysis**

Acoustic recordings were made using either a portable ultrasound detector D-240x (Pettersson Elektronik, Inc.) set on time-expansion mode connected to Sony MZ-RH10 recorder or a real time recording device developped at the University of Tuebingen (PCtape, © University of Tuebingen) connected to a laptop-computer and linked with an anaylsis software (Selena, © University of Tuebingen). In most cases, all analysed bat calls were recorded in free flight under natural conditions. One call sequence of *Rhinolophus clivosus* was recorded having the bat in hand and the microphone held in a distance of 1 m to record the resting frequency (unchanged from Doppler-shift compensation). All recorded calls of *Plecotus christii* were recorded either handheld or during hand release.

The recordings were analysed with the software BatSound Pro (Pettersson Electronik AB, Uppsala, Sweden). A sampling frequency of 44 100 samples/s, with 16 bits/sample and expansion factor of 10 were used (36 call sequences). Alternatively, we used a sampling frequency of 48 000 samples/s and expansion factor 8 (20 call sequences). A 512 pt. FFT with Hamming window was used for analyses. Obtained frequency and time resolution for spectrograms and power spectra were 1120 Hz (0.23 ms) and 975 Hz (0.27 ms), respectively. Oscilograms, power spectra and spectrograms were evaluated. For each echolocation call, the following parameters of the call were measured: pulse duration (PDUR), start frequency (SF), end frequency (EF, both SF and EF at –30 dB below the peak power spectral intensity), frequency of maximum energy (FMAXE) and inter-pulse interval (IPI, the time between two consecutive calls). Only search phase calls were measured.

In total, we analysed 56 call sequences (512 calls) of 12 bat species. Most figures of spectrograms of echolocation sequences within the text below serve as an illustration of real field conditions, and, hence, they posses a real time of particular recording on the time axes.

## ABBREVIATIONS

**Collection acronyms**

AUB – American University Beirut, Lebanon; BMNH – Natural History Museum, London, United Kingdom; CDIS – Christian Dietz private collection, Horb, Germany; CUP – Department of Zoology, Charles University, Prague, Czech Republic; EBD – Doñana Biological Station, Seville, Spain; FMNH – Field Museum Natural History, Chicago, U. S. A; HUJ – Hebrew University, Jerusalem, Israel; IOZ-BRG – Bat Research Group, Institute of Zoology, Chinese Academy of Sciences, Beijing, China; IVB – Institute of Vertebrate Biology, Academy of Sciences of the Czech Republic, Brno, Czech Republic; MHNG – Natural History Museum, Geneva, Switzerland; NMP – National Museum (Natural History), Prague, Czech Republic; SMF – Senckenberg Museum and Research Institute, Frankfurt am Mein, Germany; SMZ – South Moravian Museum in Znojmo, Czech Republic; SNM – Slovak National Museum, Bratislava, Slovakia; TAU – Tel Aviv University, Tel Aviv, Israel; ZFMK – Zoological Institute and Museum Alexander Koenig, Bonn, Germany; ZIN – Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia; ZMB – Zoological Museum, Humboldt University, Berlin, Germany; ZMM – Zemplín Museum, Michalovce, Slovakia.

**Measurements**

External measurements. LC = head and body length; LCd = tail length; LAt = forearm length; LPol = thumb length (without claw); LA = auricle length; LTr = tragus length; LaFE = horseshoe width; G = body weight.

Cranial measurements. LCr = greatest length of skull (incl. the praemaxilla in *Rhinolophus*); LCb = condylobasal length; LCc = condylocanine length; LaZ = zygomatic width; LaI = width of interorbital constriction; LaP = width of postorbital constriction; LaInf = infraorbital width; LaN = neurocranium width; LaM = mastoidal width; AN = neurocranium height; ACr = skull height; LBT = largest horizontal length of tympanic bulla; CC = rostral width between upper canines (incl.); $P^4P^4$ = rostral width between largest upper premolars (incl.); $M^2M^2$ = rostral width between second upper molars (incl.); $M^3M^3$ = rostral width between third upper molars (incl.); $I^1M^3$ = length of upper tooth-row between $I^1$ and $M^3$ (incl.); $CM^2$ = length of upper tooth-row between C and $M^2$ (incl.); $CM^3$ = length of upper tooth-row between C and $M^3$ (incl.); $M^1M^3$ = length of upper tooth-row between $M^1$ and $M^3$ (incl.); $CP^4$ = length of upper tooth-row between C and $P^4$ (incl.); LMd = condylar length of mandible; ACo = height of coronoid process; $IM_3$ = length of lower tooth-row between $I_1$ and $M_3$ (incl.); $CM_3$ = length of lower tooth-row between C and $M_3$ (incl.); $M_1M_3$ = length of lower tooth-row between $M_1$ and $M_3$ (incl.); $CP_4$ = length of lower tooth-row between C and $P_4$ (incl.).

Dental measurements (taken from *Plecotus* only). $LI^1$ = mesiodistal length of first upper incisor; $LaI^1$ = palatolabial width of first upper incisor; $AI^1$ = height of the first upper incisor crown (taken to the higher cusp); LCn = mesiodistal length of upper canine; LaCn = palatolabial width of upper canine; ACn = height of upper canine crown; $LP^3$ = mesiodistal length of first upper premolar ($P^3$); $LaP^3$ = palatolabial width of first upper premolar ($P^3$); $AP^3$ = height of the first upper premolar ($P^3$) crown; $LM^1$ = mesiodistal length of first upper molar ($M^1$); $LaM^1$ = palatolabial width of first upper molar ($M^1$); $LM^3$ = mesiodistal length of third upper molar ($M^3$); $LaM^3$ = palatolabial width of third upper molar ($M^3$); ACin = height of the mesiopalatal cingular cusp of the second upper premolar ($P^4$).

**Other abbreviations**

a = adult; A = alcoholic preparation; B = stuffed skin (balg); coll. = collected; det. = detected by a bat-detector; f = female; G = pregnant; ind. = individual of sex indeterminable; j = juvenile; K = dried skin ('carpet'); m = male; M = mean; max., min. = dimension range margins; net. = netted; obs. = observed; rec. = a call recording collected; s = subadult; S = skull; SD = standard deviation, Sk = skeleton.

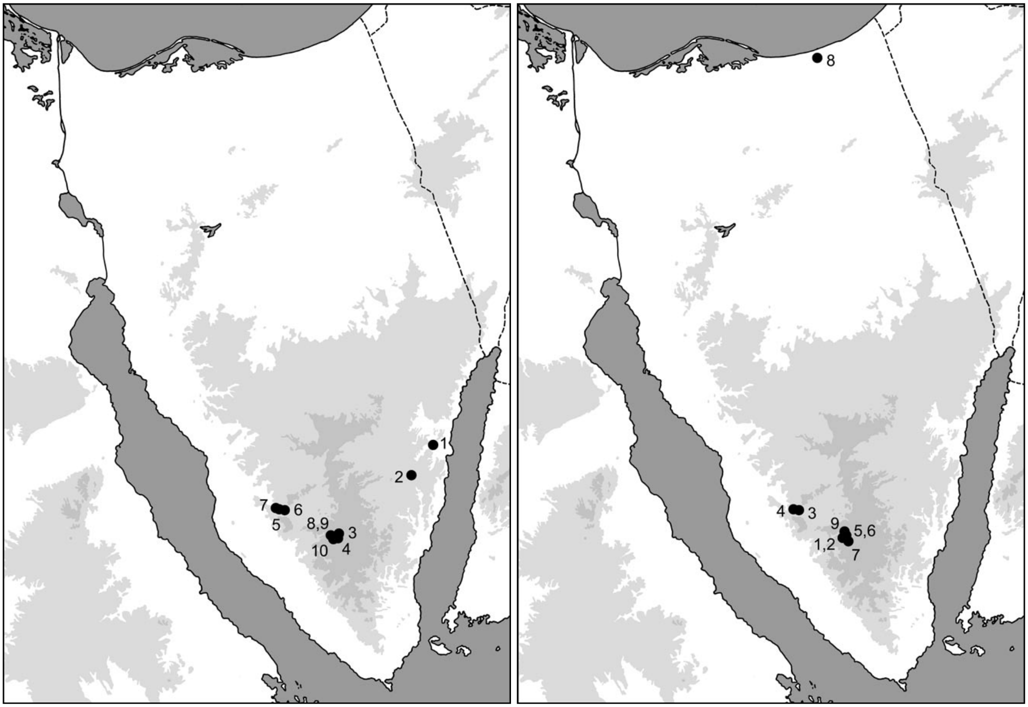
## LIST OF SPECIES

## *Rousettus aegyptiacus* (Geoffroy, 1810)

Records. **Original data**: Ain El Furtaga [1], above a pool in a canyon above the oasis (Fig. 4), 16 September 2005: net. 5 ma, 2 faG, 2 fj (coll. 1 ma, 1 fa; NMP 90527, 90528 [S+A]), 17 September 2005: net. 4 ma, 2 faG, 1 fj; – Ain Hudra [2], oasis (Fig. 5), 4 August 2005: net. 5 fa, obs. 5 inds.; 14 September 2005: net. 1 ma (NMP 90520 [S+A]); – El Milga [3], village, trees along the road, 9 August 2005: det. & rec. 1 ind.; – El Milga [4], between Wadi El Arbaein (Moses' Rock) and the Fox Camp, 1 July 2007: det. & rec. min. 1 ind.; – Feiran [5], El Braga Garden, 10 August 2005: net. 17 ma, 5 ms, 8 fa, 6 fs, plus other 30 inds. (released without sexing or ageing), 11 August 2005: obs. 3 inds., 12 August 2005: obs. 3–5 inds.; – Feiran [6], a garden in eastern edge of the oasis, 10 September 2005: net. 7 ma, 1 mj, 14 fa (8 faG), 11 fj/s (coll. 5 ma, 1 mj, 6 fa, 5 fj/s; NMP 90501, 90510 [Sk], 90502–90508, 90511 [S+A], 90509, 90512–90517 [A]); – Feiran [7], above a pool in western edge of the oasis, 8 September 2005: net. 1 fj (NMP 90492 [A]); – Wadi Itfah [8], Hamid's Garden, 3 August 2006: net. 3 fj; – Wadi Klar [9], Hamid's Garden, 1 August 2006: net. 3 fj; – Wadi Shagg [10], Oder's Garden, 27 July 2006: net. 1 faG.

Comments. *Rousettus aegyptiacus* is here reported from Sinai for the first time; ten sites of its occurrence were recorded in four areas (Fig. 2). The fruit bat was found both in the oases relatively close to the sea shore at altitudes below 800 m a. s. l. (Ain El Furtaga, Ain Hudra, Feiran; see Figs. 4, 5) and sites in the continental mountainous inner parts of the peninsula, lying above 1400 m a. s. l. (El Milga, Wadi Itfah, Wadi Klar, Wadi Shagg; Figs. 6, 64). However, all records come from southern Sinai only.

Although *R. aegyptiacus* has never before been reported from Sinai (Qumsiyeh 1985, Harrison & Bates 1991), it is a bat known to be common in some parts of the neighbouring regions. In Egypt, it is common in the Nile Delta and the Cairo region and distributed along the Nile Valley from Cairo up to Aswan (see the reviews by Kock 1969 and Qumsiyeh 1985) and even Abu Simbel (Bergmans 1994); to the west, it reaches Wadi El Natrun (Hoogstraal 1962), Burg El Arab (Wassif 1995) and Mersa Matruh (Flower 1932). The latter site represents the westernmost point of *R. aegyptiacus*




Figs. 2, 3. 2 (left) – records of *Rousettus aegyptiacus* (Geoffroy, 1810) in Sinai. 3 (right) – records of *Rhinolophus clivosus* Cretzschmar, 1830 in Sinai.

occurrence in North Africa. Although Qumsiyeh (1985) found it to be an inhabitant of the most cultivated areas of Egypt, recently a colony of this bat was discovered in the Dakha Oasis of the Libyan Desert (Churcher 1991, cf. Benda et al. 2006). In northeastern Egypt, *R. aegyptiacus* was reported by Flower (1932) from two sites adjacent to the Isthmus of Suez; Ismailia and Port Said. Until now, these old records (made in 1910 and 1915) have represented the easternmost sites of its occurrence in northern Egypt (Kock 1969, Qumsiyeh 1985).

Whilst Qumsiyeh (1985), Harrison & Bates (1991) and Bergmans (1994) reported *R. aegyptiacus* to occur in the Holy Land to the north of the southern margin of the Dead Sea only, i.e. in the relatively humid Mediterranean areas of the region, Mendelssohn & Yom-Tov (1999) and Zelenova & Yosef (2003) added several records from the Arava Valley of Israel. This distribution in arid areas connects the newly evidenced occurrence in the oases of Sinai, rather than those in the cultivated areas of the northeastern Nile Delta (cf. Flower 1932).

The occurrence of *R. aegyptiacus* in Sinai and adjacent Negev Desert areas including the Arava/Araba Valley seems to be a recent extension of the species range following recent human settlements in these arid zones. The fruit bat could be regarded a relatively conspicuous animal, which, moreover, represents a significant pest on fruit crops, as noted by local farmers. However, no evidence of its occurrence had been published prior to 1999 (an exception is an occurrence in the Wadi Fidan, an area adjacent to the northern Wadi Araba in Jordan; Amr & Disi 1988). Zelenova & Yosef (2003), who netted migratory birds into nets installed around the town of Eilat (S Israel)

Fig. 4. Canyon above the oasis of Ain El Furtaga, the netting site of *Rousettus aegyptiacus* (Geoffroy, 1810) and *Tadarida teniotis* (Rafinesque, 1814); the calls of *Hypsugo ariel* (Thomas, 1904) and *Barbastella leucomelas* (Cretzschmar, 1830) were also detected there (photo by R. Lučan).

in the period 1996–2002, caught the first individuals of *R. aegyptiacus* in spring 2002 (in total 32 bats from March to May – including three females with young); they assessed these findings as a record of quite recent invasion of *R. aegyptiacus* into the semi-arid areas of southern Israel. A similar situation also seems to be evident in Sinai; according to the observations by the local Bedouins, fruit bats became regular visitors in lower numbers to the gardens of the Wadi Gebal since 2000, irregular visitors (also in groups of up to 10 individuals) for many years in the oasis of Ain Hudra and rare and irregular visitors to the monastery gardens of the Wadi El Arbaein.

Similarly, as was reported for the population of southernmost Israel (Zelenova & Yosef 2003), in Sinai *R. aegyptiacus* has also established breeding populations. In summer 2005, we netted 16 individuals in the oasis of Ain El Furtaga over two nights; three of the captured bats were juveniles only several months old (i.e. born in the same year) and four females were pregnant (the crown-rump length of one examined foetus was 43.3 mm); in the Feiran Oasis, we netted around one hundred individuals in summer 2005 from which at least one male and one female were juveniles; from 14 adult females netted there on 10 September 2005, at least eight were pregnant (the crown-rump length of four examined foetuses varied from 37.2 to 45.0 mm, mean 40.8 mm), one carried a young some days/weeks old (Fig. 7). The evidence of juveniles as well as pregnant

Table 1. Structure and biometric characteristics of samples of *Rousettus aegyptiacus* (Geoffroy, 1810) captured in southern Sinai in August–September 2005 and in July–August 2006. For particular data see App. V, for abbreviations see p. 6

| | | females | | | | | males | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | n | **M** | min | max | SD | n | **M** | min | max | SD |
| adults | LAt [mm] | 18 | **90.78** | 86.8 | 95.3 | 2.393 | 21 | **92.91** | 89.8 | 97.8 | 2.038 |
| non-pregnant | G [g] | 4 | **104.80** | 91.2 | 117.0 | 10.759 | 21 | **121.15** | 92.2 | 142.0 | 12.742 |
| pregnant | G [g] | 13 | **122.85** | 103.0 | 135.0 | 8.474 | – | – | – | – | – |
| juveniles | LAt [mm] | 18 | **83.17** | 73.8 | 92.6 | 4.970 | 2 | **85.85** | 84.0 | 87.7 | 2.616 |
| | G [g] | 14 | **78.12** | 55.8 | 104.0 | 16.343 | 2 | **87.50** | 61.0 | 114.0 | 37.477 |

females in several parts of Sinai (Table 1) clearly shows reproduction and thus a consolidation of stable and prospering populations. Moreover, the Sinaitic and south Israeli individuals differ markedly in body size from both Egyptian and Levantine fruit bats (see Taxonomy below) and thus, they cannot be considered seasonal vagrants from the fertile regions of central Israel or the Nile Delta. Although we did not find any shelters of a colony, from the abundance of foraging fruit

Fig. 5. Ain Hudra. In this small, apparently isolated but fertile oasis, a relatively rich community of bats was recorded. Individuals of *Rousettus aegyptiacus* (Geoffroy, 1810), *Hypsugo ariel* (Thomas, 1904), *Barbastella leucomelas* (Cretzschmar, 1830), and *Plecotus christii* Gray, 1838 were netted and calls of *Rhinolophus* cf. *mehelyi* Matschie, 1901, *Eptesicus bottae* (Peters, 1869), and *Tadarida teniotis* (Rafinesque, 1814) were recorded (photo by R. Lučan).

bats in the Feiran Oasis it is likely that in some of the caves or abandoned mines surrounding the oasis (cf. Wassif & Hoogstraal 1954) a larger colony is established. (In August 2005, locals of the Feiran Oasis told us about a roost of the fruit bats in a big cave in a small wadi but were afraid to take us there as the cave was said to be used as a storage site for drug-smugglers.)

TAXONOMY. Ferguson (2002: 46) mentioned on the southern Israeli population: "In Eilat, it [i.e. *R. aegyptiacus*] probably represents the Arabian subspecies *R. aegyptiacus arabicus* [...], which is usually smaller, with a more pointed ear tip." Although Ferguson (2002) did not support this statement by any comparison or analysis of data, this observation corresponds well with the findings by Zelenova & Yosef (2003). They mentioned average forearm length (LAt) in captured males 90.3 mm (range 83.8–93.6; n=13), in females 87.9 mm (80.2–97.3; n=19) (however, Zelenova & Yosef 2003 did not note if they examined adult bats only). These values differ markedly from those of the fruit bats from (Mediterranean) Israel examined by Mendelssohn & Yom-Tov (1999), who reported mean LAt of males 92 mm (88–89; n=12) and females 93 mm (88–96; n=12). Qumsiyeh (1985) mentioned for Egyptian (Nile Valley) populations: males, 94.9 mm (90–97; n=12) and females, 91.0 mm (84–94; n=6). For LAt values of the Sinaitic fruit bats see Tables 1, 2.

Both Levantine (i.e. from Israel, W Jordan, Lebanon, W Syria, Cyprus, and S Turkey) and continental Egyptian populations of *R. aegyptiacus* have been traditionally assigned to the nominotypical subspecies, based on the geographical proximity of its type locality (the Great Pyramid, Giza, Egypt) and large body size (see the reviews by Eisentraut 1959, Bergmans 1994, and/or Benda et al. 2006). Relatively small individuals occurring in S and SE Arabia, S Iran and S Pakistan have been assigned to *R. a. arabicus* Anderson, 1902 (t.t. Aden, Yemen); other valid subspecies live exclusively in the Afro-tropics (Eisentraut 1959, Bergmans 1994, Juste &

Fig. 6. Northeastern edge of the oasis of El Milga, Er Raba valley at ca. 1540 m a. s. l. In various parts of this oasis, six bat species were recorded (photo by R. Lučan).

Table 2. Basic biometric data [in mm] on examined Sinaitic and comparative samples of *Rousettus aegyptiacus* (Geoffroy, 1810). For abbreviations see p. 6

| | Sinai | | | | | Lower Egypt | | | | | Levant | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n | **M** | min | max | SD |
| LAt | 39 | **91.93** | 86.8 | 97.8 | 2.429 | 23 | **92.15** | 86.6 | 96.2 | 2.974 | 14 | **94.33** | 90.0 | 98.1 | 2.267 |
| LCr | 13 | **41.27** | 38.91 | 43.66 | 1.329 | 30 | **43.93** | 41.47 | 46.08 | 1.220 | 17 | **43.46** | 40.68 | 45.19 | 1.168 |
| LCb | 13 | **39.55** | 37.53 | 41.47 | 1.173 | 29 | **42.36** | 39.64 | 44.47 | 1.225 | 17 | **41.79** | 39.24 | 43.57 | 1.106 |
| LaZ | 13 | **24.95** | 23.48 | 27.33 | 0.920 | 30 | **26.60** | 24.23 | 29.27 | 1.213 | 17 | **26.93** | 24.63 | 29.26 | 1.099 |
| LaI | 13 | **7.87** | 7.19 | 8.59 | 0.403 | 14 | **8.39** | 7.73 | 9.23 | 0.440 | 16 | **8.40** | 7.93 | 9.08 | 0.305 |
| LaP | 13 | **7.39** | 6.61 | 7.94 | 0.360 | 14 | **8.14** | 7.28 | 8.87 | 0.499 | 16 | **7.78** | 7.22 | 8.76 | 0.424 |
| LaN | 13 | **16.47** | 16.02 | 17.91 | 0.530 | 30 | **17.40** | 16.82 | 18.12 | 0.390 | 17 | **17.31** | 16.83 | 17.93 | 0.339 |
| AN | 13 | **12.53** | 11.56 | 13.24 | 0.453 | 30 | **13.23** | 12.31 | 14.28 | 0.569 | 17 | **13.16** | 11.64 | 13.93 | 0.570 |
| CC | 13 | **8.25** | 7.82 | 8.84 | 0.296 | 30 | **8.77** | 8.21 | 9.64 | 0.433 | 16 | **8.92** | 8.43 | 9.68 | 0.408 |
| $M^2M^2$ | 13 | **12.38** | 11.84 | 13.30 | 0.425 | 30 | **13.36** | 12.63 | 14.08 | 0.427 | 16 | **12.91** | 12.29 | 13.50 | 0.390 |
| $CM^2$ | 13 | **16.02** | 14.91 | 16.99 | 0.583 | 30 | **16.77** | 15.61 | 18.04 | 0.559 | 17 | **16.59** | 15.56 | 17.62 | 0.566 |
| LMd | 13 | **32.12** | 30.08 | 33.82 | 1.048 | 30 | **34.21** | 31.97 | 36.02 | 0.981 | 17 | **33.82** | 31.98 | 35.19 | 0.929 |
| ACo | 13 | **14.89** | 14.18 | 16.17 | 0.614 | 30 | **15.84** | 14.54 | 17.27 | 0.767 | 16 | **15.03** | 13.27 | 16.46 | 0.913 |
| $CM_3$ | 13 | **17.29** | 16.08 | 18.44 | 0.692 | 30 | **18.19** | 17.08 | 19.57 | 0.567 | 16 | **18.20** | 17.56 | 19.20 | 0.486 |
| | Iran | | | | | Yemen | | | | | Ethiopia | | | | |
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n | **M** | min | max | SD |
| LAt | 19 | **88.42** | 81.5 | 92.9 | 2.973 | 25 | **90.74** | 85.9 | 94.8 | 2.324 | 8 | **95.64** | 92.0 | 100.7 | 2.907 |
| LCr | 14 | **39.72** | 38.00 | 41.62 | 1.135 | 21 | **40.78** | 38.48 | 42.74 | 1.101 | 7 | **42.24** | 41.41 | 42.88 | 0.540 |
| LCb | 14 | **38.16** | 36.14 | 40.07 | 1.219 | 21 | **39.12** | 36.64 | 40.88 | 1.129 | 7 | **40.59** | 39.64 | 41.45 | 0.649 |
| LaZ | 14 | **24.49** | 23.42 | 26.42 | 0.932 | 21 | **24.57** | 23.13 | 26.57 | 0.936 | 7 | **25.60** | 24.22 | 26.87 | 1.000 |
| LaI | 14 | **7.71** | 7.37 | 8.37 | 0.275 | 21 | **7.81** | 7.06 | 8.65 | 0.384 | 7 | **7.96** | 7.61 | 8.37 | 0.258 |
| LaP | 14 | **7.76** | 6.97 | 8.98 | 0.505 | 21 | **7.37** | 6.63 | 8.32 | 0.466 | 7 | **8.05** | 7.58 | 8.78 | 0.385 |
| LaN | 14 | **16.41** | 15.74 | 17.19 | 0.455 | 21 | **16.34** | 15.58 | 17.02 | 0.451 | 7 | **17.02** | 16.52 | 17.96 | 0.459 |
| AN | 14 | **12.21** | 11.61 | 13.23 | 0.438 | 21 | **12.39** | 11.90 | 13.08 | 0.348 | 7 | **12.69** | 11.92 | 13.13 | 0.476 |
| CC | 14 | **8.12** | 7.68 | 8.93 | 0.376 | 21 | **8.11** | 7.58 | 8.82 | 0.286 | 7 | **8.58** | 8.08 | 9.02 | 0.301 |
| $M^2M^2$ | 14 | **12.04** | 11.34 | 12.69 | 0.418 | 20 | **12.14** | 11.65 | 12.74 | 0.273 | 6 | **12.73** | 12.47 | 13.14 | 0.263 |
| $CM^2$ | 14 | **15.39** | 14.30 | 16.21 | 0.627 | 21 | **15.81** | 14.92 | 16.70 | 0.457 | 7 | **16.43** | 15.92 | 17.06 | 0.436 |
| LMd | 14 | **31.13** | 29.68 | 32.89 | 1.032 | 21 | **31.63** | 29.63 | 33.37 | 0.888 | 7 | **33.17** | 32.40 | 34.11 | 0.661 |
| ACo | 14 | **13.47** | 12.38 | 14.36 | 0.645 | 21 | **14.24** | 12.88 | 15.37 | 0.700 | 7 | **13.17** | 12.45 | 14.02 | 0.688 |
| $CM_3$ | 14 | **16.76** | 15.75 | 17.60 | 0.618 | 21 | **17.26** | 16.54 | 18.23 | 0.493 | 7 | **17.84** | 17.35 | 18.51 | 0.418 |

Ibañez 1993, Kwiecinski & Griffiths 1999, Simmons 2005). Bergmans (1994) gave for *R. a. aegyptiacus* these LAt ranges (he did not mention mean values): males 87.1–101.4 mm (n=37), females 86.0–100.3 mm (n=22); and for *R. a. arabicus*: males 85.7–94.4 mm (n=25), females 79.9–91.2 mm (n=10). The LAt values of the Sinaitic and south Israeli samples conform rather to values of *R. a. arabicus* than to *R. a. aegyptiacus*, or create a transition between the values of both forms, and certainly do not correspond to LAt values of the nominotypical subspecies. It is surprising from a geographical point of view.

A comparison of skull dimensions of the Sinaitic *R. aegyptiacus* with those from neighbouring areas (NE Africa, Levant, S Arabia, Iran) clearly shows the Sinaitic samples to conform almost completely to the samples from Yemen and Iran (*R. a. arabicus*) – only two Sinaitic bats exceeded the range of these sets (Table 2, Fig. 8) – and only partly overlap with those from the Levant and Lower Egypt (*R. a. aegyptiacus*) or Ethiopia (*R. a. leachii* (Smith, 1829)). This comparison confirmed the observation by the above authors (Ferguson 2002, Zelenova & Yosef 2003) from southern Israel. According to the traditional view (cf. Eisentraut 1959, Bergmans 1994), the population of *R. aegyptiacus* from Sinai should be classified as *R. a. arabicus*, a form primarily described as a separate species and for a long time treated in that way (Anderson 1902, Andersen 1907, 1912, Ellerman & Morrison-Scott 1951, Harrison 1956).

The simple genetic comparison (based on complete sequences of the mitochondrial gene for cytochrome *b*, see Benda et al. 2007: 80, Table 2) of several Middle Eastern samples of *R. aegyptiacus* (from Sinai, Syria, Lebanon, Iran, and Yemen), showed the Sinaitic sample to be a member of a homogenous clade of nearly identical haplotypes which genetic distances vary within 0.1–0.4% only. This result completely disproves the supposition of two phylogenetic units within populations of *R. aegyptiacus* in the Middle East and thus the recognition of more than one subspecies there (contra Eisentraut 1959, Harrison 1964, Hayman & Hill 1971, Nader 1975, 1990, Corbet 1978, DeBlase 1980, Harrison & Bates 1991, Corbet & Hill 1992, Bergmans 1994,

Fig. 7. A female of *Rousettus aegyptiacus* (Geoffroy, 1810) carrying a juvenile, netted in the oasis of Feiran on 9 September 2005 (photo by R. Lučan).

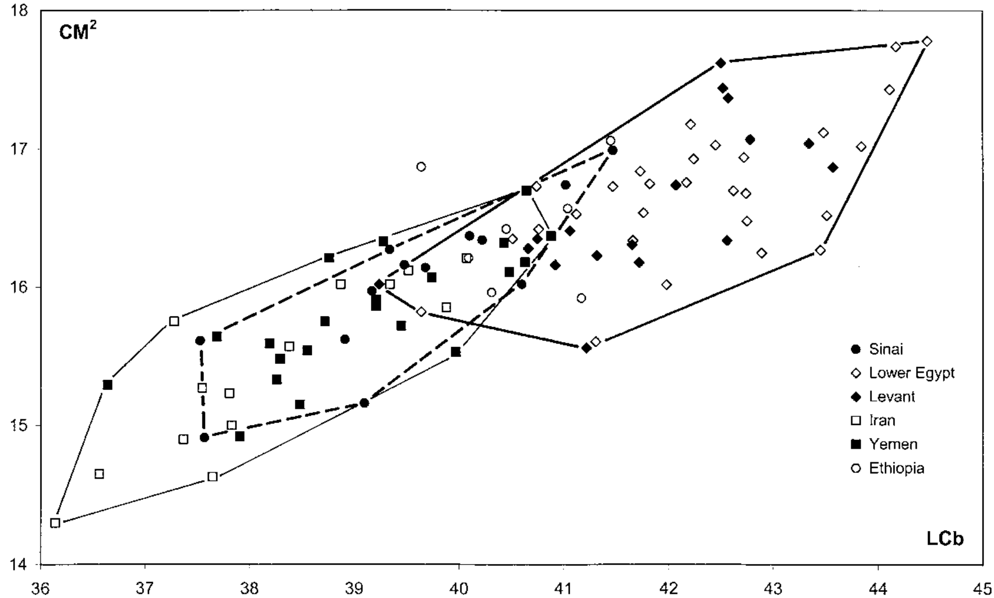



Fig. 8. Bivariate plot of examined Sinaitic and comparative samples of *Rousettus aegyptiacus* (Geoffroy, 1810): condylobasal length of skull (LCb) against the length of upper tooth-row ($CM^2$). Explanations: bold-lined polygon = samples from Lower Egypt and the Levant (n=46), i.e. of *R. aegyptiacus aegyptiacus* (Geoffroy, 1810); thin-lined polygon = samples from the southern parts of the Middle East (Iran, Yemen; n=35), i.e. nominally of *R. aegyptiacus arabicus* Anderson, 1902; dashed-lined polygon = samples from Sinai (n=13).

Koopman 1994, Bates & Harrison 1997, Al-Jumaily 1998, Kwiecinski & Griffiths 1999, Horáček et al. 2000, Snowden et al. 2000, Ferguson 2002, Simmons 2005, etc.). However, the genetic distances among the Middle Eastern populations and Egyptian or other African ones remain to be shown. The distance to bats of the Lower Egypt could play a key role to understanding the taxonomic position of the populations of the Middle East, since Giza (Lower Egypt) is the type locality of the nominotypical form.

Nevertheless, the differences in body dimensions found within a set of the genetically very close populations of *R. aegyptiacus* in the Middle East (Table 2) are the most extensive within the whole species rank (with an exception of the isolated forms from islands of the Gulf of Guinea), see Bergmans (1994) and Juste & Ibañez (1993). This enormous phenotypic plasticity contrasting with genetic homogeneity is, however, in accordance with records in some other bats, occurring both in the Mediterranean and desert habitats, at least of the genera *Rhinopoma*, *Asellia*, and *Pipistrellus* (Kock 1969, Hulva et al. 2007, Benda unpubl. data), as well as other desert-dwelling mammals (e.g. hare, *Lepus capensis* Linnaeus, 1758; Mendelssohn & Yom-Tov 1999). Populations from rather drier habitats exhibit smaller body dimensions than those from more humid conditions and such size changes seem to appear quite rapidly. Southern Sinai, from where the examined *R. aegyptiacus* samples come, belongs to the area of the lowest precipitation rate of Egypt (<25 mm per year), while the regions of common occurrence of fruit bats in Egypt lie in the area with annual precipitations of 25–200 mm and in the Levant even more, reaching 200–1000 mm (Osborn & Helmy 1980).

With regard to the extremely low genetic differences between the Sinaitic populations of *R. aegyptiacus* and the allopatric populations neighbouring them in the Middle East, the well pronounced differences among them in biometric characters (see above) suggest that the rearrangements in body size could have been attained in the course of just a few generations. The question is whether they are just a result of limited food supply in postweaning period or are of a certain adaptive value.

### *Rhinopoma cystops* Thomas, 1903

Record. **Original data**: Feiran, El Braga Garden, 12 August 2005: det., rec. & obs. 1 ind.

Comments. We regard *Rhinopoma cystops* a species separate from the Asian *R. hardwickii* Gray, 1831, in accordance with the results of genetic analysis by Hulva et al. (2007). *R. cystops* is here reported from Sinai for the first time, albeit the species identification seems not well supported due to a single recording (Fig. 9). However, although quality of recording is not well comparable to our own reference recordings from Wadi Digla at Cairo and/or from Israel, the studied parameters of the recorded call from the Feiran Oasis conform with those described by Simmons et al. (1984) (see Echolocation below) and the identification thus appears rather reliable.

Although neither *R. cystops* nor *R. microphyllum* (Brünnich, 1782) have been reported to occur in Sinai (Qumsiyeh 1985, Harrison & Bates 1991), both species could well be expected there (see the maps by Qumsiyeh & Knox Jones 1986, Schlitter & Qumsiyeh 1996, and/or Van Cakenberghe & De Vree 1994). Since representatives of *Rhinopoma* are distributed both in continental Egypt and in the Holy Land (Qumsiyeh 1985, 1996) and the arid rocky habitats typically inhabited by

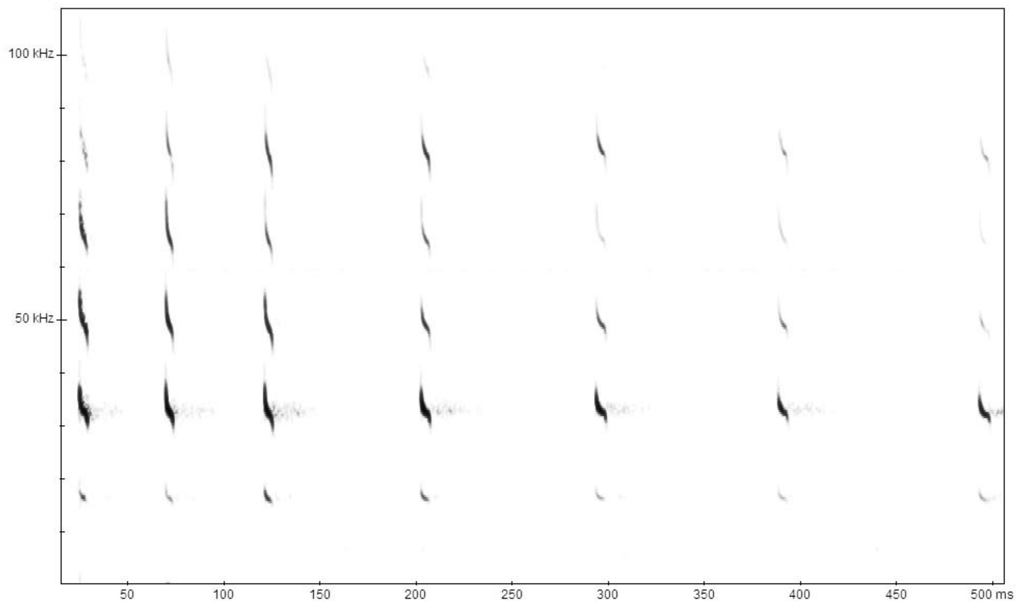



Fig. 9. Spectrogram of echolocation calls of *Rhinopoma cystops* Thomas, 1903. An individual foraging in the El Braga Garden, Feiran.

Table 3. Descriptive parameters of echolocation calls of 11 bat species from Sinai. Explanation: n – number of individual calls analysed (in parentheses number of call sequences from which calls were obtained); SF – start frequency; FMAXE – frequency with maximum energy (peak frequency); EF – end frequency; PDUR – pulse duration; IPI – inter-pulse interval; bold upper lines – mean±SD, lower lines – range

| species | n | SF | FMAXE | EF | PDUR | IPI |
|---|---|---|---|---|---|---|
| *Rhinopoma cystops* | 9 (1) | **37.6±0.9** | **33.2±0.5** | **30.2±0.6** | **6.3±0.4** | **80.6±27.6** |
| | | 36.4–38.8 | 32.8–34.4 | 29.1–30.8 | 5.6–6.9 | 38.8–124.0 |
| *Taphozous perforatus* | 8 (1) | **34.0±1.0** | **30.1±0.8** | **28.3±0.6** | **8.0±1.6** | **153.7±28.9** |
| | | 32.6–35.4 | 28.9–31.0 | 27.3–28.9 | 6.0–10.4 | 127.0–216.0 |
| *Rhinolophus clivosus* | 29 (4) | **76.7±2.2** | **87.3±0.4** | **70.5±3.9** | **55.1±10.4** | **41.0±19.0** |
| | | 72.4–81.7 | 86.1–87.9 | 63.7–76.9 | 29.3–75.0 | 6.0–84.9 |
| *Rhinolophus hipposideros* | 6 (1) | **89.9±1.1** | **107.4±0.5** | **88.5±1.5** | **54.0±6.7** | **30.7±5.3** |
| | | 88.9–91.5 | 106.7–108.0 | 86.7–90.6 | 43.0–61.2 | 22.9–36.6 |
| *Rhinolophus* cf. *mehelyi* | 12 (1) | **91.1±4.2** | **105.7±0.1** | **88.9±3.2** | **53.6±4.8** | **29.2±6.6** |
| | | 86.3–97.0 | 105.4–105.9 | 83.0–92.1 | 45.8–62.2 | 19.7–38.0 |
| *Asellia tridens* | 24 (2) | **118.7±1.6** | **121.3±0.6** | **105.3±2.4** | **10.7±1.6** | **21.1±8.0** |
| | | 114.7–121.1 | 120–122.7 | 100.9–112.9 | 8–13.3 | 11.4–42.5 |
| *Eptesicus bottae* | 17 (3) | **44.9±4.8** | **33.4±2.0** | **30.1±0.9** | **8.4±1.3** | **168.3±50.2** |
| | | 41.0–55.8 | 30.8–36.7 | 28.3–31.4 | 6.6–10.3 | 122.0–301.0 |
| *Hypsugo ariel* | 161 (17) | **62.5±8.8** | **46.5±1.0** | **43.8±0.8** | **4.1±0.7** | **99.1±29.7** |
| | | 48.3–87.0 | 44.3–49.1 | 41.6–45.7 | 2.6–5.9 | 31.8–186 |
| *Otonycteris hemprichii* | 13 (1) | **45.2±1.1** | **22.2±1.2** | **18.7±0.5** | **5.6±0.6** | **106.9±23.1** |
| | | 43.6–47.5 | 20.4–24.3 | 18.0–19.6 | 4.9–6.6 | 69.6–146.4 |
| *Plecotus christii* | 22 (3) | **45.5±1.9** | **32.6±1.1** | **24.3±1.2** | **1.5±0.1** | **64.5±47.5** |
| | | 42.5–48.7 | 31.4–35.6 | 20.8–25.7 | 1.3–1.7 | 21.0–235.0 |
| *Tadarida teniotis* | 19 (6) | **18.3±4.1** | **13.9±2.0** | **11.7±1.6** | **14.1±4.8** | **395.3±106.7** |
| | | 12.6–26.1 | 11.1–17.0 | 9.5–14.3 | 7.0–27.0 | 273.0–678.7 |

these bats are common in southern Sinai, the absence of their records is rather astonishing. Of the two *Rhinopoma* species, *R. cystops* is more common and widespread in North Africa and the Middle East (Kock 1969, Van Cakenberghe & De Vree 1994) and even in the Holy Land (Mendelssohn & Yom-Tov 1999). In Egypt, it was reported from the whole Nile Valley between Cairo and Abu Simbel as well as in some oases west of the Valley (Wadi El Natrun, El Faiyum) (Qumsiyeh 1985, Wassif 1995). No records of *R. cystops* are available from the northern part of the Eastern Desert between Cairo and the Isthmus of Suez, while from the southern Holy Land numerous findings are known, including those from Neot Hakikar, An Naqah, Quraiqira in Wadi Fidan, Ein Yahav, Petra, Timna, Bir Hindis, near Elat, and Eilat (Harrison 1964, Qumsiyeh et al. 1992, 1998, Yom-Tov et al. 1992a, Disi & Hatough-Bouran 1999, Mendelssohn & Yom-Tov 1999, Ferguson 2002, Zelenova & Yosef 2003). The present record suggest a possibility that *R. cystops* may actually appear in eastern Sinai, nevertheless, such a possibility still waits for a real confirmation and further detailed research is needed.

Echolocation. Basic parameters of the single echolocation sequence of *Rhinopoma cystops* recorded from Sinai (Fig. 9) are given in Table 3. Despite a limited number of analysed calls, obtained values of SF and EF fully conform to the data on echolocation of *R. hardwickii* (= *R. cystops*) reported by Simmons et al. (1984) from northern Egypt and Shalmon et al. (1993) from Israel rather than to those in following species.

## *Taphozous perforatus* Geoffroy, 1818

Records. **Original data**: Feiran, El Braga Garden, 11 August 2005: obs., det. & rec. min. 2 inds., 12 August 2005: det. & rec. min. 1 ind.

Comments. *Taphozous perforatus* is here reported from Sinai for the first time. The record is based on echolocation calls of several foraging individuals recorded in the Feiran Oasis (Figs. 10, 11). The occurrence of this desert dwelling bat is not surprising in Sinai, where suitable rocky desert habitats are widely available. However, the Sinaitic occurrence of *T. perforatus* seems to be rather isolated, since this bat is known to be distributed in Egypt in the Cairo region, mainly to the west of the Nile – to the south to El Faiyum and west to Wadi El Natrun – besides the occurrence in the Upper Egypt (from Quseir and from Dandara to the south; Qumsiyeh 1985). Relatively close to the Isthmus of Suez a single older record is known, from Beni Hassan (Anderson 1902). In the Holy Land, *T. perforatus* has been reported from a limited number of sites situated around the Dead Sea and northwards, being discovered there only recently (Yom-Tov & Shalmon 1989, Qumsiyeh et al. 1992, Mendelssohn & Yom-Tov 1999). Most recently, Korine & Pinshow (2004) reported two additional sites in the central Negev (Ben-Gurion grave site and Midreshet Ben-Gurion). This first record of *T. perforatus* from Sinai therefore breaks an extensive gap in its distribution between the Cairo and/or Beni Hassan and the Negev and Dead Sea regions.

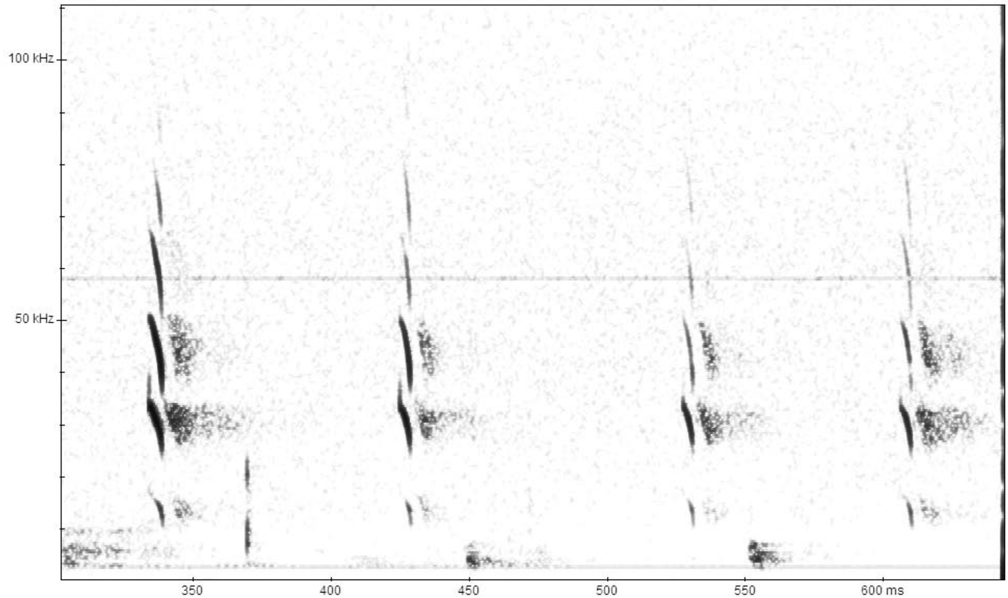
Echolocation. Basic parameters of the *Taphozous perforatus* echolocation sequence from Sinai (Figs. 10, 11) are given in Table 3. These sound recordings are identical with the reference recordings from Wadi Digla at Cairo (own recordings) and from Israel (courtesy of A. Tsoar, Jerusalem). Data on echolocation parameters of *T. perforatus* were previously reported from Israel, briefly by Shalmon et al. (1993) and Mendelssohn & Yom-Tov (1999), and in more detail by Ulanovsky et al. (2004). The latter authors, however, focused their study on bioacoustics rather than a mere description of echolocation parameters. Thus, they did not give all parameters measured by us to enable detailed comparison. We recorded slightly higher EF (Fmin sensu Ulanovsky et al. 2004), more than twice the bandwidth (average 5.7 contra 2.31 found by Ulanovsky et al. 2004), shorter PDUR (8.0 contra 13.1), and much shorter IPI (123.7 contra 386). In contrast to the study by Ulanovsky et al. (2004), we also report FMAXE, which is 30.1 kHz, on average (Shalmon et al. 1993 and Mendelssohn & Yom-Tov 1999 mentioned FMAXE at 30–31 kHz).

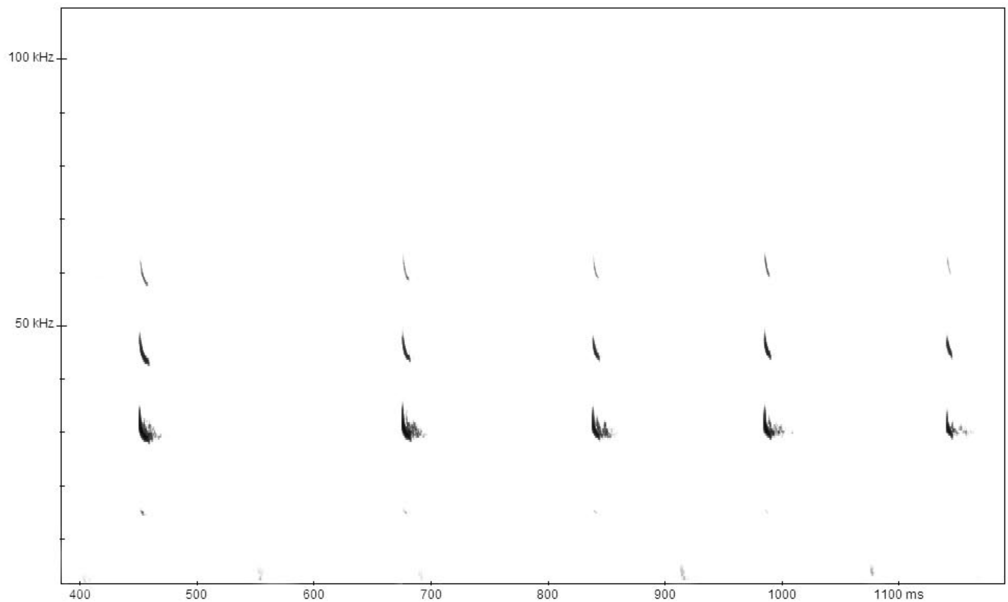
## *Nycteris thebaica* (Geoffroy, 1803)

Records. **Original data**: Feiran, El Braga Garden, 12 August 2005: det. & obs. 1 ind. – **Published data**: Mt. Sinai, 1 f (BMNH 83.8.26.1. [S+B]) (Harrison 1964), 2 inds. (BMNH) (Qumsiyeh 1985); – Sinaitic Peninsula (Anderson 1902); Sinai (Flower 1932).

Comments. We recorded a call in the Feiran Oasis that could be assigned to *Nycteris thebaica*. However, the quality of the recording (not figured) is unfortunately quite low and contains only a few calls, therefore the species identification remains uncertain. Although this bat was recorded from Sinai previously, only two individuals labelled to one site, Mount Sinai, are available (BMNH; Harrison 1964, Qumsiyeh 1985). Both presently known sites of occurrence of *N. thebaica* in Sinai come from the southern part of the peninsula.

The fact that only one unreliable record of *N. thebaica* in Sinai was made in the course of our research seems to be astonishing, since this bat has been rather commonly found in neighbouring areas. In Egypt, *N. thebaica* is known, besides its Sinaitic occurrence, mainly from the Nile Valley and Delta (Qumsiyeh 1985), including also three sites in the eastern part of the Delta (El Khatatba, Kafr Dawud and Kom Hamada; Qumsiyeh 1985). In the regions to the east of Sinai, five records




Figs. 10, 11. Spectrograms of echolocation calls of *Taphozous perforatus* Geoffroy, 1818. 10 (above) – an individual foraging in the El Braga Garden, Feiran; atypical echolocation calls. 11 (below) – different individual foraging at the same place.

were reported from the Israeli part of the Arava Valley, incl. Eilat, Neot HaKikar and Ein Yahav (Makin 1977, Yom-Tov et al. 1992a, Mendelssohn & Yom-Tov 1999), besides numerous findings in central and northern Israel (Mendelssohn & Yom-Tov 1999) representing the northeastern--most margin of the species range (Gray et al. 1999). One record was also made in Jordan, in Ar Raddass near the Dead Sea (Al-Omari et al. 2000), and from the adjacent part of north-western Saudi Arabia, at Wadi Sawawin (Harrison & Bates 1991). Such numbers of recorded localities in the surrounding territories suggests that *N. thebaica* is probably distributed in Sinai more widely than the limited available records would imply.

### *Rhinolophus clivosus* Cretzschmar, 1830

Records. **Original data**: Bir El Abed [1], small house, 29 July 2006: obs. 1 ind. ad.; – Bir El Abed [2] in Wadi Shagg, in the old church on the border between Wadi Shagg and Wadi Klar, 29 July 2006: obs. 4 inds. ad., 1 juv., net. 1 fa, 1 fs; – Feiran [3], a garden in eastern edge of the oasis, 10 September 2005: net. 1 fa (NMP 90498 [S+A]), det. & rec. min. 2 inds. – Feiran [4], El Braga Garden, 10 August 2005: net. 2 fa, 1 fs (coll. 1 f; CDIS 948 [A]), 11 August 2005: det. & rec. 1 ind., 12 August 2005: det. & rec. 2 inds.; – Wadi Klar [5], old church, 2 August 2006: net. 1 faL, 1 fj; – Wadi Klar [6], a deserted house west of Hajsalem's Garden, 4 August 2006: net. 2 fa. – **Published data**: El-Arish [8], colony of ca. 200 inds., coll. 5 m, 37 f (Wassif 1953 [as *R. acrotis*], 1995, Hoogstraal 1962); El-Arish, July 1944: 2 f, August 1951: 5 m, 17 f, September 1951: 2 m, 4 f (Wassif et al. 1984); Al Arish, 3 inds. (USNM) (Qumsiyeh 1985, cf. Sanborn & Hoogstraal 1955); – Feiran Oasis [cf. 3, 4] (Hoogstraal 1962, Wassif 1995); Feiran Oasis, 9 inds. (FMNH) (Qumsiyeh 1985, cf. Sanborn & Hoogstraal 1955); – Wadi Talaah [9], 300 km south of El-Arish, near St. Catherine's Monastery, large cave, August 1943: 4 f (Wassif 1953, Wassif & Hoogstraal 1954 [as *R. acrotis*]); St. Catherine (Wassif 1995).

Comments. *Rhinolophus clivosus* is known only from few sites in Sinai, however, these spots lie in both southern and northern parts of the peninsula (Fig. 3). Wassif (1953: 109) collected 42 specimens in the town of El Arish in northern Sinai and added observations: "the bats were members of a large colony of more than 200 individuals found together in a fairly dark corner of a large single-roomed storehouse. On various occasions individuals of this species were seen flying at night at a low levels in the crowded sole market place of the city of El-Arish. They entered shops and cafés and were most abundant in places where radio sets were in full swing." Wassif (in Wassif & Hoogstraal 1954: 66) collected four females "from a large cave in the mountain side at Wadi Talaah, near St. Catherine's monastery". Hoogstraal (1962: 156) mentioned records from "storehouses, stone huts, and hillside caves in Arish and Feiran Oasis, Sinai." He omitted Wassif's record from Wadi Talaah [= Wadi Tilah, ca. 6 km W of Deir Sant Katerin], but added that from Feiran Oasis. Possibly, Hoogstraal (1962) confused these two sites, which are, however, ca. 25 km distant from each other. On the other hand, Wassif (1995) mentioned all three sites under distribution of *R. clivosus* in Sinai. We confirmed occurrence of this bat in both areas, both by detections and recordings of its calls (Fig. 17) and by captures of individuals (see Records; Fig. 3). Four records from roosts are also available, all from abandoned houses.

The populations occurring in Sinai are considered to belong to the nominotypical subspecies that was described from Mohila [= Al Muwailih], northwestern Saudi Arabia, some 120 km from the eastern coast of Sinai (Cretzschmar 1830; see also Fig. 52). This form has also been reported from the southern part of the Holy Land (Qumsiyeh 1985, 1996). Most findings are known from Israel, where more than 15 occurrences were mentioned from the Negev and Judean Deserts and from the Arava Valley southwards to Eilat (Makin 1977, Yom-Tov et al. 1992a, Mendelssohn & Yom-Tov 1999, Korine & Pinshow 2004). In early summer 2007, a small nursery colony was found

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Figs. 12–15. Nose-leafs of two Sinaitic horseshoe bats (all photos by C. Dietz). 12, 13 (above) – *Rhinolophus clivosus* Cretzschmar, 1830. 14, 15 (below) – *Rhinolophus hipposideros* (Borkhausen, 1797). 12, 14 (left) – antero-dorsal views. 13, 15 (right) – semi-lateral views.

in the Jordan Valley north of the Dead Sea and marks the northernmost currently known margin of the range of *R. clivosus* (leg. E. Levin, I. Dietz & C. Dietz). In Jordan, it was reported from four localities adjacent to the Wadi Araba (Qumsiyeh et al. 1992, Qumsiyeh 1996, Amr 2000). Thus, rather frequent Sinaitic records connect the numerous findings from around the south of the Rift Valley in the Holy Land.

Egyptian records other than those from Sinai, coming from the Cairo region, Upper Egypt (Luxor and Korosko), and some oases west of the Nile (El Faiyum, Wadi El Natrun and W of

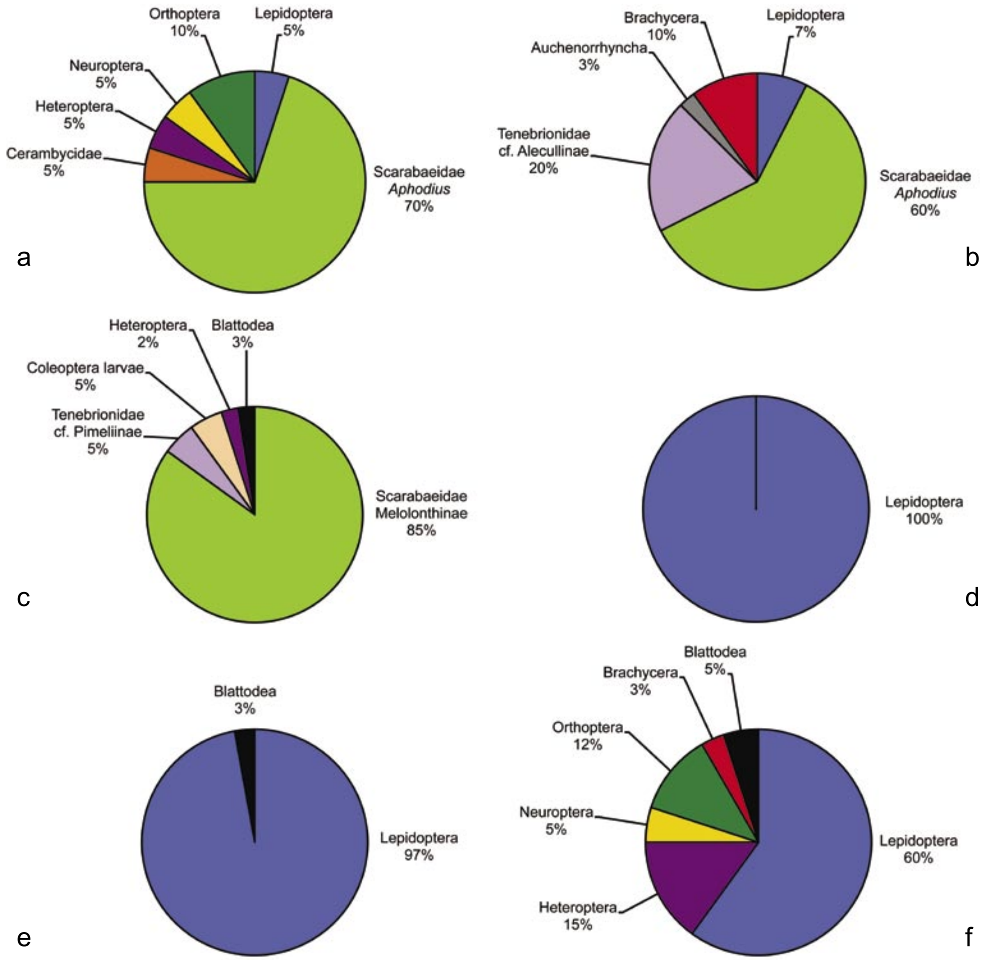



Fig. 16. Diet composition (percentage of volume): a – *Rhinolophus clivosus* Cretzschmar, 1830 (20 pellets collected from one individual); b – *Hypsugo ariel* (Thomas, 1904) (two digestive tracts analysed); c – *Otonycteris hemprichii* Peters, 1859 (two digestive tracts); d – *Barbastella leucomelas* (Cretzschmar, 1830) (two digestive tracts); e – *Plecotus christii* Gray, 1838 (seven digestive tracts); f – *Tadarida teniotis* (Rafinesque, 1814) (six digestive tracts).

Mersa Matruh) are mostly regarded to belong to a different taxon, *R. c. brachygnathus* Andersen, 1905 (Hoogstraal 1962, Qumsiyeh 1985, Wassif 1995, Csorba et al. 2003).

Feeding ecology. Based on the data obtained from southern Israel, *Rhinolophus clivosus* is a bat foraging especially around vegetation and feeding on Coleoptera, Hymenoptera and Lepidoptera (Whitaker et al. 1994, Feldman et al. 2000). Our sample of 20 faecal pellets collected from one individual from the Feiran Oasis (10 September) contained especially rests of *Aphodius* (Coleoptera: Scarabaeidae) (70% volume) and Cerambycidae (5%) (Fig. 16). The other items found were Orthoptera (10%), Heteroptera (5%), Neuroptera (5%) and Lepidoptera (5%). On the other side, an additional analysis of four fecal pellets collected from another subadult female of *R. clivosus* captured in Feiran (10 August) revealed remains of Lepidoptera only (not figured).

Echolocation. We recorded echolocation calls of *Rhinolophus clivosus* at two closely situated sites in Sinai (Figs. 17, 18) and their basic parameters are given in Table 3. Echolocation of this species is here, to our knowledge, described in detail for the first time, although brief characters of the call were given by Shalmon et al. (1993) and Mendelssohn & Yom-Tov (1999). They mentioned the range of the call of *R. clivosus* from Israel to be 44–104 kHz, with its FMAXE at 90 kHz. We found the latter value in Sinaitic individuals to be ca. 3 kHz lower. In its basic characters, *R. clivosus* echolocation generally resembles that of *Rhinolophus ferrumequinum* (Schreber, 1774), a vicariant species living in the Mediterranean arboreal zone. However, CF components of Sinaitic *R. clivosus* have higher FMAXE by ca. 6 kHz, PDUR is longer by 5 ms on average and IPI is much shorter (~ two-times), than in European *R. ferrumequinum* (e.g. Russo & Jones 2002).

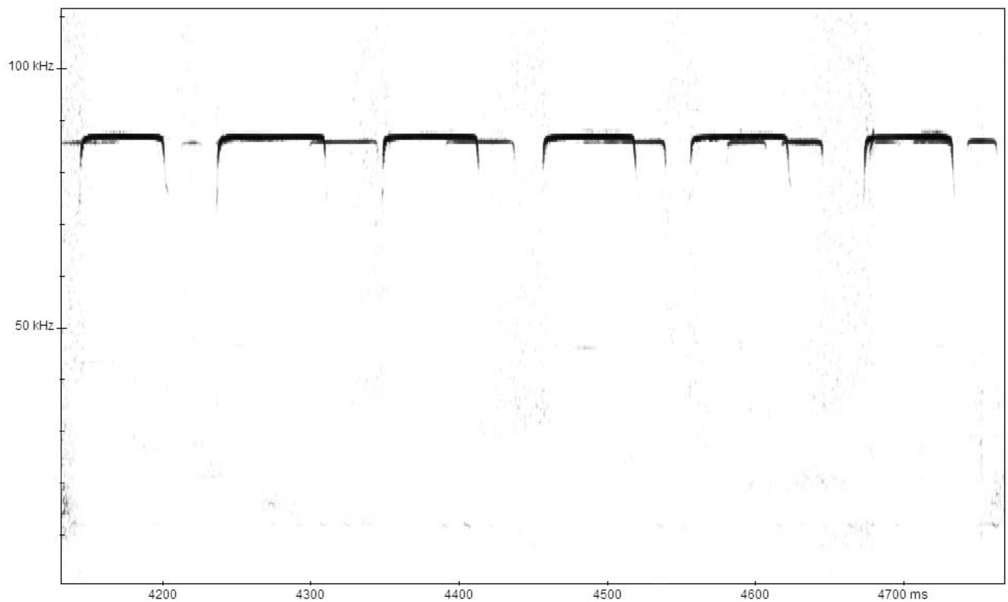



Fig. 17. Spectrogram of echolocation calls of *Rhinolophus clivosus* Cretzschmar, 1830: two individuals foraging in a garden in the eastern edge of the Feiran Oasis.

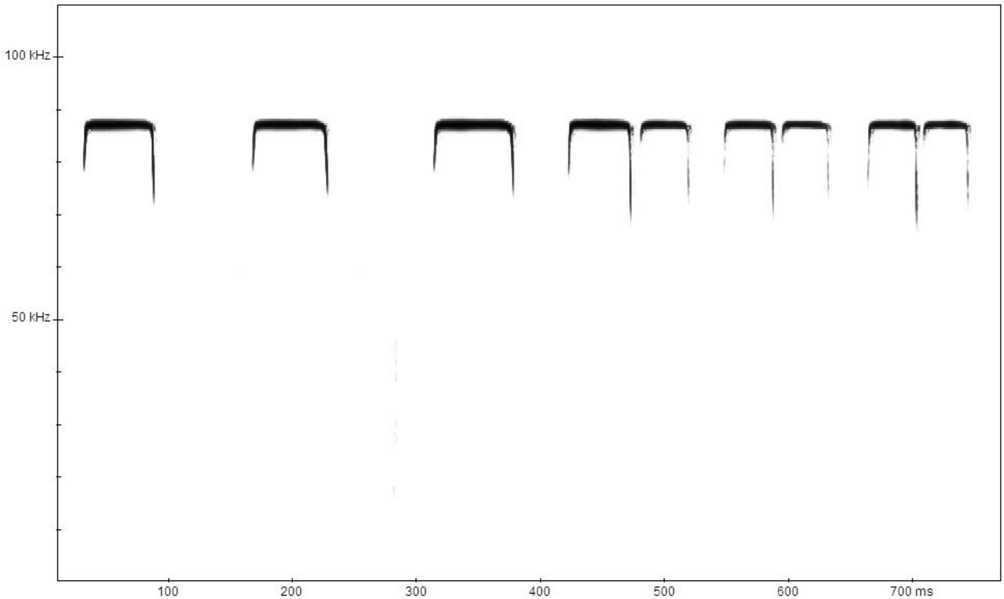



Fig. 18. Spectrogram of echolocation calls of *Rhinolophus clivosus* Cretzschmar, 1830: a handheld individual.

Fig. 19. The oasis of Ain Sudr, western slope of the Et Tih Plateau. Record site of *Rhinolophus hipposideros* (Borkhausen, 1797), *Hypsugo ariel* (Thomas, 1904) and *Plecotus christii* Gray, 1838 (photo by P. Benda).

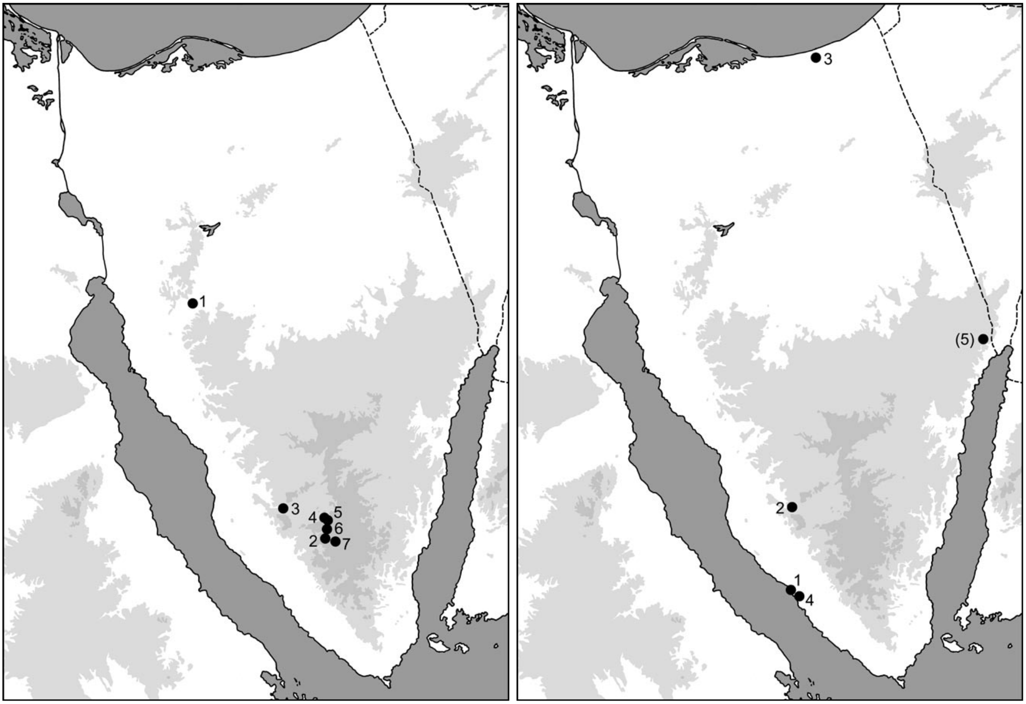
## *Rhinolophus hipposideros* (Borkhausen, 1797)

Records. **Original data**: Ain Sudr [1], oasis (Fig. 19), 18 September 2005: det. & obs. min. 1 ind. – Farsh El Romana [2], Abu Hamat Garden (Fig. 20), 8 August 2005: det., rec. & obs. 1 ind., 15 August 2005: det., rec. & obs. 1 ind.; – Feiran [3], El Braga Garden, 12 August 2005: det., rec. & obs. 1 ind.; – Sheikh Awad [4], El Karm Ecolodge (Fig. 49), 17 August 2005: net. 1 ms, 1 fs, 18 August 2005: det., rec. & obs. 1 ind.; – Sheikh Awad [5], Sulliman's Garden, 12 July 2007: found 1 fa, 1 mj; – Wadi Klar [6], Abu Dagash, cave, 2 August 2006: net. 1 ms, 1 fa. – **Published data**: Al Arbaein [7], August 1943: 1 m (Wassif et al. 1984); – Wadi Feiran near Feiran Oasis [cf. 3], hillside cave, 21 May 1953: 1 m (FMNH 74476) (Wassif & Hoogstraal 1954, Hoogstraal 1962); Feiran Oasis (Sanborn & Hoogstraal 1955, Qumsiyeh 1985).

Comments. *Rhinolophus hipposideros* is a species with a mostly Mediterranean distribution, which, however, also reaches the Afro-tropical region via the Rift Valley from the Levant, over Sinai and western Saudi Arabia to Sudan, Eritrea, Djibouti, and Ethiopia (see Benda et al. 2006 for a review). Its occurrence in southern Sinai (Fig. 21) represents the only distribution spot in Egypt (Qumsiyeh 1985) and the westernmost point of the species' range south of the Levant (Harrison & Bates 1991).

In the neighbouring Levantine countries *R. hipposideros* occurs mainly in the mild climatic areas to the north of the Dead Sea (Qumsiyeh 1996), although several records are also known from the central Negev Desert and the northern part of the Arava Valley (Nahal Zin, Ein Ziq, Berekhot Navit, Neot HaKikar, Ein Yahav) (Harrison 1964, Yom-Tov et al. 1992a, Korine & Pinshow 2004). The extending Sinaitic distribution of this bat could seem to be extreme range projection of this Mediterranean species from the ecological point of view, however, the number of records both in desert oases (Feiran, Ain Sudr; Fig. 19) and mountain habitats (El Arbaein,

Fig. 20. The oasis of Farsh El Romana, Abu Hamat Garden. The foraging habitat of *Rhinolophus hipposideros* (Borkhausen, 1797) (photo by C. Dietz).




Figs. 21, 22. 21 (left) – records of *Rhinolophus hipposideros* (Borkhausen, 1797) in Sinai. 22 (right) – records of *Asellia tridens* (Geoffroy, 1813) in Sinai.

Farsh El Romana, Sheikh Awad, Wadi Klar; Figs. 20, 49) shows a well established and prospering population. Most of the new findings represent records of foraging individuals, the only roost was found in Sulliman's Garden of Sheikh Awad, where an adult female with a volant young was discovered, and possibly also in the Wadi Klar, where two bats were found in a small cave (like the one published by Wassif & Hoogstraal 1954).

Feeding ecology. In the Farsh El Romana Oasis, one *Rhinolophus hipposideros* was observed from close distances for several hours within two nights. The bat was foraging very close to the ground (10–15 cm above surface) and close to the vegetation and even within smaller fig trees and bushes (Fig. 20). The bat foraged continously on the wings. When flying above the barren ground its head was directed to the ground and echolocation calls were highly directed to the ground and could only be detected with a help of the bat-detector when it was placed on the ground. In this situation winged ants (Hymenoptera) emerging from the ground were captured in large numbers. Within fig trees and bushes small flying insects (mostly Homoptera and Culicidae) were captured, a large moth (Noctuidae, winglength 22 mm) was attacked more than 10 times but the bat failed to take it. The bat foraged even around four mist-nets placed in the garden and passed between to foraging sites either below the net or through two holes in the net with 6 and 8 cm in diameter. To pass the net its wings were attached to the body. After doing this several time the bat did not

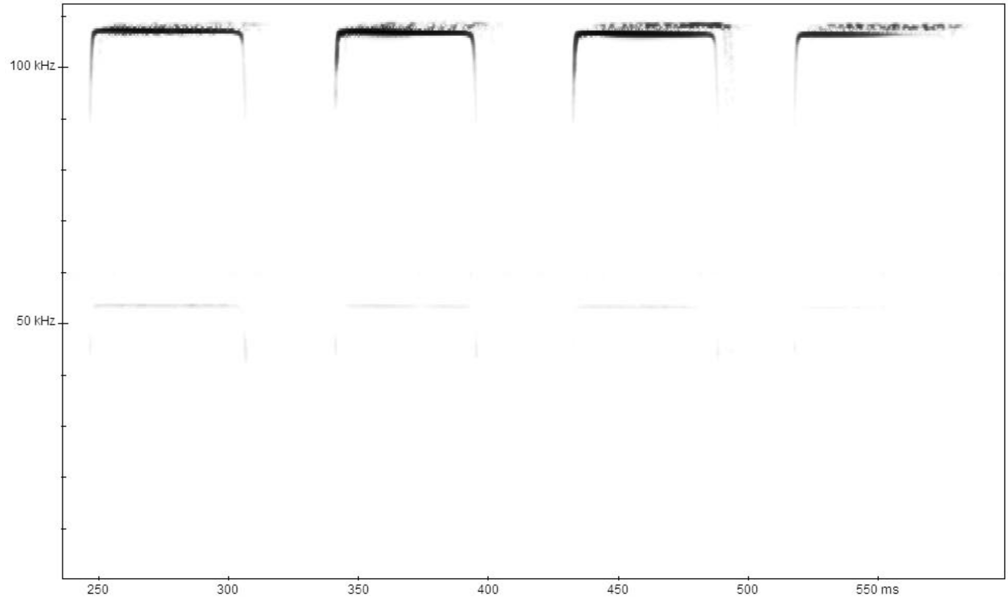



Fig. 23. Spectrogram of echolocation calls of *Rhinolophus hipposideros* (Borkhausen, 1797). An individual foraging in the Abu Hamat Garden, Farsh El Romana (cf. Fig. 20).

mind it anymore when the observer was less that 50 cm from the net and standing still but escaped with high agility when the observer was even slightly moving.

ECHOLOCATION. Basic parameters of one recorded echolocation sequence of *Rhinolophus hipposideros* from Sinai (Fig. 23, Table 3) fall within the lower limit of variation reported for this species from Europe (cf. Russo & Jones 2002). Based on our field observations (bat-detectoring in the heterodyne mode), it seems that peak frequency of CF component of echolocation calls in the Sinaitic populations of *R. hipposideros* is ca. 107 kHz, i.e. roughly of 4 kHz below that in European populations. However, it generally conforms with the findings of Mendelssohn & Yom-Tov (1999), who reported from various parts of Israel extremely wide frequency variation (probably their CF components), with values at 104 kHz, 108 kHz and 110 kHz (Shalmon et al. 1993 mentioned the range of FMAXE from 104–108 kHz). It suggests, that in extreme variable habitats on the southern distribution range margins, *R. hipposideros* has a much wider frequency range, which seem to be less variable in the Mediterranean conditions (Russo & Jones 2002).

### ***Rhinolophus* cf. *mehelyi* Matschie, 1901**

RECORD. **Original data**: Ain Hudra, oasis (Fig. 5), 13 September 2005: det. & rec. 1 ind.

COMMENTS. *Rhinolophus* cf. *mehelyi* is here reported from Sinai for the first time, based on echolocation calls of an individual recorded in the Ain Hudra Oasis (Fig. 24). Of course, we cannot exclude completely a possibility that the respective recordings might represent an abnormal call

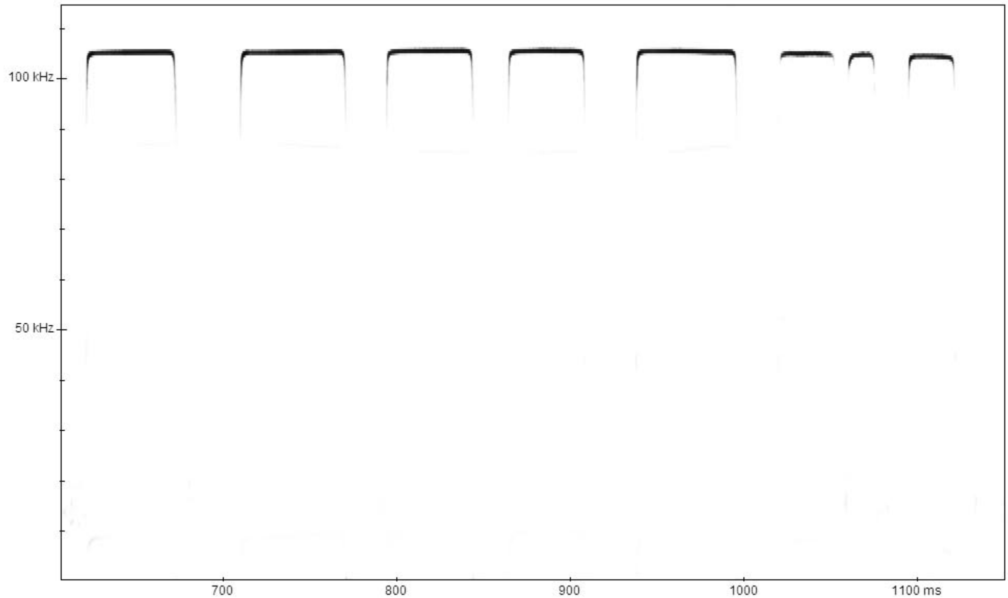



Fig. 24. Spectrogram of echolocation calls belonging possibly to *Rhinolophus* cf. *mehelyi* Matschie, 1901. An individual flying around a water pit in the Ain Hudra Oasis.

of *R. hipposideros* (see Echolocation below). Consequently, we consider the Sinaitic distribution of this bat only tentative, until it is confirmed by collection of an individual.

In Egypt, *R. mehelyi* was known only from two locations in much less arid regions than Sinai; the Cairo region and western part of the Nile Delta between Alexandria to Burg El Arab (Anderson 1902, Flower 1932, Qumsiyeh 1985). The record from Saqqara near Cairo had represented the southernmost evidence of this species in its whole distribution range (Qumsiyeh 1985) at 29° 51' N (Osborn & Helmy 1980), however, the new record from Ain Hudra is situated even more southward (28° 54' N). The locality is situated in a desert region what does not seem too typical for the species. However, the only known Jordanian record comes from An Naqah, a comparable desert habitat in the northern part of the Wadi Araba (Qumsiyeh 1996, Qumsiyeh et al. 1998) and also the records from arid parts of central Mesopotamia are from rather desert context (Harrison & Bates 1991, Benda et al. 2006). Conversely, the remaining confirmed Levantine records of *R. mehelyi* are reported exclusively from the Mediterranean habitats (Qumsiyeh 1996, Benda & Horáček 1998, Mendelssohn & Yom-Tov 1999).

Echolocation. Echolocation parameters obtained from a single recorded call of *Rhinolophus* cf. *mehelyi* (Fig. 24) sequence are given in Table 3. Peak frequency of CF component of the calls fully conforms to the values reported for this species from Europe (see Salsamedi et al. 2005 for a review). However, our material is limited to only 12 calls obtained from a single sequence and therefore, it could not be ruled out that we recorded an abnormal call from *R. hipposideros*. Such a possibility could not be rejected, as the observed *R. hipposideros* calls differed by less than 2 kHz (see above) and those from Israel were reported as having very similar values (Mendelssohn &

Yom Tov 1999). Only more field recordings of good quality from Sinai and adjacent territories could help resolve this problem.

### *Asellia tridens* (Geoffroy, 1813)

Records. **Original data**: El Tur [1], Hammam Musa (Fig. 25), above a pool, 10 September 2005: det. & rec. 1 ind.; – Feiran [2], El Braga Garden, 11 August 2005: obs., det. & rec. 1 ind. – **Published data**: El Arish [3] (Hoogstraal 1962); – Tor [4], 1 f (Anderson 1902); Tor, 1823 (Stresemann 1954); – Sinai, 3 inds./2 f (USNM) (Qumsiyeh 1985, Owen & Qumsiyeh 1987); – [eastern Sinai] [5] (Hoath 2003).

Comments. Although *Asellia tridens* is a bat known to have been present in Sinai for a long time – for the first time it was found by F. Hemprich and C. Ehrenberg in 1823 (*fide* Stresemann 1954) – only three sites of occurrence are known. The records come both from northern and southern parts of the peninsula, but only from lower altitudes (from sea level to ca. 700 m a. s. l.; see Records and Fig. 22). Hoath (2003) marked another record of *A. tridens* in Sinai onto the distribution map for this species in Egypt, indicating the area of Ras El Naqb, however, he did not mention any precise locality or its source. We recorded foraging calls of *A. tridens* at two places (Fig. 26, 27). In Feiran, the bat was recorded foraging around palm trees and bushes in the densely vegetated part of the oasis. From the area of El Tur in southwestern Sinai, this bat was confirmed three times in 180 years (Hemprich & Ehrenberg 1823 [*fide* Stresemann 1954], Anderson 1902, this review). Since El Tor is a lowland desert town, where natural underground spaces are likely to be uncommon, *A. tridens* most probably uses synathropic shelters there.

*A. tridens* is the most widespread bat species in continental Egypt; it occurs in the Cairo region, the whole Nile Valley, Red Sea coast, and oases in the Western and Southeast Deserts of Egypt (Wassif 1959, Hoogstraal 1962, Qumsiyeh 1985, own data). However, this species is absent in the Nile Delta and Mediterranean coastal belt of Egypt (Gaisler et al. 1972) with the only exception of El Arish, Sinai (Hoogstraal 1962). It is similar to the situation in central Israel, where *A. tridens*

Fig. 25. Hammam Musa resort near El Tur, western Sinai; the area, where *Asellia tridens* (Geoffroy, 1813) and *Plecotus christii* Gray, 1838 were repeatedly recorded (photo by R. Lučan).

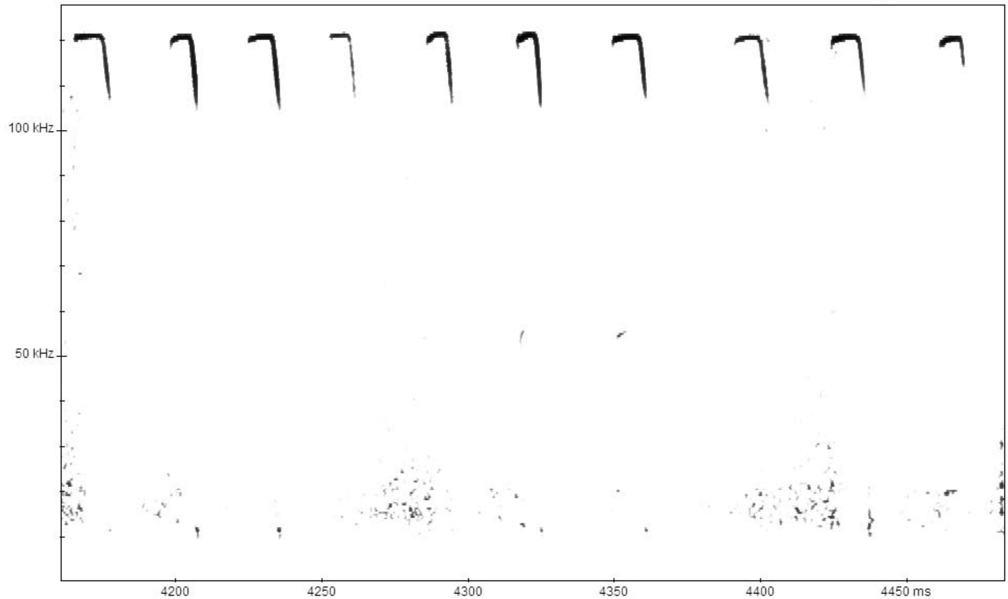



Fig. 26. Spectrogram of echolocation calls of *Asellia tridens* (Geoffroy, 1813). An individual foraging at a water pool at Hammam Musa close to El Tur.

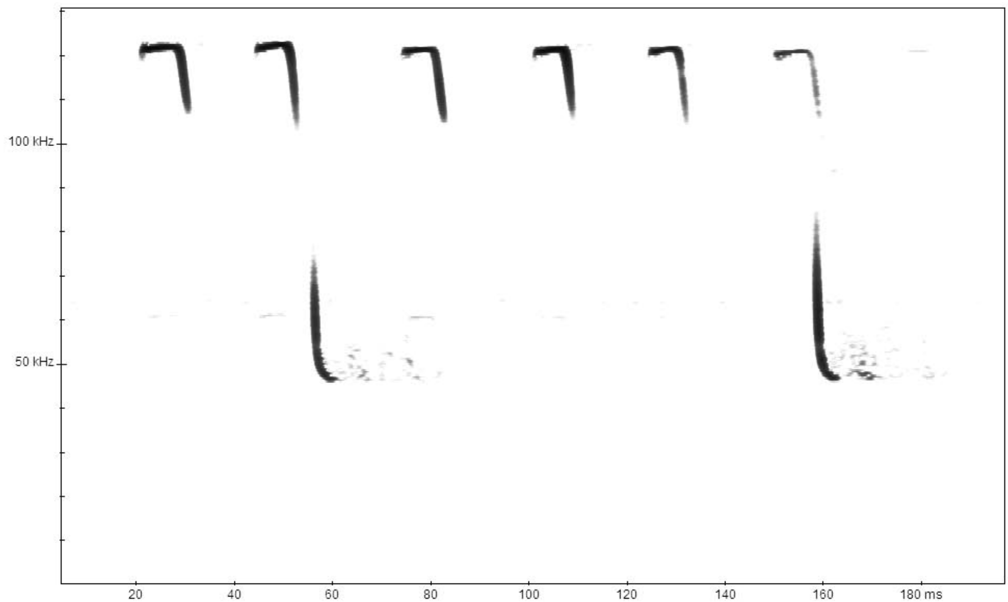



Fig. 27. Spectrogram of echolocation calls of *Asellia tridens* (Geoffroy, 1813) and *Hypsugo ariel* (Thomas, 1904). Two simultaneously foraging individuals in the El Braga Garden, Feiran.

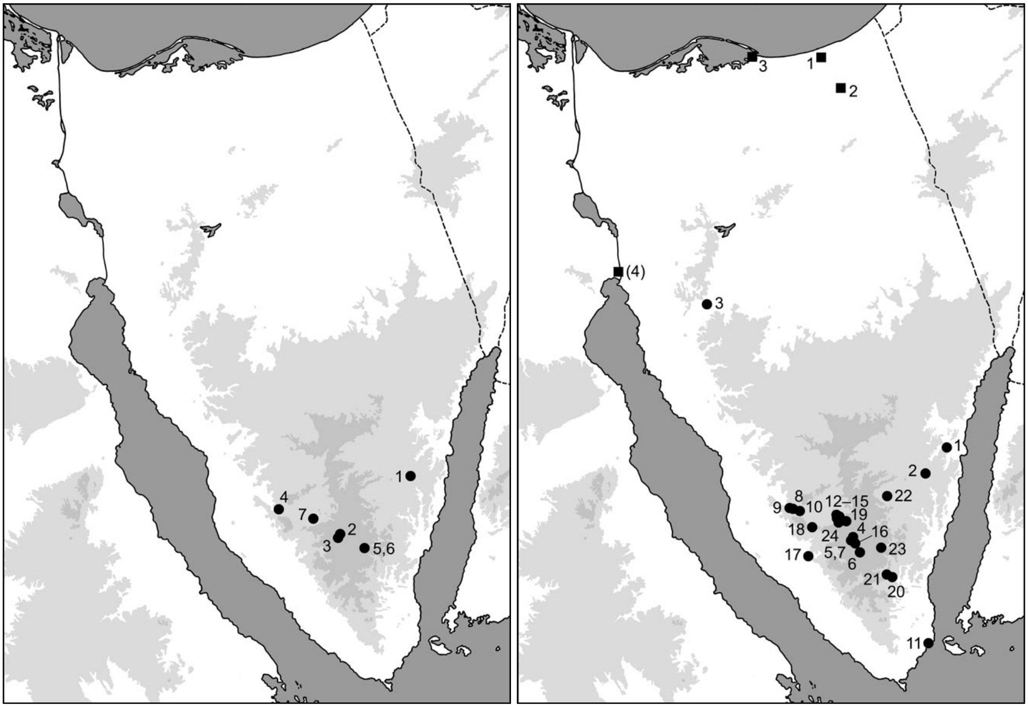
was recorded from sea coast as well as from the Rift Valley (Mendelssohn & Yom-Tov 1999). However, in the part of the Holy Land to the east of Sinai, this bat is widespread in desert habitats of the Dead Sea area and the Arava/Araba Valley (Harrison 1964, Yom-Tov et al. 1992a, Qumsiyeh et al. 1998, Disi & Hatough-Bouran 1999, Mendelssohn & Yom-Tov 1999), and recently it was recorded also in the Negev Desert (Korine & Pinshow 2004). The numerous findings in the regions west and east of Sinai, similar in habitat conditions, suggest that *A. tridens* may be distributed in Sinai more widely than the limited available records have shown.

ECHOLOCATION. We recorded echolocation calls of *Asellia tridens* at two sites in Sinai (Figs. 26, 27); their basic parameters are given in Table 3. As compared to published data on echolocation of *A. tridens* from African as well as Syrian populations (Möhres & Kulzer 1955a, b, Pye 1972, Gustafson & Schnitzler 1979, Jones et al. 1993, Benda et al. 2006), the frequency of CF component of Sinaitic individuals is somewhat higher – about 121 kHz. On the other hand, these values correspond with those reported from Israel by Shalmon et al. (1993) and Mendelssohn & Yom-Tov (1999). Furthermore, sex- and age-related differences in echolocation parameters were described in this species (Jones et al. 1993) and Doppler-shift compensation may alter the frequency as well suggesting that these variables may be a source of differences in reported call frequencies.

## *Eptesicus bottae* (Peters, 1869)

RECORDS. **Original data**: Ain Hudra [1], oasis (Fig. 5), 5 August 2005: det. & rec. 1–3 inds.; – El Milga [2], Fox Camp, olive grove in a Bedouin garden, 3 July 2006: net. 1 ma; – El Milga [3], St. Katherine Research Centre, 30 July 2005: det. & rec. 2 inds., 2 August 2005: det. & rec. 4 inds.; – Feiran [4], El Braga Garden, 10 August 2005: net. 1 ma (CDIS 947 [A]; Fig. 28), 11 August 2005: obs., det. & rec. 4 inds., 12 August 2005: det. & rec. 2–4 inds.; – Wadi Nasb [5], Awad's

Fig. 28. Portrait of a male of *Eptesicus bottae* (Peters, 1869) from the oasis of El Milga, Sinai (photo by C. Dietz).

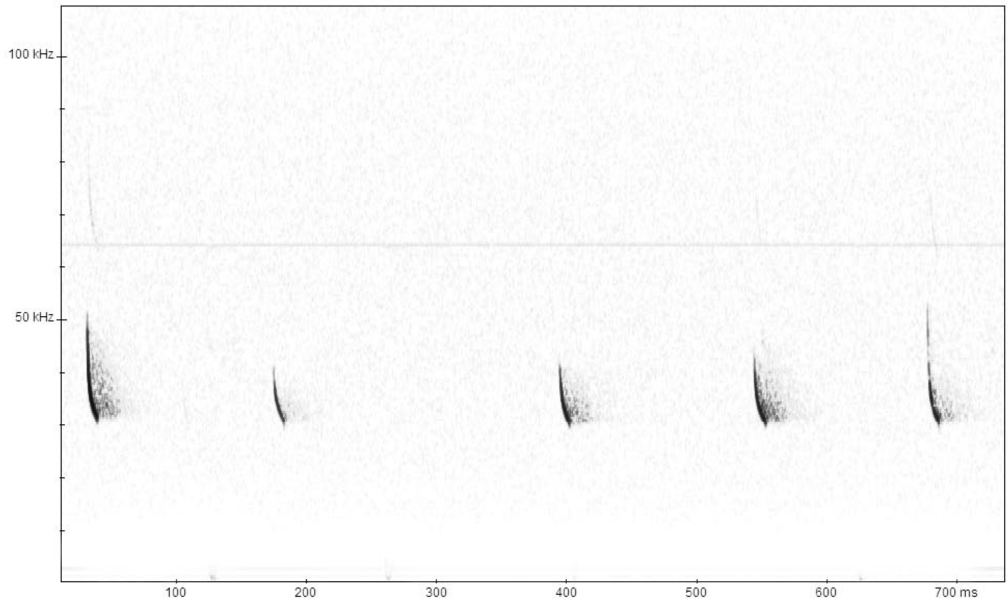


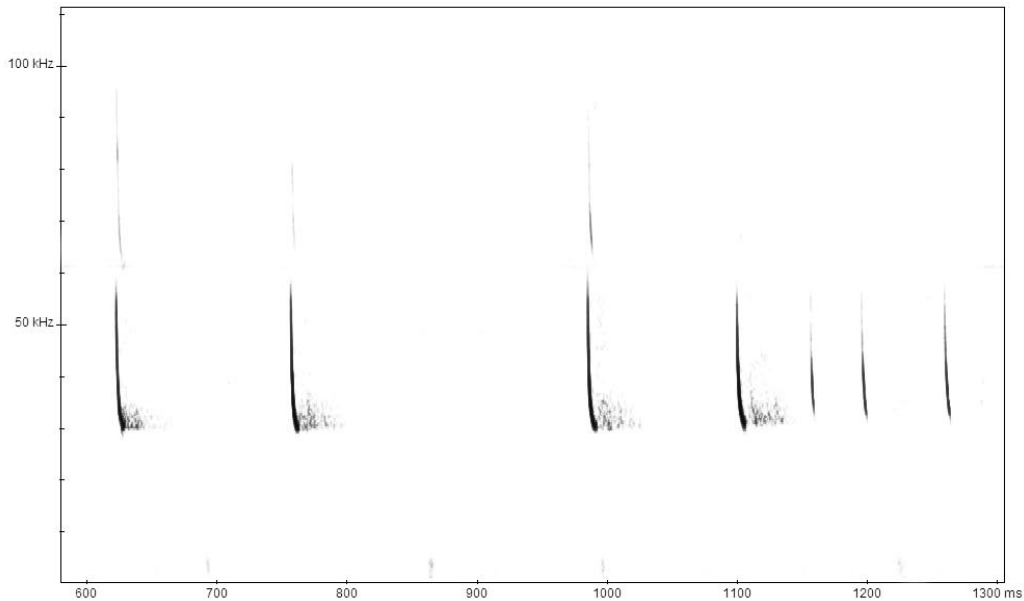

Figs. 29, 30. 29 (left) – records of *Eptesicus bottae* (Peters, 1869) in Sinai. 30 (right) – records of *Hypsugo ariel* (Thomas, 1904) (circles) and *Pipistrellus kuhlii* (Kuhl, 1817) (squares) in Sinai.

Garden, 28 June 2006: net. 1 ma; – Wadi Nasb [6], Mousa's Garden, 29 June 2006: net. 1 ma; – Wadi Sulaf [7], Wadi El Braga Camp, 10 July 2007: det. & rec. min. 1 ind.

Comments. *Eptesicus bottae* is here reported from Sinai for the first time, four individuals were netted and echolocation calls of numerous others were recorded at five areas (Ain Hudra, El Milga, Feiran, Wadi Nasb, Wadi Sulaf) in the southern part of the peninsula (Fig. 29). The recordings were identified with help of a male captured in the Feiran Oasis which provided the control sound recordings; by comparison of sound recordings of this individual and with reference recordings from Israel (courtesy of A. Tsoar, Jerusalem), we identified most of the previously "mystery calls" collected throughout southern Sinai as belonging to this species. Thus, *E. bottae* seems to be relatively widespread species in the southern part of the peninsula.

In Egypt only two previously recorded sites are known, with just six specimens reported from the Cairo region (Nader & Kock 1983, 1990a); whereas in the southern Holy Land, *E. bottae* seems to be a common inhabitant. Mendelssohn & Yom-Tov (1999) marked in their distribution map of this species in Israel eighteen records in the Judean and Negev Deserts and along the Arava Valley, from the strip stretching from Ein Gedi at the Dead Sea to Elat at the Gulf of Aqaba; seven other records from the central Negev were reported by Korine & Pinshow (2004). In Jordan this species is known from a similar geographic extent along the Dead Sea and Wadi Araba from at least four sites (Amr 2000). This suggests that this species is not primarily an African faunal element; the




Figs. 31, 32. Spectrogram of echolocation calls of *Eptesicus bottae* (Peters, 1869). 31 (above) – an individual foraging at St. Katherine Research Centre, El Milga. 32 (below) – an individual foraging in the El Braga Garden, Feiran.

Cairo region, where this bat is extremely rare, seems to be a projection of the regular distribution range covering desert parts of the western Asia (see Nader & Kock 1990a and/or Benda et al. 2006 for reviews of distribution).

Echolocation. Basic parameters of echolocation calls of *E. bottae* (Figs. 31, 32) are given in Table 3. Although we analysed only limited series of calls, the values obtained conform to the 32–33 kHz range of FMAXE reported from Israel by Shalmon et al. (1993) and Mendelssohn & Yom-Tov (1999) and only slightly exceed those reported by Holderied et al. (2005).

### *Hypsugo ariel* (Thomas, 1904)

Records. **Original data**: Ain El Furtaga [1], a canyon above the oasis (Fig. 4), 15 September 2005: det. & rec. 1–2 inds.; – Ain Hudra [2], oasis (Fig. 5), 4 August 2005: net. 1 ma, 1 fs (coll. 1 m; CDIS 946 [S+A]), det. & rec. 4 inds., 5 August 2005: obs, det. & rec. 8 inds., 13 September 2005: det. & rec. 1–2 inds., 4 July 2006: net. 1 ma, 3–5 July 2007: det. & rec. min. 3 inds. each night; – Ain Sudr [3], oasis (Fig. 19), 18 September 2005: det. min. 1 ind.; – El Milga [4], Deir Sant Katerin, at the entrance, 9 August 2005: det. & rec. 1 ind., 8 July 2007: det. & rec. min. 1 ind.; – El Milga [5], St. Katherine Research Centre, 30 July 2005: det. & rec. 2 inds., 9 August 2005: det. & rec. 2 inds.; – El Milga [6], Rotog, 28 July 2007: det. & rec. min. 1 ind.; – El Milga [7], village (Fig. 6), 9 August 2005: det. & rec. 1 ind.; – Feiran [8], El Braga Garden, 11 August 2005: obs., det. & rec. 3 inds., 12 August 2005: obs., det. & rec. 1 ind.; – Feiran [9], above a pool in western edge of the oasis, 8 September 2005: net. 1 m, 1 f (NMP 90493, 90494 [S+A]), det. & rec. ca. 5 inds.; – Feiran [10], a garden in eastern edge of the oasis, 9 September 2005: det. & rec. min. 1 ind. – Sharm El Sheikh [11], airport, 24 August 2005: det. & rec. 2 inds.; – Sheikh Awad [12], at the El Karm Ecolodge (Fig. 49), 17 and 18 August 2005: obs., det. & rec. 15–20 inds., 19 July 2006: net. 1 fs; – Sheikh Awad [13], Awad Garden, 11 July 2007: det. 1 ind.; – Sheikh Awad [14], Mohammed's Garden, 19 July 2006: net. 1 fa; – Sheikh Awad [15], Oder's Garden, 20 July 2006: net. 1 faL; – Wadi El Arbaein [16], Ramadan's Garden (Fig. 34), 1 August 2005: net. 1 ma (CDIS 945 [S+A]; Fig. 33); – Wadi Hibran [17], Bedouin village, 26 July 2007: det. & rec. min. 1 ind.; – Wadi Hibran [18], a camp at the pass to Wadi Sulaf, 25 July 2007: det. & rec. min. 1 ind.; – Wadi Kharba [19], village, 12 July 2007: det. 1–2 foraging inds.; – Wadi Kid [20], garden in small village, 19 July 2007: net. 1 ma; – Wadi Kid [21], hill top garden, 18 July 2007: net. 3 fj; – Wadi Marra [22], open area approximately 800 m from the road in a perpendicular direction, 11 July 2006: net. 1 ma; – Wadi Nasb [23], Awad's Garden, 22 July 2006: net. 1 fa; – Wadi Sulaf [24], Wadi El Braga Camp, 10 July 2007: net. 1 fa, det. & rec. min. 1 ind. – **Published data**: St. Katherine Monastery [4], 2 inds. (HUJ) (Qumsiyeh 1985 [as *Pipistrellus bodenheimeri*]).

Comments. Here we regard the populations previously assigned to *Hypsugo bodenheimeri* (Harrison, 1960) to be conspecific with those of *H. ariel* (Thomas, 1904), in accordance with the results of the presented analysis and opinions of several authors (see Taxonomy below). We thus regard both these names to be synonyms under a priority of the latter (the generic nomenclature follows Horáček & Hanák 1986, Horáček et al. 2000, Benda et al. 2002, and Simmons 2005). *H. ariel* in its current rank is distributed from C and NE Sudan, over Sinai and the S Holy Land to W Saudi Arabia, SW and E Yemen and the Socotra Island (Qumsiyeh 1985, Harrison & Bates 1991, Gaucher & Harrison 1995, own unpubl. data).

From Egypt, *Hypsugo ariel* has previously been known to occur only in Sinai; the specimen of *H. ariel* being reported from the Upper Egypt (Seiyala; Gaisler et al. 1972, Qumsiyeh 1985), was subsequently clearly identified as *Pipistrellus deserti* Thomas, 1902 (Hill & Harrison 1987). *H. ariel* has been known from Sinai from two specimens collected at St. Katherine Monastery (Deir Sant Katerin) possibly in the period 1967–1982 (see Werner 1988: 358) and deposited in the zoological collection of the Hebrew University, Jerusalem (Qumsiyeh 1985). We found this species to be widespread and abundant in all parts of southern Sinai. It was recorded in twelve areas there, primarily in, but not restricted to, the mountainous parts of the peninsula (Fig. 30) and the number of records or *H. ariel* make this the most frequently recorded bat in Sinai (see Table 14). These results are similar to the situation found in southern Israel by Yom-Tov et al. (1992b). Mendelssohn & Yom-Tov (1999) summarised 17 sites of *H. ariel* records in Israel (it is the third most frequently found bat in desert Israel, after *Tadarida teniotis* and *Eptesicus bottae*), coming mainly from the area of the Dead Sea and the Arava Valley, but also from the southern and central Negev Deserts. However, only three records are available from Jordan (Qumsiyeh et al. 1992, Disi & Hatough-Bouran 1999), all from the southwestern part of the country, adjacent to Wadi Araba. Thus, the distribution pattern found in Sinai is similar to the one in the Holy Land. Furthermore, from the abundant records we report in south Sinai we would expect further records of *H. ariel* in the presently unexplored northern areas of Sinai corresponding to its distribution pattern to south and east.

TAXONOMY. *Hypsugo ariel* (Thomas, 1904) has been described under the genus *Pipistrellus* Kaup, 1829 on the basis of two specimens collected in the Eastern Desert of Egypt, 22° N, 35° E, 2000 ft (Wadi Alagi/Alagy, presently under Sudanese administration, Flower 1932) by Arthur M. Mac-

Fig. 33. An individual of *Hypsugo ariel* (Thomas, 1904) from the oasis of El Milga, Sinai (photo by C. Dietz).

Fig. 34. Wadi El Arbaein, southern edge of the Ramadan's Garden, the netting site of *Hypsugo ariel* (Thomas, 1904) and *Plecotus christii* Gray, 1838 (photo by C. Dietz). From the broader area of this wadi, three other bat species were reported: *Rousettus aegyptiacus* (Geoffroy, 1810), *Rhinolophus hipposideros* (Borkhausen, 1797) and *Tadarida teniotis* (Rafinesque, 1814).

killingin on 12 August 1903 (Thomas 1904). The main features of this species were described as follows (Thomas 1904: 157–158): "General colour above pale buffy, the slaty bases of the hairs showing through; below similar, but slightly paler. Membranes pale brown, without lighter edging; […] Ears rather short; inner margin strongly convex bellow, with very small basal lobule, slightly convex above; tip rounded off; outer margin convex, […] with a long, low, rounded antitragal lobe. Tragus rather short, broadest rather above its inner base, inner margin straight, tip rounded, outer margin evenly convex; […] Skull, as compared with that of *P*. *nanus* [= *Neoromicia nanus* (Peters, 1852)], similar in size, but with a broader, flatter muzzle and smaller brain-case. […] Incisors slender, conical, unicuspid terminally, though each has a minute basal cusplet on its cingulum behind; the outer two thirds the height of the inner. Small upper premolar unusually minute, hidden in the inner angle between the closely adpressed canine and large premolar, and lower than their cingula". For a long time, only three specimens were assigned to this species*; along with the type series of two bats, an individual from Rahad (Kordofan, central Sudan) was included (Flower 1932) (from a pair of bats reported by Flower, only one skin without skull remained in BMNH; Kock 1969, Koopman 1975). A fourth individual assigned to *P. ariel* has been reported by Makin & Harrison (1988: 419); a dead 'male in rather poor condition' was found at Nahal Zeëlim, north Negev, Israel (31° 21' N, 35° 20' E). As concluded by Harrison & Bates (1991: 93), *Pipistrellus ariel* (in their sense) is extremely rare bat known only from three localities (also see above); however, they also stressed that "this species is quite closely related to *Pipistrellus bodenhemeri*. More material of *P. ariel*, both from Egypt and Israel is required, to make a fuller assessment of the status of these two taxa."

Harrison (1960) described the species *Pipistrellus bodenheimeri* on the basis of an adult female shot at 'Yotvata, Wadi Araba, 40 km. north of Eilat, Israel'. He distinguished it from *Pipistrellus ariel* Thomas (Harrison 1960: 264) on the basis of larger skull size, darker coloration, bicuspid first upper incisors and slightly larger small upper premolars [$P^3$]. Harrison (1964) also assigned to this species four individuals collected in southern and eastern Yemen (Jazirat al Abid at Aden, and Seiyun), together with a specimen collected again at the type locality in Israel. Other records from Israel were reported by Makin (1977) from Ein Yahav and Ein Gedi and later by Makin & Harrison (1988) from Eilat. These records were mentioned by Qumsiyeh (1985), who added two further specimens from Sinai (see above). Gaucher & Harrison (1995) mentioned two individuals of *P. bodenheimeri* from Saudi Arabia (Asir escarpment near Taif); these bats were coloured dark greyish above instead of pale buffy as usual in this species.

Yom-Tov et al. (1992a, b) recorded and examined an extremely large number of *P. bodenheimeri* (more than 250 individuals) from six sites in the Dead Sea area of Israel (from Ain Fashka to Neot Hakikar) along with one of *P. ariel* (published already by Makin & Harrison 1988, see above); they noted concerning the latter form (Yom-Tov et al. 1992a: 133): "This species is similar in size to *P. bodenheimeri*, but differs in having a unicuspid upper incisor and a more delicate skull (Harrison 1960). However *P. bodenheimeri* caught at En Gedi on 19 October 1987 (Tel Aviv University, Zoological Museum, M.8054) and identified by Dr. D. L. Harrison as *P. bodenheimeri* had a unicuspid upper incisor. This finding raises the possibility that *P. ariel* and *P. bodenheimeri* are conspecifics, if not synonymous." Makin & Harrison (1988) describing the individual of *P. ariel* from Nahal Zeëlim concluded, that all main traits (body and skull size, most of dental and cranial characters, structure of penis and baculum) are the same or very close to *P. bodenheimeri* (for baculum size and shape see also Harrison 1982) but with two exceptions; the upper incisors – the first one is unicuspid and narrow and the second incisor is higher, reaching $^2/_3$ of height of the crown of the first one – and the shape of muzzle and ears (this state of differences was repeated by subsequent authors; Harrison & Bates 1991, Koopman 1994, Mendelssohn & Yom-Tov 1999, Amr 2000, Riskin 2001, Ferguson 2002†). However, with respect of the latter characters it would be proper to remark that their examination was made from a dead specimen found in a poor condition (Makin & Harrison 1988, Qumsiyeh 1996). Thus, the only remaining reliable

*Note. Another remark concerning a possible record of *H. ariel* in Africa was published by Sanborn & Hoogstraal (1955: 177): "Hoogstraal and Kaiser believe that they observed this bat at Bir Kansisrob, Gebel Elba [= Sudan Admin. Area of Egypt], but were not able to secure specimens."

†Note. Ferguson (2002) suggested *H. bodenheimeri* (which he considered separate from *H. ariel*) to be a smaller desert subspecies of *Hypsugo savii* (Bonaparte, 1837), a larger Mediterranean member of the genus. However, such opinion is quite isolated while the separate status of *H. bodenheimeri* has been broadly accepted (see above and Benda et al. 2006 for a review). Besides the apparent differences in body and skull size, *H. savii* differs totally from *H. ariel/bodenheimeri* in coloration of the pelage and naked parts, in the shape of baculum and in ecological requirements (e.g., Harrison 1960, 1982, Harrison & Bates 1991). The results of genetic comparison of these two forms also confirmed their separation well (Mayer et al. 2007).

Table 4. Basic biometric data [in mm] on examined Sinaitic and comparative samples of *Hypsugo ariel* (Thomas, 1904) and of *H. arabicus* (Harrison, 1979) from Oman and Iran. For abbreviations see p. 6

| | Sinai | | | | | Holy Land | | | | | Sudan | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n | **M** | min | max | SD |
| LAt | 15 | **31.18** | 28.8 | 32.5 | 1.065 | 6 | **30.27** | 29.3 | 31.3 | 0.700 | 1 | **30.80** | – | – | – |
| LCr | 4 | **11.57** | 11.39 | 11.79 | 0.182 | 4 | **11.38** | 10.82 | 12.12 | 0.545 | 2 | **11.13** | 10.98 | 11.27 | 0.205 |
| LCb | 4 | **11.10** | 10.92 | 11.41 | 0.227 | 4 | **10.82** | 10.23 | 11.71 | 0.628 | 2 | **10.60** | 10.38 | 10.82 | 0.311 |
| LaZ | 4 | **7.03** | 6.84 | 7.21 | 0.151 | 1 | **7.02** | – | – | – | 0 | – | – | – | – |
| LaI | 4 | **2.70** | 2.62 | 2.81 | 0.089 | 4 | **2.69** | 2.42 | 2.88 | 0.194 | 2 | **2.68** | 2.62 | 2.73 | 0.078 |
| LaInf | 4 | **3.49** | 3.37 | 3.62 | 0.134 | 4 | **3.54** | 3.22 | 3.73 | 0.228 | 2 | **3.45** | 3.42 | 3.48 | 0.042 |
| LaN | 4 | **5.63** | 5.51 | 5.73 | 0.091 | 4 | **5.59** | 5.10 | 5.87 | 0.355 | 2 | **5.52** | 5.48 | 5.56 | 0.057 |
| LaM | 4 | **6.14** | 5.93 | 6.29 | 0.155 | 4 | **5.96** | 5.44 | 6.38 | 0.394 | 2 | **5.88** | 5.75 | 6.01 | 0.184 |
| ANc | 4 | **4.02** | 3.89 | 4.17 | 0.123 | 4 | **3.92** | 3.66 | 4.25 | 0.272 | 2 | **3.82** | 3.75 | 3.88 | 0.092 |
| CC | 4 | **3.42** | 3.23 | 3.61 | 0.156 | 4 | **3.42** | 3.30 | 3.70 | 0.189 | 2 | **3.47** | 3.20 | 3.73 | 0.375 |
| $M^3M^3$ | 4 | **4.70** | 4.63 | 4.73 | 0.047 | 4 | **4.66** | 4.23 | 4.93 | 0.313 | 1 | **4.66** | – | – | – |
| $CM^3$ | 4 | **3.92** | 3.77 | 4.06 | 0.120 | 4 | **3.84** | 3.63 | 4.12 | 0.206 | 2 | **3.80** | 3.79 | 3.80 | 0.007 |
| LMd | 4 | **7.85** | 7.75 | 8.01 | 0.113 | 4 | **7.63** | 7.42 | 8.22 | 0.394 | 2 | **7.63** | 7.55 | 7.71 | 0.113 |
| ACo | 4 | **2.26** | 2.12 | 2.36 | 0.111 | 4 | **2.28** | 2.12 | 2.51 | 0.170 | 2 | **2.34** | 2.31 | 2.37 | 0.042 |
| $CM_3$ | 4 | **4.22** | 4.11 | 4.36 | 0.123 | 4 | **4.06** | 3.64 | 4.44 | 0.328 | 2 | **4.03** | 3.98 | 4.08 | 0.071 |

| | continental Yemen | | | | | Iran | | | | | Oman |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n=1 |
| LAt | 17 | **29.92** | 28.1 | 32.1 | 1.121 | 12 | **31.06** | 29.9 | 32.4 | 0.667 | 30.9 |
| LCr | 12 | **11.48** | 10.63 | 11.83 | 0.334 | 9 | **11.43** | 11.08 | 11.63 | 0.167 | 11.32 |
| LCb | 12 | **10.99** | 10.19 | 11.50 | 0.371 | 8 | **10.79** | 10.36 | 11.04 | 0.205 | 10.77 |
| LaZ | 10 | **7.05** | 6.68 | 7.33 | 0.214 | 8 | **7.28** | 7.00 | 7.52 | 0.180 | 7.13 |
| LaI | 12 | **2.61** | 2.44 | 2.74 | 0.076 | 9 | **2.89** | 2.75 | 2.98 | 0.083 | 3.01 |
| LaInf | 12 | **3.62** | 3.34 | 3.84 | 0.139 | 9 | **3.35** | 3.09 | 3.42 | 0.110 | 3.34 |
| LaN | 12 | **5.52** | 5.34 | 5.67 | 0.105 | 9 | **5.94** | 5.72 | 6.10 | 0.138 | 5.75 |
| LaM | 12 | **6.09** | 5.87 | 6.32 | 0.145 | 9 | **6.18** | 5.96 | 6.32 | 0.133 | 6.23 |
| ANc | 12 | **3.97** | 3.73 | 4.14 | 0.109 | 9 | **4.16** | 4.03 | 4.35 | 0.105 | 4.07 |
| CC | 12 | **3.46** | 3.27 | 3.64 | 0.133 | 9 | **3.37** | 3.18 | 3.44 | 0.078 | 3.20 |
| $M^3M^3$ | 12 | **4.76** | 4.47 | 5.18 | 0.199 | 9 | **4.66** | 4.35 | 4.82 | 0.135 | 4.57 |
| $CM^3$ | 12 | **3.99** | 3.74 | 4.28 | 0.171 | 9 | **3.92** | 3.75 | 4.10 | 0.095 | 3.97 |
| LMd | 12 | **7.85** | 7.42 | 8.13 | 0.223 | 9 | **7.67** | 7.38 | 7.88 | 0.171 | 7.83 |
| ACo | 12 | **2.33** | 2.16 | 2.46 | 0.082 | 9 | **2.30** | 2.11 | 2.42 | 0.103 | 2.28 |
| $CM_3$ | 11 | **4.24** | 4.02 | 4.47 | 0.163 | 9 | **4.11** | 3.98 | 4.22 | 0.070 | 4.18 |

distinguishing character is the different number of cusps on the first upper incisor (Corbet 1978, Yom-Tov et al. 1992a, Qumsiyeh 1996, see also Gaucher & Harrison 1995).

We compared a limited material of skulls of *ariel/bodenheimeri* complex from two areas of distribution, northwestern Arabia (i.e. Sinai, Israel, Jordan; n=8) and southern Arabia (Yemen incl. Socotra: n=16), with the type series of *Pipistrellus ariel* from NE Sudan (n=2) and also with a series of *Hypsugo arabicus* (Harrison, 1979), a morphologically very similar species from Oman and Iran (n=10). For this comparison, we also examined the type specimens of these three taxa (see Appendix II).

In the body and skull size, all these bats more or less concurred (Table 4). In the width of rostrum, the feature mentioned to be in *ariel* narrower than in *bodenheimeri*, the Sudanese and Arabian samples agreed in the ratio LCr/LaInf, only the *arabicus* samples were relatively slightly narrower

(Fig. 35). However, the size and shape of both upper incisors were extremely varied among the compared samples. In the Arabian (= *bodenheimeri* sensu Harrison & Bates 1991) samples two basic dental morphotypes were present, '*bodenheimeri*' bicuspid incisors and '*ariel*' unicuspid incisors (Table 5). Moreover, some of the unicuspid '*ariel*' morphotypes could be considered intermediate as unicuspid incisors showed a more or less developed ridge or rudimentary cusplet on the palatodistal surface of the crown or an enlarged posterior part of cingulum (Fig. 36b, c); in these '*ariel*' morphotypes, the second upper incisor was larger relative to the size of the first upper incisor than in the '*bodenheimeri*' morphotype (Fig. 36c, g). All samples of *arabicus* presented only one dental morphotype, with the bicuspid first upper incisor. Both Sudanese skulls (type series of *ariel*) showed unicuspid morphotype.

Such extreme variation in the limited set of compared skulls showed that both morphotypes (unicuspid '*ariel*' and bicuspid '*bodenheimeri*') are present in the Arabian continental populations (n=17; '*ariel*' n=4; '*bodenheimeri*' n=11; intermediate n=2; Table 5). Although the bicuspid morphotype seems to be roughly twice as frequent as the unicuspid and intermediate ones, the relatively high frequency of the '*ariel*' morphotype within the population generally assigned to *H. bodenheimeri* cannot be dismissed as a minor aberration. Thus, we understand the above mentioned structure of upper incisors to be inapplicable for taxonomic differentiation in the *ariel/bodenheimeri* complex.

Discriminant analysis of dimensions from the above mentioned skull samples clearly separated three clusters (13 dimensions as in Table 4 with an exception of LaZ; CV1=70,14% of variance, CV2=19,32%; Fig. 37); (1) cluster of *H. arabicus* (Oman and Iran), (2) cluster of *H.* '*bodenheimeri*' from Socotra, and (3) cluster of all other remaining samples (Sudan, Sinai, Holy Land, and

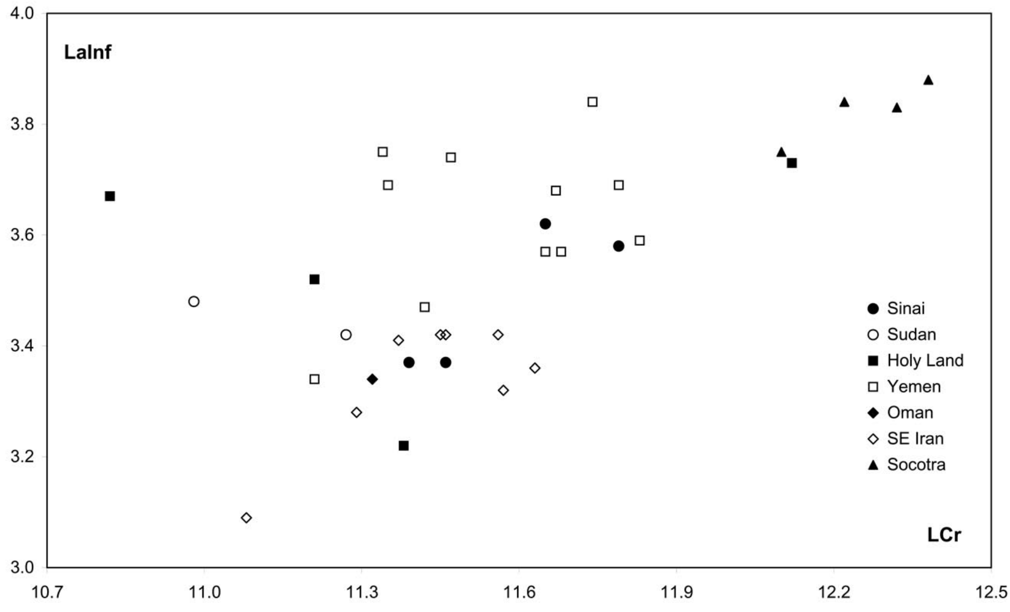



Fig. 35. Bivariate plot of examined Sinaitic and comparative samples of *Hypsugo ariel* (Thomas, 1904) and *H. arabicus* (Harrison, 1979): greatest length of skull (LCr) against the infraorbital width of rostrum (LaInf). See text for details.

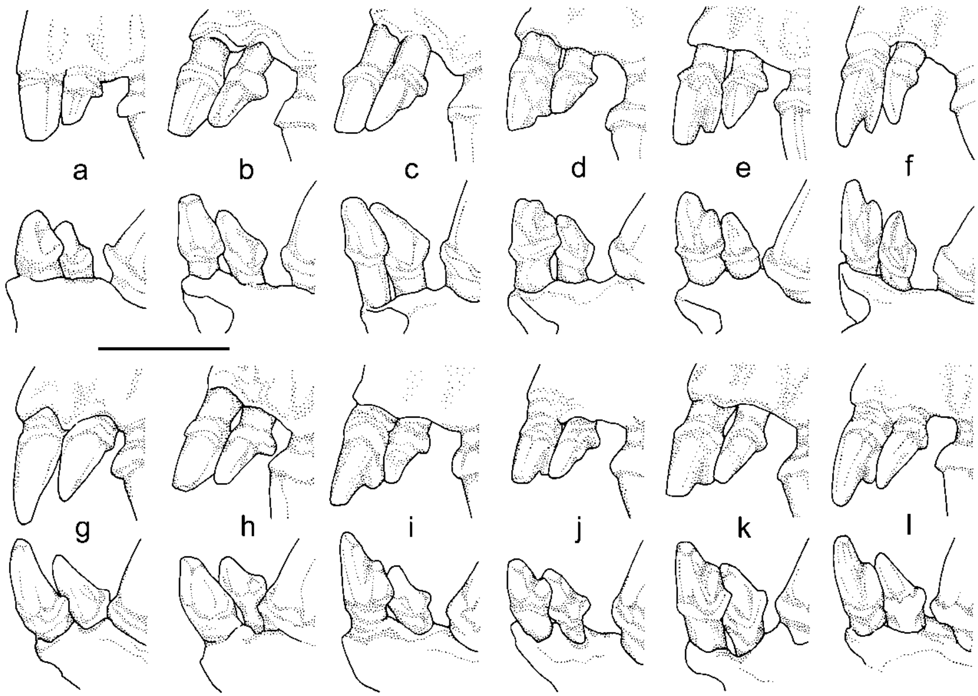



Fig. 36. Left upper incisors of *Hypsugo ariel* (Thomas, 1904); upper lines (above letters) – labial views, lower lines (below letters) – palatal views; upper row (a–f) – samples from northern part of the range (Sudan, Sinai, Holy Land), lower row (g–l) – samples from southern part of the range (Yemen). Legend: a – male (BMNH 4.11.4.6.), Wadi Alagy, Sudan; b – male (CDIS 945), Wadi El Arbaein, Sinai; c – male (NMP 92095), Wadi Rum, Jordan; d – female (NMP 90494), Feiran, Sinai; e – male (NMP 90493), Feiran, Sinai; f – male (CDIS 946), Ain Hudra, Sinai; g – female (NMP pb3024), Hawf, Yemen; h – female (NMP pb3027), Hawf, Yemen; i – male (NMP pb3022), Hawf, Yemen; j – female (NMP pb3054), Sayhut, Yemen; k – female (NMP pb3050), Damqawt, Yemen; l – male (NMP pb3058), Al Nueimah, Yemen. Scale bar = 1 mm.

Yemen). As the third cluster comprised of samples assigned both to *H. ariel* and *H. bodenheimeri* populations as well as the type specimens of both these descriptions the analysis suggests very similar or even identical skull shape in both forms.

Since in all other morphologic characters these two forms were reported to agree, as already shown by other authors (see above), we assume it to be appropriate to classify both named forms (*ariel* and *bodenheimeri*) under the one species, *H. ariel*. *H. arabicus* on the other hand represents a well defined separate species based on characters other than dentition (skull shape, skin and pelage coloration, penis shape, baculum, etc.). Furthermore, the taxonomic status of the Socotranese population of *H. ariel* should also be revised; these bats were most often regarded as *H. bodenheimeri* (Corbet 1978, Menu 1987, Guichard 1992, Koopman 1994, Wranik et al. 1999, etc.), however, the above analysis suggested further possible separate position for this island population.

From samples collected in Sinai one bat presented the '*ariel*' dental morphotype (Fig. 36b), an individual collected in the Wadi El Arbaein (CDIS 945), while three other collected specimens (Fig. 36d–f) showed the '*bodenheimeri*' dental morphotype. Considering morphotypes of all bats

Table 5. Distribution of some dental characters within examined samples of *Hypsugo ariel* (Thomas, 1904) and of *H. arabicus* (Harrison, 1979). Relative size of the second upper incisor ($I^2$) is expressed as a percent ratio of its crown square to that of the first incisor ($I^1$) taken across the cingulum. For other details concerning the dental characters see text

| character | population / taxon | | | | | |
|---|---|---|---|---|---|---|
| | northern / *H. ariel* | | southern / *H. ariel* | | eastern / *H. arabicus* | |
| | n | % | n | % | n | % |
| **$I^1$ morphotype** | **6** | | **11** | | **9** | |
| bicuspid | 4 | 66.7 | 7 | 63.6 | 9 | 100.0 |
| intermediate | – | – | 2 | 18.2 | – | – |
| unicuspid | 2 | 33.3 | 2 | 18.2 | – | – |
| **$P^3$ presence** | **6** | | **12** | | **9** | |
| both present | 4 | 66.7 | 10 | 83.3 | 9 | 100.0 |
| one present | 2 | 33.3 | – | – | – | – |
| both absent | – | – | 2 | 16.7 | – | – |
| **$I^2$ relative size** | **6** | | **11** | | **9** | |
| > 90% of $I^1$ | 1 | 16.7 | 5 | 45.4 | 3 | 33.3 |
| 70–90% of $I^1$ | 2 | 33.3 | 3 | 27.3 | 6 | 66.7 |
| < 70% of $I^1$ | 3 | 50.0 | 3 | 27.3 | – | – |
| mean [%] | 76.1 | | 82.5 | | 87.1 | |

known from Sinai (incl. those reported by Qumsiyeh 1985), the '*ariel*' morphotype represents 16.7% of the examined Sinaitic bats. A comparison of the echolocation calls of the '*ariel*' dental morphotype (CDIS 945) and '*bodenheimeri*' morphotype from Ain Hudra (CDIS 946) showed

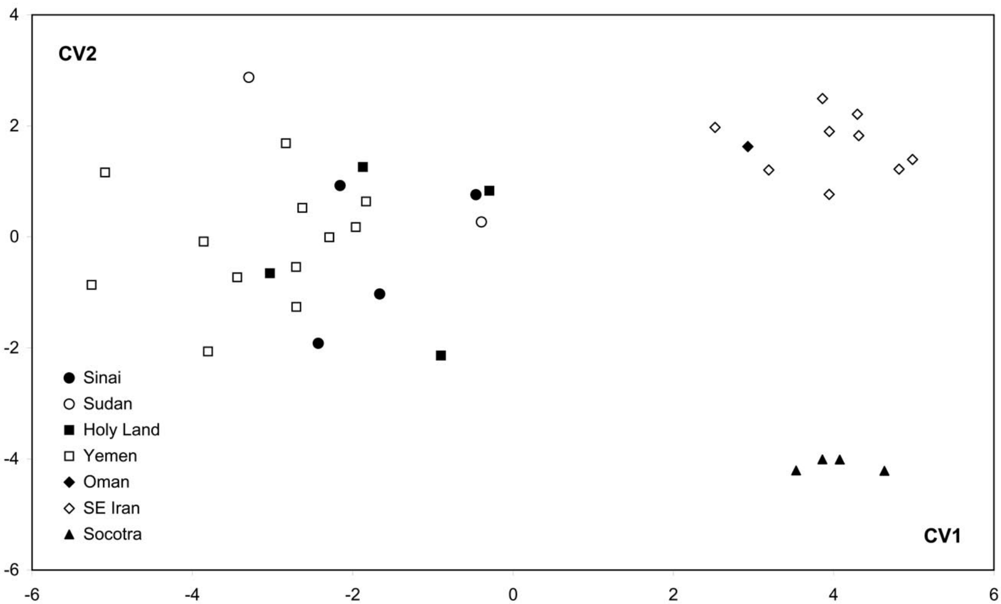



Fig. 37. Bivariate plot of examined Sinaitic and comparative samples of *Hypsugo ariel* (Thomas, 1904) and *H. arabicus* Harrison, 1979: results of the discriminant analysis of skull dimensions (for details see text).

no variation (Dietz 2005a, b). Distance between genomic sequences obtained from these two bats (895 bp of the mitochondrial gene ND1; Mayer et al. 2007) represented only 0.34%. Apparently, it is not sufficient to support a species difference between the two forms. As the geographic distance between the sample sites was ca. 60 km only, the data suggest rather a presence of haplotype polymorphism within the species than a smooth divergence-by-distance substructures.

Thus, our records and analyses confirm doubts on the taxonomic position of *H. bodenheimeri* as a separate species, expressed already by Qumsiyeh et al. (1992), Yom-Tov et al. (1992a), Mendellsohn & Yom-Tov (1999), Horáček et al. (2000), Benda et al. (2002), Dietz (2005a), Simmons (2005), and Mayer et al. (2007) about . Therefore, we propose *Hypsugo bodenheimeri* (Harrison, 1960) to be conspecific with *Hypsugo ariel* (Thomas, 1904).

Feeding ecology. According to data from Israel, *Hypsugo ariel* is a bat which forages above water pools and around vegetation edges, being reported to feed opportunistically on Diptera, Hymenoptera, Coleoptera and/or Lepidoptera (Yom-Tov et al. 1992b, Whitaker et al. 1994, Feldman et al. 2000). The digestive tracts of two individuals collected in the Feiran Oasis of Sinai contained particularly small beetles of the genus *Aphodius* (Scarabeidae) (60% volume) and other Coleoptera (most probably Tenebrionidae: Aleculinae) (20%). The other recorded prey categories were Brachycera (10%), Lepidoptera and Auchenorrhyncha (Fig. 16). Furthermore, some fragments from representatives of other groups of Coleoptera were recorded from faeces (probably of Cerambycidae). Results of the analysis of *H. ariel* diet from Sinai as well as observations of foraging individuals correspond well with results of the previous studies from the southern Holy Land.

Echolocation. Basic parameters of echolocation calls of *H. ariel* (Fig. 27, 38–43) are given in Table 3. To our knowledge, we report the first detailed information on echolocation design of

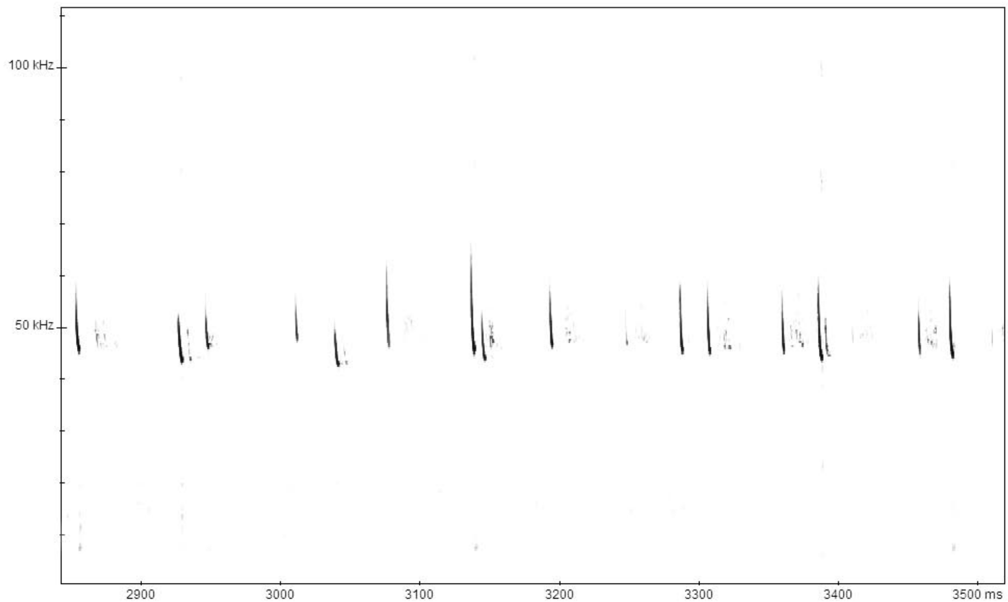
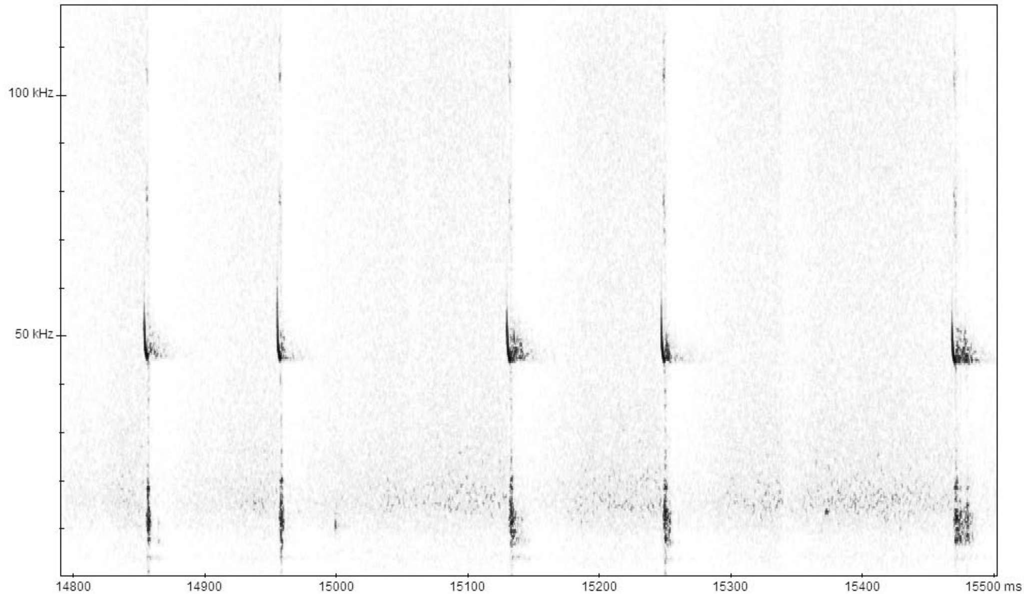
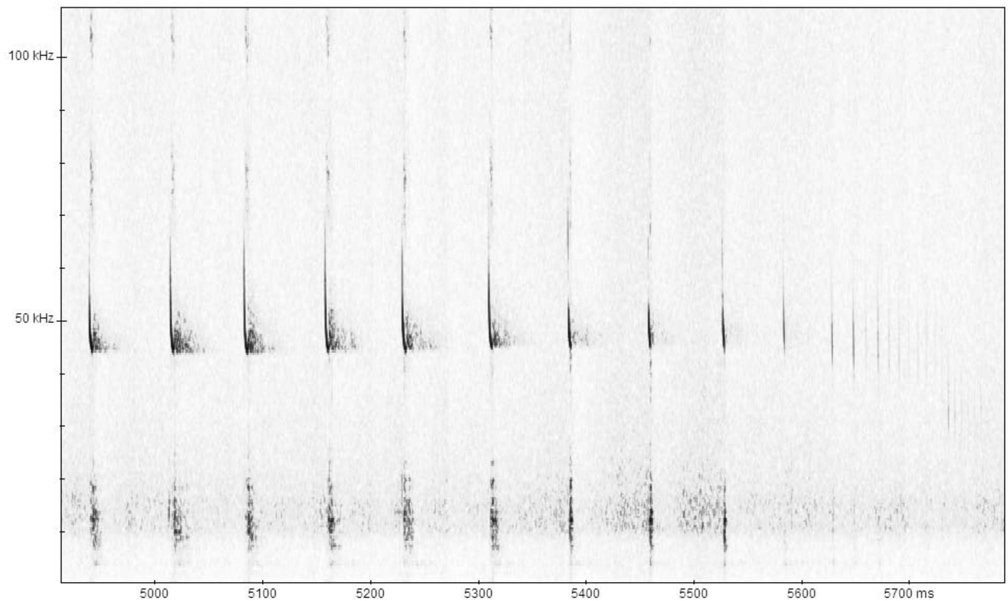
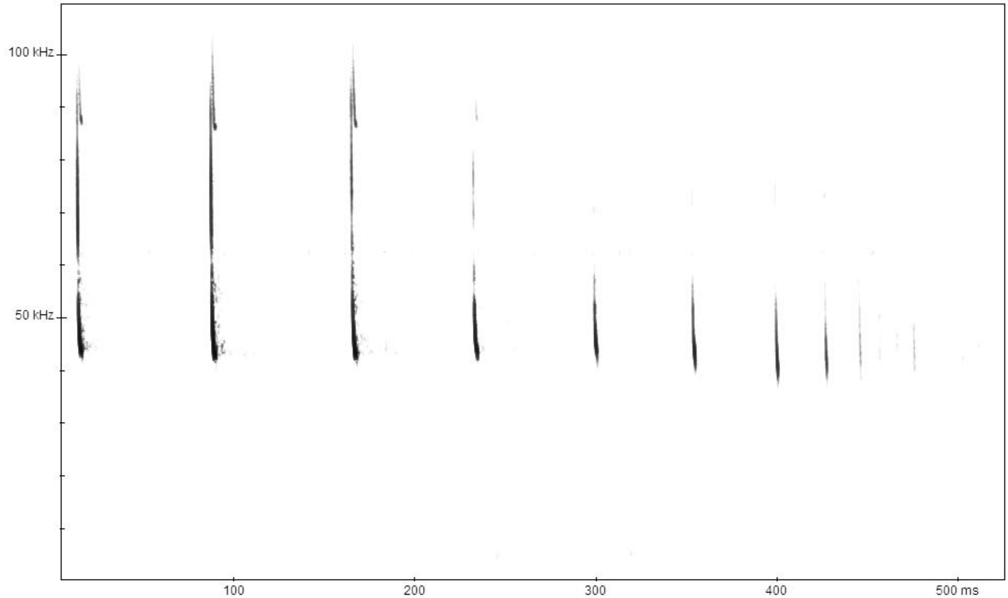


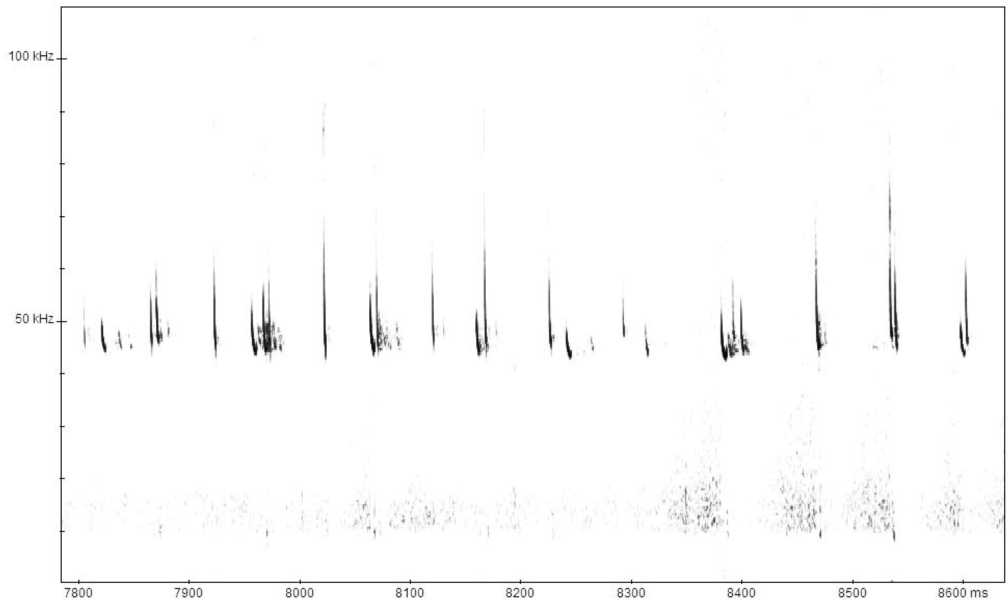

Fig. 38. Spectrogram of echolocation calls of *Hypsugo ariel* (Thomas, 1904): two individuals foraging at a water pool close to the Ain El Furtaga Oasis.




Figs. 39, 40. Spectrograms of echolocation calls of *Hypsugo ariel* (Thomas, 1904): 39 (above) – an individual foraging in open space in the Ain Hudra Oasis. 40 (below) – approaching phase finished with terminal buzz of an individual foraging in open space in the Ain Hudra Oasis.




Figs. 41, 42. Spectrograms of echolocation calls of *Hypsugo ariel* (Thomas, 1904). 41 (above) – approaching phase finished with terminal buzz of an individual foraging in St. Katherine Research Center, El Milga. 42 (below) – three individuals simultaneously foraging at a water pool at western edge of the Feiran Oasis.

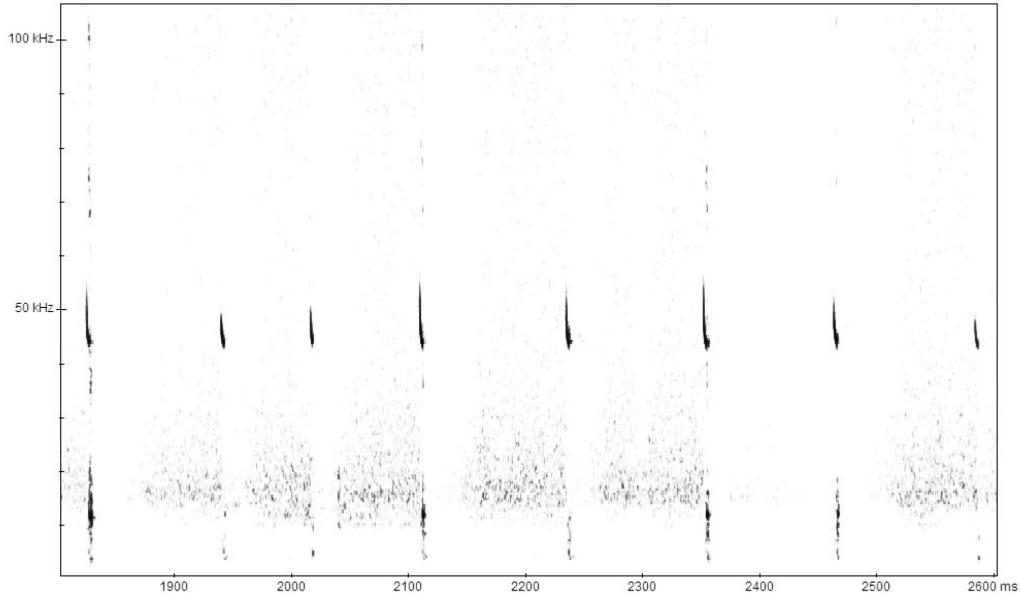



Fig. 43. Spectrogram of echolocation calls of *Hypsugo ariel* (Thomas, 1904): an individual foraging in open space in the Feiran Oasis.

this species. The only exception are the brief descriptions given by Shalmon et al. (1993) and Mendelssohn & Yom-Tov (1999), who mentioned the range of vocalisation of *Pipistrellus bodenheimeri* (= *H. ariel*) to be between 17 and 71 kHz with maximum energy at 44–45 kHz. Based on our quite rich data (cf. 161 calls obtained from 17 call sequences), echolocation design of *H. ariel* in most characters is nearly identical with European *Pipistrellus pipistrellus* (Schreber, 1774), except for shorter PDUR (see Russo & Jones 2002). However, these two species should not be confused in the Middle East even in the quite improbable case of sympatric occurrence, since the Levantine populations of *P. pipistrellus* produce higher FMAXE (~ 50 kHz; Shalmon et al. 1993, Mendelssohn & Yom-Tov 1999, Benda et al. 2006).

### *Pipistrellus kuhlii* (Kuhl, 1817)

Records. **Published data**: El-Arish [1], August 1951: 8 f (Wassif et al. 1984); – Magdabah [2], 30 km S of El-Arish, roof of the one-chambered police post, 3 m, 2 f (Wassif 1953); – Zarnikh Is. [3], Sabkhet El Bardawil, 1 ind. (HZM) (Qumsiyeh 1985); Zarnikh, 20 km W of El Arish, 1 ind. (HZM) (Harrison & Bates 1991) – [petraeische Arabien (Cretzschmar 1830)]; – [Suez and its neighbourhood [4], 1 m, 7 f (Anderson 1902)].

Comments. *Pipistrellus kuhlii* is known from Mediterranean and semi-desert habitats of the Middle East and North Africa; in these environments, it is considered the most abundant bat species (Flower 1932, Qumsiyeh 1985, Mendelssohn & Yom-Tov 1999, Benda et al. 2006). In Sinai, this species has been recorded only to the north, from and near the town of El Arish (Fig. 30). Anderson (1902) mentioned eight specimens originating in ‘Suez and its neighbourhood’, thus possibly also from the Sinaitic territory (cf. Harrison & Bates 1991). Cretzschmar (1830: 74) described his new bat species *Vespertilio marginatus* (= *P. kuhlii*) from ‘Nubien und das petraeische Arabien’. The type locality could partly mean Sinai (Ellerman & Morrison-Scott 1951, Kock 1969, Gaisler et al. 1972, Qumsiyeh 1985, Qumsiyeh et al. 1992; see also under *Barbastella leucomelas*), however, it was later mentioned as 'Aegypten' (Rüppell 1842) or 'In Ägypten, Nubien und dem peträischen Arabien' (Fitzinger 1866). According to the type specimen labelling, Anderson (1902) suggested to restrict type locality to 'Egypt'. This opinion was definitely accepted by subsequent authors (Mertens 1925, Allen 1939, Ellerman & Morrison-Scott 1951, Kock 1969, Gaisler et al. 1972, Koopman 1975, etc.).

*P. kuhlii* has shown a similar distribution pattern in the neighbouring countries as in Sinai. In continental Egypt, it occurs in the northern part of the Nile Valley (to N of Tel El Amarnah in Minya Gov.; 27° 39' N) including El Faiyum, Nile Delta from Burg El Arab to Suez and near Ismailia, Wadi El Natrun, and environs of Mersa Matruh (Anderson 1902, Flower 1932, Madkour 1977, Wassif et al. 1984, Qumsiyeh 1985, Wassif 1995, etc.). It is absent from any desert oases or from the Upper Egypt to S of Minya Governorate; two females reported by Anderson (1902) from 'Khayzal and Luxor' in Upper Egypt were found by Qumsiyeh (1985) to belong to *P. deserti*, a Saharan vicariant to *P. kuhlii*. Thus, distribution of *P. kuhlii* is limited to the northern part of Egypt, mainly to populated fertile areas.

A complete absence of the species in repeated bat-detectoring records from Sharm El Sheikh and neighbouring towns and sea resorts of southern Sinai (Horáček, ad verb.), i.e. habitats in which *P. kuhlii* achieves enormous abundance in the true Mediterranean, provides an indirect but quite a strong support for its absence in the southern part of the peninsula.

Mendelssohn & Yom-Tov (1999: 135) summarised the Israeli occurrence of *P. kuhlii* as: "it is the most common insectivorous bat in the Mediterranean zone, but is also found in the Northern Negev and Judean Deserts in the Dead Sea Area"; they showed many sites in the northern and central Israel, but did not indicate any record from the southern Negev (to S of 30° 30' N) and the Arava Valley. Korine & Pinshow (2004) presented twelve records from central Negev around Sede Boqer, and this area probably represents the southern margin of the species' regular range in the Holy Land. In Jordan, *P. kuhlii* is known to occur only to north of the Dead Sea, including oases in the Syrian Desert (Qumsiyeh et al. 1998). However, Zelenova & Yosef (2003) recently reported an individual netted at Eilat (S Israel) in 2002, apparently the first record in the southern desert areas of the Holy Land.

Although we did not record *P. kuhlii* in the course of our fieldwork in southern Sinai, the latter report suggests that in the eastern part of Sinai, adjacent to the southern Negev, this species may also be present in the harsh desert habitats.

### *Otonycteris hemprichii* Peters, 1859

Records. **Original data**: Feiran [1], above a pool in western edge of the oasis, 8 September 2005: net. 1 fa (NMP 90495 [S+A]; cf. Benda et al. 2006; Fig. 44); – Feiran [2], a garden in eastern edge of the oasis, 10 September 2005: net. 1 ma (NMP 90500 [S+A]; cf. Benda et al. 2006), det. & rec. 1 ind.; – Wadi Nasb [3], Mousa's Garden, 29 June 2006: net. 1 ma, 22 July 2006: net. 1 ma; – Wadi Sulaf [4], Wadi El Braga Camp, 10 July 2007: net. 3 ma. – **Published data**: El-Arish [5], August 1944: 1 m (Wassif 1953, 1995, Wassif et al. 1984).

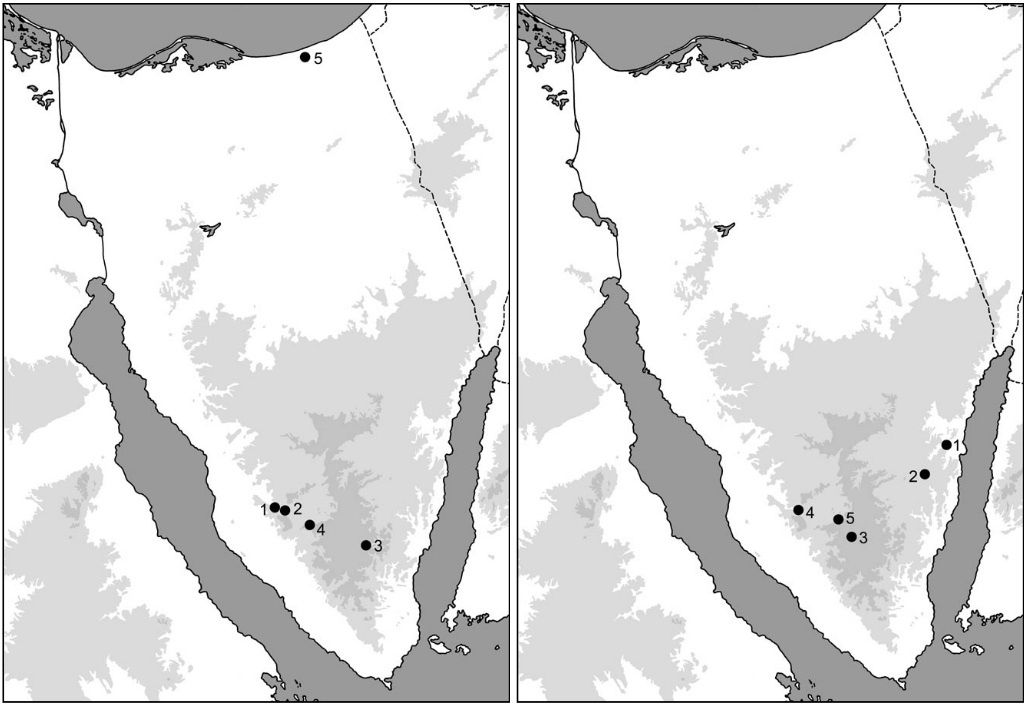
Comments. *Otonycteris hemprichii* is known from four areas in Sinai, however, these spots lie both in southern and northern parts of the peninsula (Fig. 45). Wassif (1953: 110) reported an individual to be collected in northern Sinai: "a male long-eared bat was procured from an old building in the city of El-Arish." Our four records come from rather synanthropic habitats, although the bats were netted in the barren parts of wadis into nets installed above artifical water reservoirs (an exception is a relatively fertile garden on the eastern edge of the Feiran Oasis). Since *O. hemprichii* is a true desert dweller (Horáček 1991, Fenton et al. 1999), occurring both in rather mild semi-desert areas

Fig. 44. A female of *Otonycteris hemprichii* Peters, 1859 from the oasis of Feiran, Sinai (photo by P. Benda).

(Lower Egypt, Mesopotamia) as well as in harsh continental deserts (Sahara, Iran Plateau, Central Asia), it would be presumed to be present throughout the Sinaitic peninsula and the limited records available are most unexpected. On the other hand, all the locals we asked reported a very pale and large big-eared bat coming to fireplaces and even inside buildings, particularly in winter. This could indicate a wider distribution of *O. hemprichii* in Sinai.

In the neighbouring territories to Sinai, *O. hemprichii* has not been reported to be rare, with records from about twenty localities within the relatively restricted area of the southern part of the Holy Land. Its distribution patterns there resemble well that of *Rhinolophus clivosus* (see above). In Israel, *O. hemprichii* occurs mainly in the Negev and Judean Deserts to the south of the Dead Sea, in the northern and also southernmost parts of the Arava Valley; Mendelssohn & Yom-Tov (1999) reported at least eleven records from this area (and only three from northwards of Be'er Sheva [ca. 31° 15' N]: Ein Gedi, Nabi Musa and Rosh Ha'Ayin), Zelenova & Yosef (2003) added two individuals netted at Eilat; Korine & Pinshow (2004) collected data from four localities around Sede Boqer in the central Negev Desert. Similar type of distribution has been observed in Jordan; Amr (2000) reported five sites of *O. hemprichii* occurrence along the Rift Valley from the Dead Sea area (incl.) to Wadi Ramm (along with two records in the Syrian Desert, E Jordan).

To the west, *O. hemprichii* is known to occur in continental Egypt mainly from the Cairo region as south as to El Faiyum and west to Wadi El Natrun (Qumsiyeh 1985, Wassif 1995). Isolated




Figs. 45, 46. 45 (left) – records of *Otonycteris hemprichii* Peters, 1859 in Sinai. 46 (right) – records of *Barbastella leucomelas* (Cretzschmar, 1830) in Sinai.

records were reported from west of Alexandria and from the Siwa and Kharga Oases (Anderson 1902, Gaisler et al. 1972). Besides a record from 20 miles east of Cairo (Sanborn & Hoogstraal 1955) and another one from Kosseir [= Quseir] (Klunzinger 1878), *O. hemprichii* has not been found in the Eastern Desert of Egypt (Qumsiyeh 1985). Surprisingly, it has not been found in the Egyptian portion of the Nile Valley except for the type specimens, which might originate from the 'Niltal zwischen nördlich von Assuan, Ägypten [= N of Aswan, S Egypt], bis Chondek, N-Sudan [= Al Khandaq, N Sudan]' (Kock 1969: 183–184, 215).

From such a distribution pattern, this would support the previous suggestions by Harrison (1964), Qumsiyeh (1985) and Harrison & Bates (1991) that the Egyptian and Arabian (incl. the Sinaitic) populations are slightly isolated from each other and represent two distinct subspecies (see the review by Benda et al. 2006); *O. h. hemprichii* Peters, 1859 in Egypt, while *O. h. jin* Cheesman et Hinton, 1924 in Sinai, Holy Land and southern part of the Arabian peninsula. However, the results of morphologic and genetic analyses (Benda et al. 2006, Benda & Gvoždík in prep.) showed close proximity of these populations and therefore their subspecific division is improper (similarly as already suggested by Kock 1969 and Nader & Kock 1983). Therefore, the gaps in the known distribution of *O. hemprichii* in the Afro-Arabian part of its range are more likely a consequence of lack of records and a lesser intensity of field investigations than any real differences in local phylogenetic patterns. It certainly also holds true for the Sinaitic populations.

Feeding ecology. *Otonycteris hemprichii* is a gleaner, passively listening for prey on the ground and a facultative echolocator only (Horáček 1991). According to previous studies based on material from different parts of the Middle East and Central Asia, the most important prey categories seem to include large ground arthropods; Scorpionida, Solpugida, Coleoptera (Tenebrionidae, Scarabaeidae, Carabidae), Blattodea, Orthoptera, Heteroptera, and Hymenoptera were found to compose its diet there (Horáček 1991, Whitaker et al. 1994, Arlettaz et al. 1995, Fenton et al. 1999, Benda et al. 1999, 2006).

The most important prey categories found in digestive tracts of two individuals of *O. hemprichii* collected in Sinai were larger beetles from the Scarabaeidae family (85% volume), most probably of the Melolonthinae group. The other items were smaller representatives of Tenebrionidae (most probably Pimeliinae), Coleoptera larvae, Heteroptera, and Blattodea (Fig. 16). Substantial amount of larger scarabaeids in the diet probably indicates a certain human impact to foraging habitats – our samples were collected in an extensive oasis (Feiran) and the higher proportion of Scarabaeidae in the diet is similar to results obtained in Sapir, Israel (Whitaker et al. 1994). In desert areas more distant from human settlements, other prey items like Scorpionida, Solpugida, Orthoptera or Tenebrionidae are categories of major importance in the diet of *O. hemprichii* (Horáček 1991, Arlettaz et al. 1995, Benda et al. 1999, 2006). The record of Coleoptera larvae proves *O. hemprichii* use a ground gleaning foraging strategy.

Echolocation. Echolocation parameters of a single call sequence of *Otonycteris hemprichii* from the Feiran Oasis (Figs. 47, 48) are given in Table 3. Echolocation calls of *Otonycteris* are very short, broadband frequency-modulated signals with maximum intensity at around 22 kHz (Fig. 47). It resembles to echolocation design in European representatives of the genus *Eptesicus*

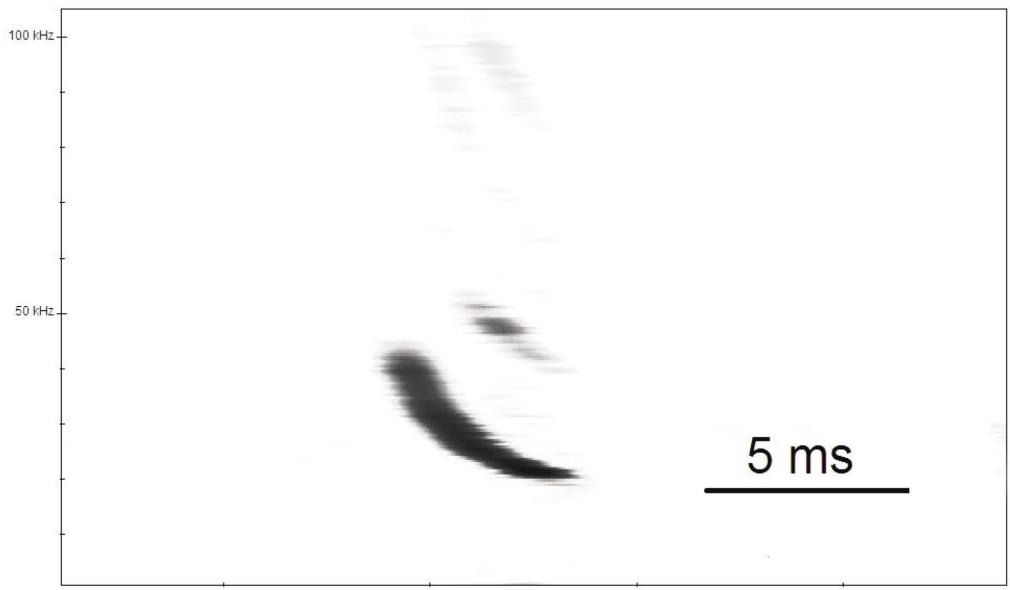



Fig. 47. Spectrogram of single echolocation call of *Otonycteris hemprichii* Peters, 1859: *Eptesicus*-like type of the call ending at about 20 kHz.

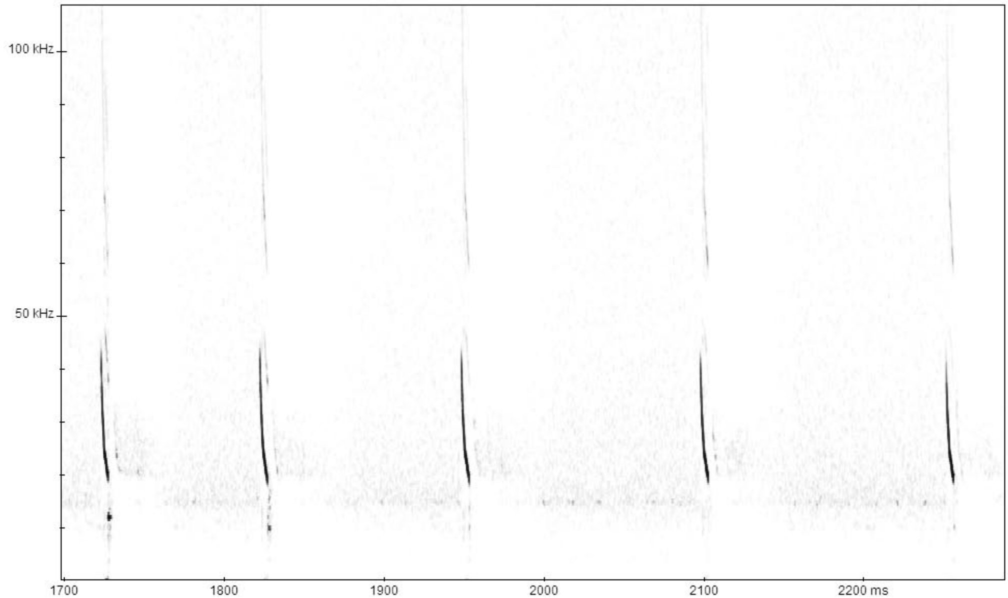



Fig. 48. Spectrogram of echolocation call of *Otonycteris hemprichii* Peters, 1859: an individual foraging in a garden in the eastern edge of the Feiran Oasis.

Rafinesque, 1820 but pulse duration is even shorter (Russo & Jones 2002). The first information on echolocation call of *O. hemprichii* was given by Horáček (1991) from Central Asia; he described it as a short series of low-frequency clicks with regular low repetition rate increasing when approaching a prey and terminating with feeding. Call ranges from 18–40 kHz with peak intensity at 30–32 kHz (Horáček 1991). Similar data were reported by Shalmon et al. (1993) and Mendelssohn & Yom-Tov (1999) from Israel, they mentioned a range from 20–40 and 20–37 kHz, respectively, with FMAXE at 34 kHz. While our analysis shows roughly the same bandwidth of echolocation signals, we found a much lower peak frequency than the previous authors. We argue that the difference may be caused by instrumental device used by Horáček (1991), since his description was made solely based on listening the sounds from a heterodyning bat-detector and no bioacoustic analytic tool was then used (I. Horáček, ad verb.). His data on peak intensity refer to span of the highest acoustic resolution in heterodyne record, not to the end frequency of a call. Mendelssohn & Yom-Tov (1999) did not mention the way of measuring of the values they reported, probably they mean the same.

### ***Barbastella leucomelas*** **(Cretzschmar, 1830)**

Records. **Original data**: Ain El Furtaga [1], a canyon above the oasis (Fig. 4), 15 September 2005: det. & rec. 1–2 inds.; – Ain Hudra [2], oasis (Fig. 5), 14 September 2005: net. 1 ma (NMP 90521 [S+A]), 15 September 2005: net. 1 ma (NMP 90522 [S+A]), det. & rec. 1–2 inds.; – El Milga [3], St. Katherine Research Centre, 29 July 2005: obs., det. & rec. 5 inds., 30 July 2005: net. 2 fa (CDIS 941, 942 [S+A]; Figs. 57, 58), 8 July 2007: net. 1 ma, det. & rec. min. 5–6 inds.; St. Katherine Research Centre and its surroundings, 30 July 2005: obs., det. & rec. min. 20 inds., 2 August 2005: obs., det. & rec. min. 20 inds., 9 August 2005: obs., det. & rec. min. 10 inds.; – Feiran [4], a garden in the eastern edge of the oasis, 9 September 2005: det. & rec. 1 ind.; – Sheikh Awad [5], El Karm Ecolodge (Fig. 49), 17 August 2005: det. & rec.

1–2 inds. – **Published data**: Das petraeische Arabien [restricted to Sinai probably by Flower 1932, see the Comments] (Cretzschmar 1830 [as *Vespertilio leucomelas*]), 1822 and/or 1826: 2 inds. (SMF II.M.1.a, II.M.1.b [S+B]) (Rüppell 1842 [as *Synotus leucomelas*], cf. Rüppell 1829) = 2 inds. (SMF 4343 [lectotype], 12393 [paralectotype]) (Mertens 1925, Kock 1969 [as *Barbastella barbastellus*]).

COMMENTS. *Barbastella leucomelas* is here reported from five sites in southern Sinai; the records are represented by five individuals netted and numerous detected (Fig. 46). Previously, only two specimens have been known from Sinai, collected by Eduard Rüppell in (most probably) the southern part of the peninsula in 1822 and/or 1826 (Rüppell 1829, 1842) (see below). There are very few other records and/or individuals of *B. leucomelas* available; two individuals were collected from Eritrea (von Heuglin 1877, Hayman & Hill 1971) and one from a 'Coast of Arabia' (Harrison 1964), and during the last 40 years six individuals were evidenced in southern Israel (Makin 1976, 1977, Harrison & Makin 1988, Mendelssohn & Yom-Tov 1999, Zelenova & Yosef 2003). The distributional range of *B. leucomelas* is centered to the areas around the northern edges of the Red Sea, however, from Egypt this bat is known only from Sinai. From Saudi Arabia it remains most probably unknown (Fig. 50), although Qumsiyeh (1985) placed Harrison's (1964) record there (see above). The Sinaitic records of *B. leucomelas* presented here could be considered a validation of the Rüppell's findings (sometimes doubted from the geographical point of view, see e.g. Corbet & Hill 1980) after some 180 years.

*B. leucomelas* was described under the name combination *Vespertilio leucomelas* by Cretzschmar (1830 *fide* Mertens 1925: 19) based on specimens collected by E. Rüppell (Fig. 51) in the course of his journey to northeastern Africa and adjacent territories in 1822–1827 (Cretzschmar

Fig. 49. El Karm Ecolodge in Sheikh Awad, roosting and foraging site of *Barbastella leucomelas* (Cretzschmar, 1830) and *Rhinolophus hipposideros* (Borkhausen, 1797) (photo by C. Dietz). In the area of the ecolodge, five species of bats were found: individuals of *Rhinolophus hipposideros* (Borkhausen, 1797), *Hypsugo ariel* (Thomas, 1904) and *Plecotus christii* Gray, 1838 netted and calls of *Barbastella leucomelas* (Cretzschmar, 1830) and *Tadarida teniotis* (Rafinesque, 1814) recorded.

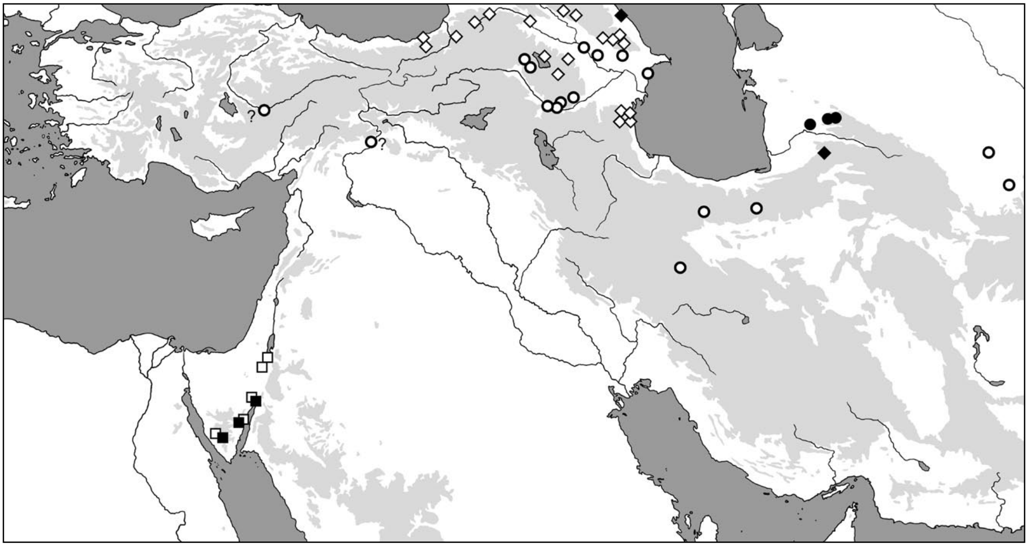


Fig. 50. Records of *Barbastella* Gray, 1821 in the Middle East. Legend: full symbols – sites of revised material origin, open symbols – sites of non-revised material origin, squares – *B. leucomelas* (Cretzschmar, 1830), circles – *B. darjelingensis* (Hodgson, 1855), diamonds – *B. barbastellus* (Schreber, 1774).

1826). Cretzschmar (1830: 73) mentioned as the 'Vaterland' and 'Aufenthalt' of this new species, available as the type locality, "Das petraeische Arabien. Alte verödete Wohnungen". Such a vague geographical term (Arabia Petraea, the Rocky Arabia) designates an area of arid mountains in present-day Jordan, Israel and Sinai with the ruined Nabatean town of Petra (SW Jordan) as a centre (i.e. the former Roman province Arabia Petraea lying to south and east of Judaea), sometimes it also covers the northern parts of the Hijaz Range, and slightly differs in each specific opinion (see e.g. Marsh 1994 for a review of the usage of this term). According to this broader definition, the original specimen/s (Cretzschmar did not mention the primary number of individuals or any type material) could have come from several modern states in the northwestern corner of the Arabian Peninsula. Rüppel (1842: 156) defined the origin of his specimens (he clearly mentioned two individuals collected by him) as 'Arabien'. At the same time, Gray (1838) mentioned the species *Plecotus leucomelas* Ruppell (= *Barbastella leucomelas* Cretzschmar) to inhabit North Africa. Dobson (1878) mentioned the distribution in Arabia Petraea. Later, Fitzinger (1866: 9) noted almost exactly according to Cretzschmar: "Von Dr. Rüppell an den Küsten des rothen Meeres im peträischen Arabien in alten Wohnungen aufgefunden." De Winton (in Anderson 1902), who considered Sinai as a part of Egypt, mentioned: "The bat described by Cretzschmar from Arabia Petraea has been identified as a specimen of the Barbastelle (*B. barbastellus*) of Europe. Heuglin records it from Massowah [= Mits'iwa, Eritrea; see von Heuglin 1877], so there is every probability that this species, occasionally at any rate, finds its way to the neigbouring country of Egypt." Thus, De Winton (o.c.) most probably did not recognise Arabia Petraea to cover Sinai as well. Palacký (1902: 18) co-identified the 'peträisches Arabien', an Asian range of *Synotus barbastellus*, within a part of Palestine (of that time = the area covered mostly by present-day Israel). Mertens (1925), Allen (1939), Tate (1942) and Lay (1967) mentioned as the type locality of *V. leucomelas* 'Arabia petraea', Bianki (1917) 'Каменистая Аравія' (= Rocky Arabia).

The first author to recognise the site of collection of the type series of *V. leucomelas* (Arabia Petraea) as Sinai was most probably Flower (1932: 384), however, he did not elucidate the reason. Subsequently to him, Sinai became commonly used as the type locality and/or the distribution area of this species (one of the first was for example Ryberg 1947), particularly, when this 'synonymy' ["Arabia Petraea (= Sinai)"] was mentioned by Ellerman & Morrison-Scott (1951) in their comprehensive and universally used book. By the subsequent authors, the type locality has been referred to Sinai sometimes without any note on Arabia or Arabia Petraea (Sanborn & Hoogstraal 1955, Harrison 1956, 1964, Hoogstraal 1962, Kuzjakin 1965, Kock 1969, Wallin 1969, Hayman & Hill 1971, Largen et al. 1974, Neuhauser & DeBlase 1974, Makin 1977, Corbet 1978, DeBlase 1980, Qumsiyeh 1985, 1996, Harrison & Makin 1988, Yoshiyuki 1989, Nader 1990, Harrison & Bates 1991, Koopman 1993, Bates & Harrison 1997, Qumsiyeh et al. 1998, Rydell & Bogdanowicz 1997, Zhang 1997, Mendelssohn & Yom-Tov 1999, Horáček et al. 2000, Ferguson 2002, Simmons 2005, Mayer et al. 2007, Zhang et al. 2007, etc.).

Additionaly, Harrison (1964: 176) elaborated the type locality and concluded: " 'Arabia Petraea' (= Sinai. It is clear from Rüppell's (1826) map of this region, showing the routes of his journeys, that 'Arabia Petraea' was applied by him to Sinai.). […] the type locality 'Arabia Petraea' was considered by Ellerman and Morrison-Scott (1951) to indicate Sinai, and this is clearly correct when Rüppell's map is considered". Harrison & Bates (1991) repeated this opinion. However, neither Harrison (1964) nor Harrison & Bates (1991) specified a source of the Rüppell's map.

Fig. 51. Facsimile of the figure of *Vespertilio leucomelas* published by Cretzschmer (1830), based on a specimen collected by Eduard Rüppell (presumably) in southern Sinai.

Cretzschmar (1826–1830) described a series of mammals, including seven species of bats, based on specimens collected by E. Rüppell in the course of his journey to Northeast Africa and adjacent territories in 1822–1827 and sent by him to Senckenberg Museum at Frankfurt (Rüppell 1829). Cretzschmar (1826: ii–iii) in an introduction chapter briefly described the initial phases of Rüppell's journey which was headed also to Arabia: "Seit dem Anfang des Jahres 1822. […] Der erste Ausflug der Reisenden führte sie nach dem Sinai und der Acaba am östlichen Ufer des rothen Meeres, wo Rüppell die Goldminen des Vizekönigs Mehemet Ali Pascha von Egypten, in dessen Auftrag untersuchte. Auf der Rückreise berührten sie den Menzala See, und rüsteten sich sodann zu einer Reise nach Nubien, dessen Hauptstadt Neu Dongola sie am Ende 1822. erreichten." In subsequent parts of this introduction, Cretzschmar described solely the journeys throughout the territories of present-day Egypt and Sudan. From this description it is clear that Rüppell visited only Sinai in Arabia, and the town of Aqaba (present-day southwestern Jordan) was the easternmost point of his trip. On the other hand, in this introduction Cretzschmar did not use the term Arabia Petraea. However, as this introduction was most probably prepared in 1826, when the 'Rüppell's Atlas' began to be issued (Klausewitz 2002), Cretzschmar had not got the material collected in this year, when Rüppell's journey was almost finished (Rüppell 1929) and that part of the material could also have included bats being mostly described only in 1830 (see Martens 1925). Thus, in 'Rüppell's Atlas', edited and in large part written by Cretzschmar (1826–1830), is most probably not hidden the actual sense of the term 'Das petraeischen Arabien' mentioned as the type locality for *V. leucomelas* by Cretzschmar (1830).

Although the species *V. leucomelas* was described by Cretzschmar, it was described on the basis of specimens sent by Rüppell from Africa and most probably also labelled by him. Therefore, the terms used on vouchers associated with the collected specimens can be found in the Rüppell's book describing the journey to North Africa in 1822–1827 along with numerous observations from this journey (Rüppell 1829). Rüppell (1842) mentioned 'Arabien' as the area of origin of the type series of *V. leucomelas* (sensu Martens 1925 and Kock 1969) collected by himself, which seems to correspond with the Cretzschmar's 'Das petraeischen Arabien'. From this, it seems to be clear, that all mentions by Rüppell concerning Arabia could be theoretically associated with the type locality of *B. leucomelas*.

Rüppell (1829: 6) in the second chapter "Chronologische Skizze meiner Reisen in Africa" described the whole course of the journey; he started: "Zu Anfang des Jahres 1822 in Egypten angelangt, beschäftigte mich im Frühling eine Excursion durch das peträische Arabien über Suez nach Neghele [= Nakhl], Akaba, Noebe [= Nuweibah] und [Wadi] Nasb; dann die Sommer eine Ausflucht nach dem Fajoum, und später nach Damiette […]. Im November nach Oberegypten abgereist […]." This description roughly corresponds with that given by Cretzschmar (1826). The subsequent period, 1823–1825, Rüppell spent solely on the African continent, but in about the last full year of the journey he wrote (p. 9): "Während der ersten Hälfte des folgenden Jahres (1826) beschäftigten wir uns an den Küsten der beiden Meerbusen von Suez und Akaba. Wegen Landexcursionen verließ ich zweimal die naturhistorische Sammler; die eine dieser Landexcursionen fürte mich von Tor über Ras Mehamet [= Ras Muhammad], Scherum [= Sharm El Sheikh] und Minna el Dahab nach dem Sinai [= Mt. Sinai]; die andere ging von Mohila [= Al Muwailih] nach Beden [= Al Bid] und Magna [= Al Maqnah]."

In the course of both these trips (in 1822 and 1826), Rüppell visited in Arabia the coastal parts of southern Sinai both on the western and the eastern sides, as well as the areas of inner mountain massives of Sinai, mostly those in surrounding of the Saint Katherine Monastery (Deir Sant Katerin). During the latter trip, however, he also visited the coastal region of the present NW Saudi Arabia (the towns of Al Muwailih, Al Bid and Al Maqnah). Nevertheless, in the chapter "Topographische Skizze des peträischen Arabiens" (pp. 179–191), Rüppell describes 'peträische

Arabien' as only the triangular area of southern Sinai, to the south of the connecting line between the towns of Suez and Aqaba (in this chapter he also described his field observations of several vertebrate species, unfortunately none of bats); also in his 'Karte des petraeische Arabien' (Rüppell's 1829: Taf. 11; Fig. 52), where the visited areas of the proper Arabian Peninsula to the east of the Gulf of Aqaba he named 'Das wüste Arabien [= Desert Arabia]' (do not change with the 'Arabia Deserta' = desolate Arabia, the present Syrian Desert). In the style of a diary, Rüppell described his first trip to Sinai in the chapter "Tagebuch meiner Reise von Suez über Neghele nach Akaba, und von dort über Noebe nach dem Kloster St. Katharina im Jahr 1822" (pp. 241–273), however, there is no note about a bat collection available.

From the Rüppell's (1829) descriptions and according to his travelling schedule it is fully clear, that in his concept the 'Arabia Petraea' represents 'the area of the Sinaitic peninsula to the south of the connecting line between the towns of Suez and Aqaba', as pointed above, see also Fig. 52. Since it seems to be appropriate to consider localities given by Cretzschmar to be in accordance

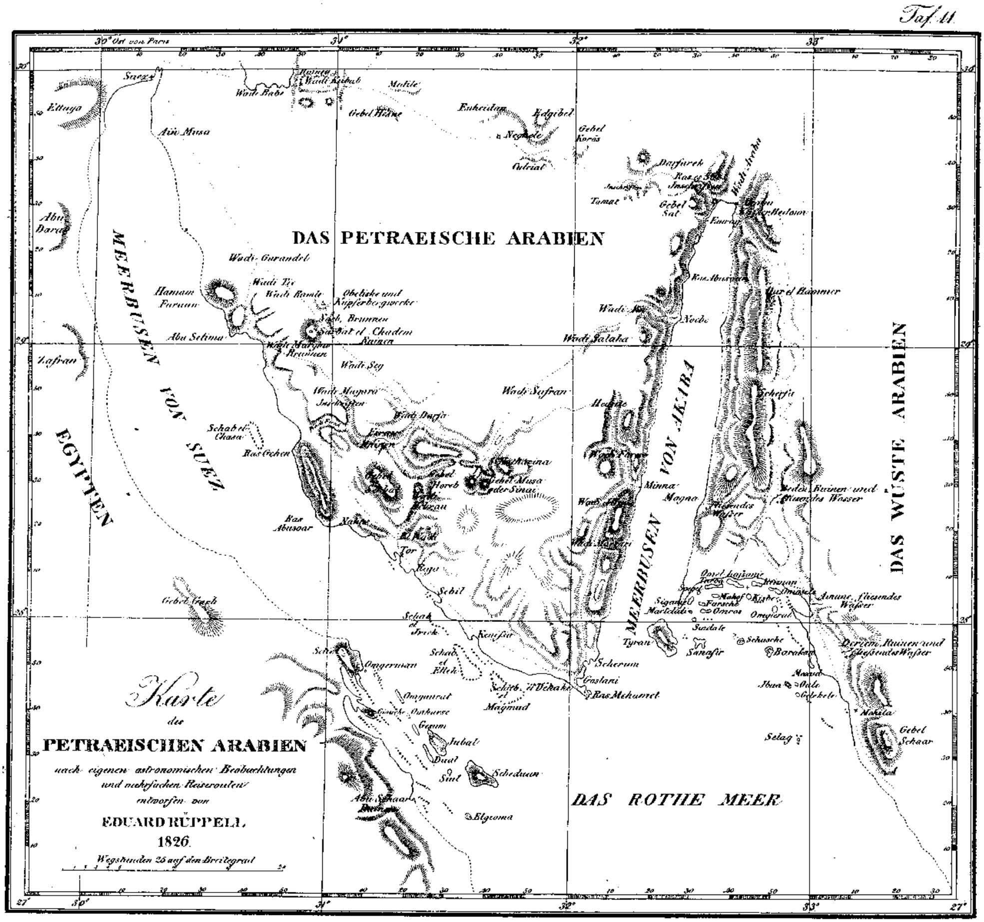



Fig. 52. Facsimile of the map of Sinai and surroundings published by Rüppell (1829).

with those given by the collector, with the above 'area' is most convenient to associate the type locality of the species *Vespertilio leucomelas* Cretzschmar, 1830 = *Barbastella leucomelas* (Cretzschmar, 1830). In this area, the type series (lectotype: SMF II.M.1.a = SMF 4343; paralectotype: SMF II.M.1.b = SMF 12393; Mertens 1925, Kock 1969) was collected in 1822 and/or 1826.

TAXONOMY. *Barbastella leucomelas* has been long time considered a synonym of its European congener, *B. barbastellus* (Schreber, 1774), distributed also in Morocco and Canary Islands (Rydell & Bogdanowicz 1997): the Sinaitic population (or rather the Cretzschmar's description) was regarded a part of the *B. barbastellus* species rank by numerous older authors (e.g. Dobson 1878, Jentink 1887, De Winton in Anderson 1902, Trouessart 1904, Senna 1905, Miller 1907, Mertens 1925, Flower 1932, Allen 1939); among modern authors, this systematic position was suggested by Kock (1969), Largen et al. (1974), Qumsiyeh (1985, 1996), and Ferguson (2002). However, majority of the contemporary authors consider *B. leucomelas* a species distributed across a large part of temperate Asia from Arabia and Caucasus to Japan (Tate 1942, Ellerman & Morrison-Scott 1951, Hoogstraal 1962, Etemad 1964, 1967, 1969, Strelkov 1963, Kuzjakin 1965, Meyer-Oehme 1968, Wallin 1969, Gaisler 1970, Hayman & Hill 1971, Neuhauser & DeBlase 1974, Roberts 1977, 1997, Corbet 1978, Strelkov et al. 1978, Corbet & Hill 1980, DeBlase 1980, Strelkov 1981, Butovskij et al. 1985, Harrison & Makin 1988, Yoshiyuki 1989, Harrison & Bates 1991, Corbet & Hill 1992, Habilov 1992, Koopman 1993, 1994, Nowak 1994, Borisenko & Pavlinov 1995, Bates & Harrison 1997, Rydell & Bogdanowicz 1997, Zhang et al. 1997, Mendelssohn & Yom-Tov 1999, Horáček et al. 2000, Alfred et al. 2002, Wang 2003, Duff & Lawson 2004, Schober 2004, Rahmatulina 2005, Simmons 2005, etc.).

Zhang et al. (2007) showed a separate position of *B. leucomelas* from Sinai, to be a species distinct both from European and Asian populations previously suggested to be conspecifics, based on analysis of sequences of the NADH dehydrogenase 1 mitochondrial gene subunit (ND1). Zhang et al. (2007) adopted the compared sequences of *B. leucomelas* from Mayer et al. (2007) who extracted them from the specimens collected at the St. Katherine Research Centre on 29 July 2005 (CDIS 941, 942; see Records above and Appendix III). The latter authors demonstrated extremely high genetic distance (13.3%) between the Sinaitic *B. leucomelas* and Central European *B. barbastellus*. Zhang et al. (2007) added the results from comparison also with Asian samples (SW and NE China, Taiwan and Japan), which showed in all cases extremely high genetic distances (12.8–18.7% [K2P]; Zhang et al. 2007: 1397, Table 2). Zhang et al. (2007) also rather confirmed species status for Japanese populations, but disowned it for the Taiwanese ones, both statuses preliminary suggested by Lin et al. (2002).

We performed genetic comparison of partial sequences (609 bp) of the mitochondrial gene for cytochrome *b* (cyt *b*) of the Sinaitic samples of *B. leucomelas* with the available *Barbastella* samples from Morocco, Canary Islands, various parts of Europe, northern Iran, China and Taiwan (see Appendix III). The results of this analysis (Fig. 53) showed very similar pattern as those resulted from the ND1 comparison (Mayer et al. 2007, Zhang et al. 2007). The analysed samples belong to four main lineages corresponding with particular species (Fig. 53); (1) *Barbastella barbastellus* from Europe and Morocco, Iran, and Canary Islands, (2) *Barbastella* sp. from SW China (Sichuan) and Taiwan, and (3) *B. leucomelas* from Sinai, being sister to (4) *B. beijingensis* Zhang, Han, Jones, Lin, Zhang, Zhu, Huang et Zhang, 2007, from NE China. The genetic diversity within *B. barbastellus* correspond with that described by Juste et al. (2003); the Canarian population being most distant within the species (the K2P distance of 4.1–5.0%; Table 6) and represents well the recently described subspecies *B. b. guanchae* Trujillo, Ibáñez et Juste, 2002 (Trujillo et al. 2002). The rather extensive distance of the N Irani samples from European and Moroccan conspecifics (2.7–3.6%) could correspond with the geographical distance of the Hyrcanian region from these parts of the species range (at least 2400 km as the crow flies). There are confirmed separate species positions of two SW Palaearctic populations associated with North Africa, the Moroccan/Canarian and the Sinaitic ones. The Southeast Asian samples create a species of its own being distant by 14.8–16.6% from other forms (Table 6; see also Zhang et al. 2007); the most appropriate name for this form is *B. darjelingensis* (Hodgson, 1855) (Benda & Mlíkovský 2008).

The close association of *B. leucomelas* with *B. beijingensis* (although distant by 11.8/13.3%; satisfactory for full species status of each, Table 6) is interesting from the biogeographical point of view. These species are geographically the most distant forms of *Barbastella* in Asia and inhabit quite dissimilar habitats; while *B. leucomelas* is a dweller of harsh arid areas, *B. beijingensis* inhabits warm temperate zone forest (Zhang et al. 2007). These two species differ also markedly in morphology; *B. beijingensis* is a bat significantly larger than *B. leucomelas* (Table 7, Zhang et al. 2007): *B. beijingensis* is (most probably) the largest representative of the genus (in size close to *B. darjelingensis*), whilst *B. leucomelas* the smallest one (in size close to *B. barbastellus*). Since

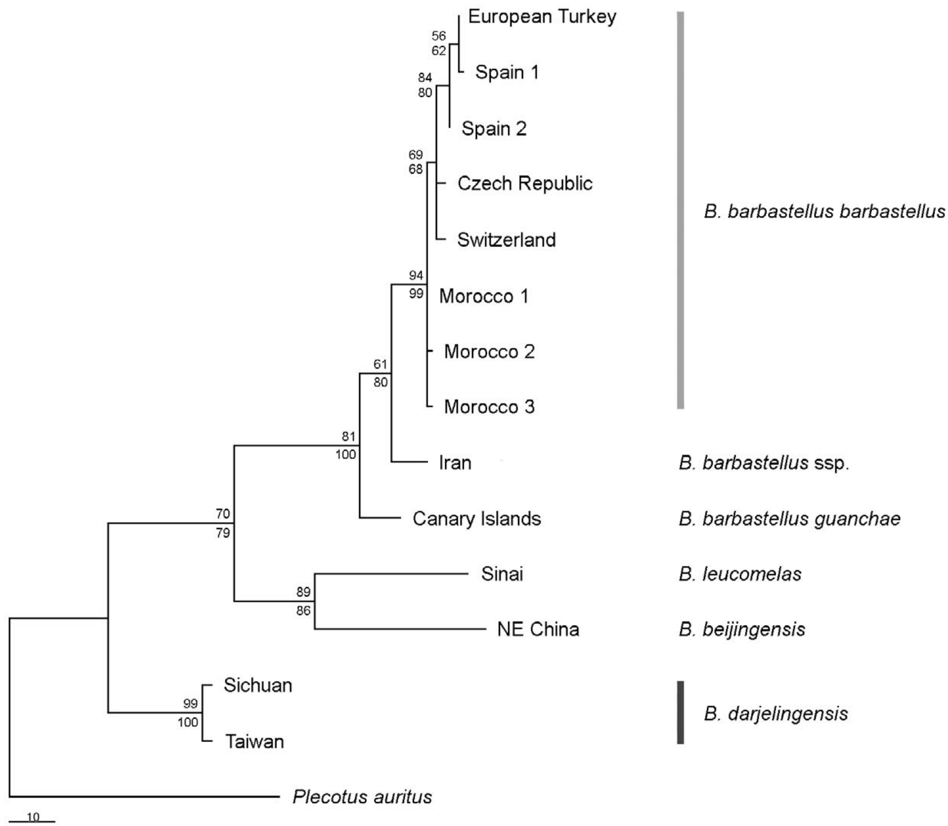



Fig. 53. Maximum likelihood tree (–lnL=2119.21973) computed under HKY+I substitution model using 100 additions of sequences and tree bisection-reconnection swapping algorithm. Bootstrap support for maximum likelihood (100 pseudoreplicates) is indicated above, for maximum parsimony using the same tree search algorithm (1000 pseudoreplicates) below the respective branches.

Table 6. Genetic divergences among the examined haplotypes of partial sequences (609 bp) of cytochrome *b* mitochondrial gene of *Barbastella* Gray, 1821. Above the diagonal – uncorrected p distances, below the diagonal – corrected distances (Kimura 2-parameter model)

| K2P \ p dist | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] | [13] | [14] | [15] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [1] Sinai | | 0.144 | 0.146 | 0.146 | 0.148 | 0.143 | 0.144 | 0.146 | 0.144 | 0.146 | 0.136 | 0.118 | 0.131 | 0.131 | 0.190 |
| [2] Morocco 1 | 0.168 | | 0.002 | 0.011 | 0.026 | 0.002 | 0.007 | 0.007 | 0.010 | 0.008 | 0.039 | 0.153 | 0.136 | 0.136 | 0.194 |
| [3] Morocco 2 | 0.170 | 0.002 | | 0.010 | 0.028 | 0.003 | 0.008 | 0.008 | 0.008 | 0.010 | 0.041 | 0.154 | 0.138 | 0.138 | 0.195 |
| [4] Morocco 3 | 0.170 | 0.012 | 0.010 | | 0.039 | 0.013 | 0.011 | 0.011 | 0.002 | 0.003 | 0.048 | 0.154 | 0.144 | 0.144 | 0.194 |
| [5] Iran | 0.172 | 0.027 | 0.029 | 0.038 | | 0.029 | 0.033 | 0.033 | 0.036 | 0.034 | 0.039 | 0.151 | 0.136 | 0.136 | 0.200 |
| [6] European Turkey | 0.166 | 0.002 | 0.003 | 0.013 | 0.028 | | 0.008 | 0.008 | 0.011 | 0.010 | 0.041 | 0.151 | 0.135 | 0.135 | 0.195 |
| [7] Czech Republic | 0.168 | 0.007 | 0.008 | 0.012 | 0.034 | 0.008 | | 0.007 | 0.010 | 0.008 | 0.043 | 0.149 | 0.136 | 0.136 | 0.194 |
| [8] Switzerland | 0.170 | 0.007 | 0.008 | 0.012 | 0.034 | 0.008 | 0.007 | | 0.010 | 0.008 | 0.043 | 0.154 | 0.140 | 0.140 | 0.197 |
| [9] Spain 1 | 0.168 | 0.010 | 0.008 | 0.002 | 0.037 | 0.012 | 0.010 | 0.010 | | 0.005 | 0.046 | 0.156 | 0.143 | 0.143 | 0.200 |
| [10] Spain 2 | 0.170 | 0.008 | 0.010 | 0.003 | 0.036 | 0.010 | 0.008 | 0.008 | 0.005 | | 0.044 | 0.151 | 0.141 | 0.141 | 0.197 |
| [11] Canary Islands | 0.157 | 0.041 | 0.043 | 0.050 | 0.041 | 0.043 | 0.044 | 0.044 | 0.048 | 0.046 | | 0.151 | 0.143 | 0.143 | 0.189 |
| [12] NE China | 0.133 | 0.180 | 0.182 | 0.182 | 0.177 | 0.177 | 0.175 | 0.182 | 0.184 | 0.177 | 0.177 | | 0.141 | 0.138 | 0.194 |
| [13] Sichuan | 0.148 | 0.154 | 0.157 | 0.165 | 0.154 | 0.152 | 0.154 | 0.159 | 0.163 | 0.161 | 0.163 | 0.161 | | 0.007 | 0.167 |
| [14] Taiwan | 0.148 | 0.155 | 0.157 | 0.166 | 0.154 | 0.152 | 0.155 | 0.159 | 0.163 | 0.161 | 0.163 | 0.156 | 0.007 | | 0.161 |
| [15] *Plecotus auritus* | 0.225 | 0.230 | 0.232 | 0.240 | 0.230 | 0.232 | 0.230 | 0.235 | 0.240 | 0.235 | 0.223 | 0.229 | 0.192 | 0.183 | |

we did not have an opportunity to examine any specimen of *B. beijingensis*, for other possible differences see Zhang et al. (2007). However, *B. leucomelas* differs morphologically also from other representatives of the genus.

We examined a unique material of eight specimens (incl. the types) of *B. leucomelas*, i.e. more than a half of all the known specimens (incl. the released ones!), and compared it with European and Asian samples of *B. barbastellus* and *B. darjelingensis* from Central Asia (see Fig. 50 and Appendix II for the comparative material origin). According to size, the compared samples created two main clusters, the larger individuals originated from Central Asia (*B. darjelingensis*) and the smaller ones, from Arabia, Iran and Europe (*B. leucomelas* and *B. barbastellus*). The comparison of skull dimensions (Fig. 54; Table 7) showed three morphotypes among the compared samples (Fig. 55). (1) The most distinct one is represented by the Arabian samples of *B. leucomelas*; these bats have small skulls with absolutely and, particularly, relatively very short and narrow rostrum and rather narrow braincase, but relatively large tympanic bullae (the latter character was emphasised also by Harrison & Makin 1988). (2) The morphotype of European and Hyrcanian (Azerbaijan and N Iran forests) samples of *B. barbastellus* which is in average only slightly larger in absolute dimensional values than the first morphotype, differ from it having relatively smaller bullae but a larger and wider rostrum and a relatively much wider braincase. (3) The morphotype of Central Asian bats (*B. darjelingensis*) differ from the above two morphotypes by being absolutely larger in most dimensions, almost without overlap in any value, and having a relatively much longer and wider rostrum, while the dimensions of the braincase and tympanic bullae are in their relative dimensions in between the relative values of the above morphotypes. Comparison of selected body dimesions (LAt, LPol) taken from museum specimens showed body size in the morphotype (3) (*B.*

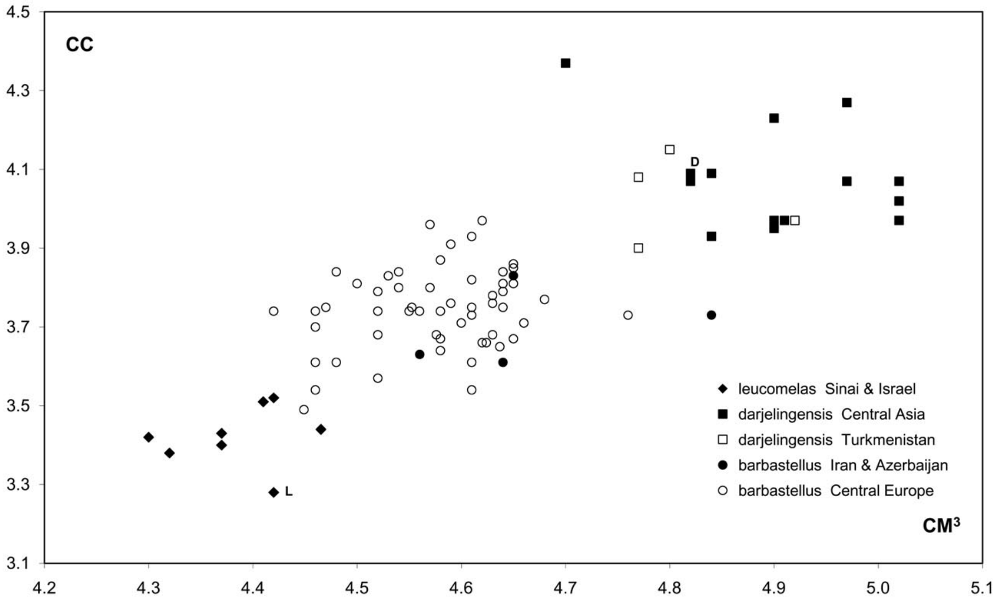



Fig. 54. Bivariate plot of examined Sinaitic and comparative samples of *Barbastella* Gray, 1821: length of the upper tooth--row (CM$^3$) against the rostral width across the upper canines (CC). Explanations: L = lectotype specimen of *Vespertilio leucomelas* Cretzschmar, 1830; D = type specimen of *Plecotus darjelingensis* Hodgson, 1855.

Table 7. Basic biometric data [in mm] on and dimensional ratios of examined Sinaitic and comparative samples of *Barbastella* Gray, 1821. * – after Zhang et al. (2007); for abbreviations see p. 6.

| | Sinai (*leucomelas*) | | | | | Israel (*leucomelas*) | | | | | Central Asia (*darjelingensis*) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n | **M** | min | max | SD |
| LAt | 7 | **38.71** | 37.4 | 39.9 | 0.937 | 2 | **39.25** | 39.0 | 39.5 | 0.354 | 10 | **41.87** | 40.7 | 44.5 | 1.081 |
| LPol | 6 | **4.65** | 4.4 | 4.8 | 0.152 | 0 | – | – | – | – | 8 | **5.95** | 5.6 | 6.5 | 0.283 |
| LCr | 4 | **13.99** | 13.88 | 14.08 | 0.087 | 2 | **14.13** | 14.12 | 14.13 | 0.007 | 17 | **15.00** | 14.51 | 15.52 | 0.314 |
| LCb | 4 | **13.06** | 12.91 | 13.15 | 0.113 | 2 | **13.15** | 13.13 | 13.17 | 0.028 | 17 | **14.13** | 13.47 | 14.73 | 0.369 |
| LaZ | 4 | **7.26** | 7.19 | 7.36 | 0.082 | 2 | **7.43** | 7.35 | 7.50 | 0.106 | 16 | **8.01** | 7.62 | 8.35 | 0.203 |
| LaI | 6 | **3.45** | 3.30 | 3.57 | 0.103 | 2 | **3.37** | 3.37 | 3.37 | 0.000 | 18 | **3.68** | 3.45 | 3.85 | 0.108 |
| LaInf | 6 | **3.88** | 3.80 | 4.04 | 0.086 | 2 | **3.90** | 3.87 | 3.92 | 0.035 | 18 | **4.25** | 4.05 | 4.45 | 0.122 |
| LaN | 5 | **6.98** | 6.76 | 7.47 | 0.278 | 2 | **6.81** | 6.67 | 6.95 | 0.198 | 17 | **7.52** | 7.28 | 7.88 | 0.144 |
| ANc | 4 | **5.22** | 5.10 | 5.35 | 0.110 | 2 | **5.16** | 5.15 | 5.17 | 0.014 | 17 | **5.55** | 5.25 | 5.84 | 0.154 |
| LBT | 6 | **3.16** | 3.10 | 3.21 | 0.038 | 2 | **3.07** | 3.02 | 3.12 | 0.071 | 17 | **3.27** | 3.16 | 3.42 | 0.079 |
| CC | 6 | **3.41** | 3.28 | 3.51 | 0.076 | 2 | **3.47** | 3.42 | 3.52 | 0.071 | 18 | **4.07** | 3.90 | 4.37 | 0.126 |
| M$^3$M$^3$ | 6 | **5.27** | 5.19 | 5.39 | 0.083 | 2 | **5.35** | 5.25 | 5.45 | 0.141 | 16 | **5.90** | 5.57 | 6.12 | 0.141 |
| CM$^3$ | 6 | **4.39** | 4.32 | 4.47 | 0.050 | 2 | **4.36** | 4.30 | 4.42 | 0.085 | 18 | **4.88** | 4.70 | 5.02 | 0.095 |
| LMd | 6 | **8.73** | 8.62 | 8.93 | 0.125 | 1 | **8.95** | – | – | – | 18 | **9.64** | 9.12 | 10.04 | 0.239 |
| ACo | 6 | **2.40** | 2.27 | 2.45 | 0.065 | 1 | **2.48** | – | – | – | 18 | **2.62** | 2.40 | 2.76 | 0.112 |
| CM$_3$ | 6 | **4.86** | 4.81 | 4.96 | 0.053 | 2 | **4.80** | 4.75 | 4.85 | 0.071 | 18 | **5.33** | 5.13 | 5.54 | 0.118 |
| | Central Europe (*barbastellus*) | | | | | Iran & Azerbaijan (*barbastellus*) | | | | | NE China* (*beijingensis*) | | | | |
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n | **M** | min | max | SD |
| LAt | 39 | **38.96** | 36.9 | 41.0 | 0.963 | 4 | **40.90** | 39.7 | 41.6 | 0.852 | 7 | **42.93** | 37.8 | 46.4 | 2.930 |
| LPol | 37 | **4.83** | 4.1 | 5.5 | 0.298 | 4 | **5.15** | 4.8 | 5.4 | 0.265 | 0 | – | – | – | – |
| LCr | 54 | **14.19** | 13.74 | 14.56 | 0.194 | 4 | **14.28** | 13.99 | 14.51 | 0.215 | 2 | **15.45** | 15.20 | 15.70 | 0.354 |
| LCb | 54 | **13.35** | 12.92 | 13.70 | 0.164 | 4 | **13.57** | 13.31 | 13.73 | 0.187 | 2 | **14.35** | 14.20 | 14.50 | 0.212 |
| LaZ | 46 | **7.52** | 7.28 | 7.79 | 0.132 | 4 | **7.40** | 7.04 | 7.68 | 0.265 | 2 | **8.40** | 8.00 | 8.80 | 0.566 |
| LaI | 54 | **3.54** | 3.39 | 3.75 | 0.087 | 4 | **3.50** | 3.33 | 3.59 | 0.117 | 2 | **4.00** | 3.90 | 4.10 | 0.141 |
| LaInf | 52 | **3.92** | 3.68 | 4.16 | 0.114 | 4 | **3.93** | 3.84 | 4.14 | 0.139 | 0 | – | – | – | – |
| LaN | 54 | **7.33** | 6.97 | 7.62 | 0.126 | 4 | **7.28** | 6.85 | 7.56 | 0.327 | 0 | – | – | – | – |
| ANc | 54 | **5.21** | 4.81 | 5.52 | 0.135 | 4 | **5.15** | 5.06 | 5.27 | 0.087 | 0 | – | – | – | – |
| LBT | 53 | **3.05** | 2.80 | 3.21 | 0.107 | 4 | **3.13** | 2.88 | 3.23 | 0.165 | 2 | **2.95** | 2.90 | 3.00 | 0.071 |
| CC | 54 | **3.74** | 3.49 | 3.97 | 0.103 | 4 | **3.70** | 3.61 | 3.83 | 0.101 | 2 | **4.15** | 4.00 | 4.30 | 0.212 |
| M$^3$M$^3$ | 54 | **5.46** | 5.21 | 5.83 | 0.125 | 4 | **5.44** | 5.27 | 5.64 | 0.184 | 2 | **6.10** | 5.70 | 6.50 | 0.566 |
| CM$^3$ | 54 | **4.58** | 4.42 | 4.76 | 0.071 | 4 | **4.67** | 4.56 | 4.84 | 0.119 | 2 | **4.80** | 4.70 | 4.90 | 0.141 |
| LMd | 51 | **9.11** | 8.71 | 9.41 | 0.144 | 4 | **9.15** | 9.07 | 9.31 | 0.113 | 2 | **9.70** | 9.50 | 9.90 | 0.283 |
| ACo | 52 | **2.45** | 2.27 | 2.64 | 0.090 | 4 | **2.50** | 2.44 | 2.58 | 0.059 | 0 | – | – | – | – |
| CM$_3$ | 53 | **4.97** | 4.72 | 5.17 | 0.097 | 4 | **5.06** | 4.89 | 5.28 | 0.163 | 2 | **5.20** | 5.10 | 5.30 | 0.141 |
| | Sinai & Israel (*leucomelas*) | | | | | Central Asia (*darjelingensis*) | | | | | Central Europe (*barbastellus*) | | | | |
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n | **M** | min | max | SD |
| CM$^3$/LCr | 6 | **0.312** | 0.304 | 0.317 | 0.005 | 17 | **0.326** | 0.319 | 0.338 | 0.005 | 54 | **0.323** | 0.308 | 0.335 | 0.005 |
| CC/LCr | 6 | **0.246** | 0.242 | 0.250 | 0.004 | 17 | **0.271** | 0.258 | 0.300 | 0.010 | 54 | **0.264** | 0.247 | 0.280 | 0.007 |
| CC/CM$^3$ | 8 | **0.781** | 0.742 | 0.796 | 0.018 | 18 | **0.833** | 0.791 | 0.930 | 0.034 | 54 | **0.818** | 0.768 | 0.867 | 0.023 |
| LaInf/LCr | 6 | **0.277** | 0.274 | 0.291 | 0.007 | 17 | **0.284** | 0.271 | 0.300 | 0.008 | 52 | **0.276** | 0.260 | 0.293 | 0.008 |
| LaN/LCr | 6 | **0.488** | 0.472 | 0.496 | 0.009 | 17 | **0.502** | 0.480 | 0.527 | 0.014 | 54 | **0.517** | 0.497 | 0.539 | 0.010 |
| ANc/LCr | 6 | **0.371** | 0.364 | 0.380 | 0.007 | 17 | **0.370** | 0.359 | 0.379 | 0.006 | 54 | **0.367** | 0.343 | 0.386 | 0.008 |
| ANc/LaN | 6 | **0.760** | 0.741 | 0.773 | 0.013 | 17 | **0.739** | 0.686 | 0.780 | 0.025 | 54 | **0.711** | 0.654 | 0.749 | 0.019 |
| LBT/LCr | 6 | **0.223** | 0.214 | 0.229 | 0.005 | 17 | **0.218** | 0.204 | 0.228 | 0.006 | 53 | **0.215** | 0.195 | 0.230 | 0.008 |
| LPol/LAt | 6 | **0.120** | 0.113 | 0.126 | 0.005 | 8 | **0.142** | 0.135 | 0.153 | 0.006 | 37 | **0.124** | 0.110 | 0.138 | 0.007 |

*darjelingensis*) to be markedly larger than in (1) and (2), and moreover, the thumb length (LPol) in the morphotype (3) is not only absolutely but also relatively larger than in the remaining two.

The discriminant analysis splitted without any overlap the comparative material of *Barbastella* skulls into clearly separated clusters corresponding to the above defined morphotypes representing three species (Fig. 56; whole set of 14 measurements analysed; CV1=69.73% of variance; CV2=25.21%); almost identical results were produced by the principal component analysis of the skull dimensions (not shown; 13 most significant dimensions analysed [LCR, LCb, LaZ, LaInf, ANc, CC, $M^3M^3$, $CM^3$, LMd, $CM_3$, CC/LCr, LaN/LCr, ANc/LaN]; PC1=65.38% of variance; PC2=17.69%). The morphologic comparison also showed dimensional homogeneity within the particular morphotypes, not suggesting further divergences within the compared species and/or populations.

These results suggest the body and skull size to be the main morphologic character for distinguishing the species/morphotypes in Asian populations of the genus *Barbastella*, while previously

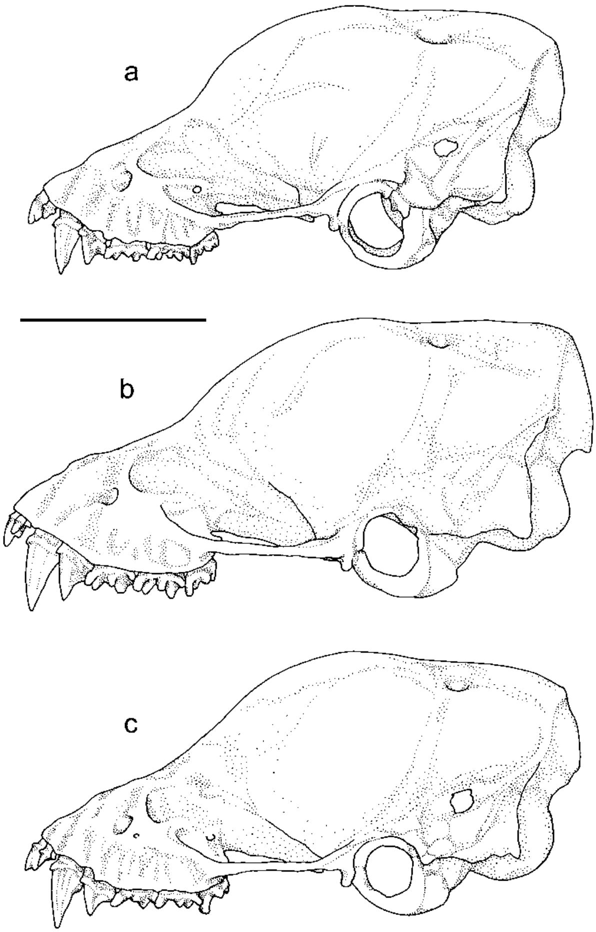



Fig. 55. Skulls of three species of the genus *Barbastella* Gray, 1821: *B. leucomelas* (Cretzschmar, 1830) (above: male, NMP 90521, Ain Hudra, Sinai), *B. darjelingensis* (Hodgson, 1855) (middle: male, NMP 91466, Tashkent, Uzbekistan), and *B. barbastellus* (Schreber, 1774) (below: female, NMP 92029, Tisovec, Slovakia). Scale bar = 5 mm.

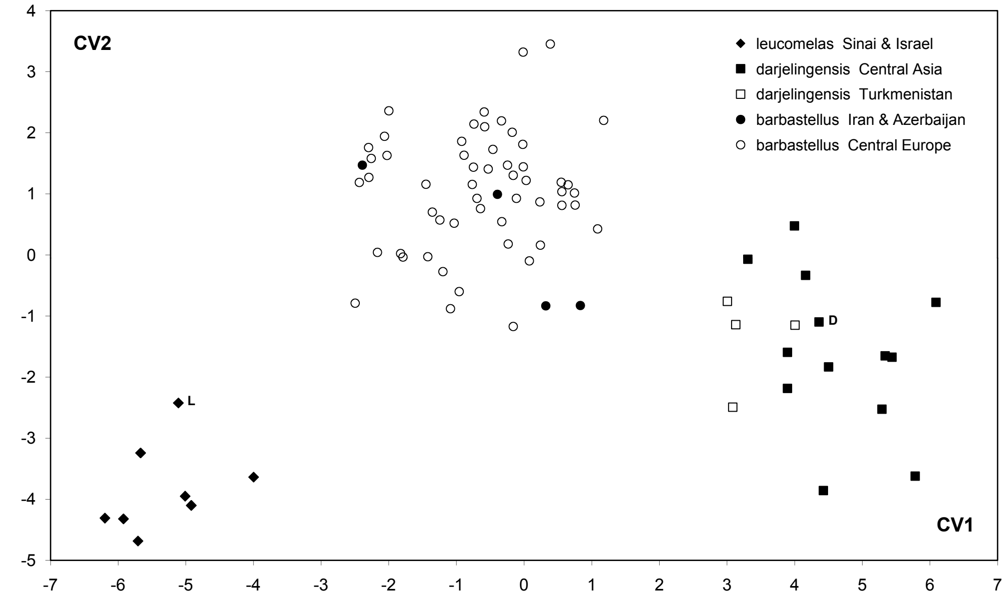



Fig. 56. Bivariate plot of examined Sinaitic and comparative samples of *Barbastella* Gray, 1821: results of the discriminant analysis of skull dimensions. For explanations see text and Fig. 54.

mainly the pelage coloration and morphology of the ear pinna (i.e. presence or absence of the projecting lobule in the middle of posterior margin of the pinna) were considered valid traits of the particular taxa. Since the latter character as a trait effective for identification of the *Barbastella* species was reasonably doubted already by Hackethal et al. (1988), a number of authors considered the pelage coloration to be an important character for taxonomic appraisal of the Asian populations, particularly when the lobule on posterior margin of the pinna is absent in these populations (Satunin' 1909, 1914, Bianki 1917, Bobrinskoj 1925, Ognev 1927, Bianki in Ognev 1928, Kuzjakin 1934, 1950, 1965, Tate 1942, Neuhauser & DeBlase 1974, Strelkov et al. 1978, DeBlase 1980, Harrison & Bates 1991, Bates & Harrison 1997, Lin et al. 2002, etc.). However, the dark coloured, small individuals of *Barbastella*, living in the eastern parts of the Hyrcanian forests in Iran, belong to *B. barbastellus*, as proved by the above analyses and do not represent the form *B. leucomelas darjelingensis* as DeBlase (1980) suggested (nevertheless, in Iran occurs also true *B. darjelingensis* according to the skull dimensions given by Etemad 1964, 1969, Neuhauser & DeBlase 1974, and DeBlase 1980). The published data on size of the Transcaucasian bats of the genus *Barbastella* (e.g. Satunin 1908, 1914, 1915, Ognev 1928, Rahmatulina 2005) show also the occurrence of two forms there (at least in parapatry, see Fig. 50), smaller *B. barbastellus* (proved also by our analysis) and larger *B. darjelingensis*.

The skin and pelage coloration of the examined Sinaitic specimens (see Figs. 57, 58) is identical to the description made by Harrison & Makin (1988) and Harrison & Bates (1991: 104): "The head and back are blackish in colour, but with the hairs from the shoulders backwards strongly tipped with pale golden buff. On the ventral surface the bases of the hairs are dark blackish brown, but with white or buffy tips on the breast, becoming more pronounced distally. The general effect produced is a blackish throat and upper chest and an abdomen with a mixed black and white colour, fading to white in the inguinal region". This coloration thus creates certain transition between those known/described from European *B. barbastellus* and Asian *B. darjelingensis* (with an exception of the Kopetdag Mts populations described by Strelkov et al. 1978), but it resembles rather that of *B. barbastellus* (having much less intensive pale tipping of dorsal hairs and overall darker ventral pelage) than the variable coloration of *B. darjelingensis* from arid areas of the NE Middle East and Central Asia as described by e.g. Kuzjakin (1934) and/or Neuhauser & DeBlase (1974).

The absence of the projecting lobule in the middle of the posterior margin of the pinna has been treated as a typical character for Asian populations of *Barbastella* including the Arabian ones (Harrison 1964, Qumsiyeh 1985, Harrison & Makin 1988, Koopman 1994, Harrison & Bates 1991, Ferguson 2002). However, in four alcohol specimens recently collected in Sinai, very small lobules are present (Fig. 58). Although these features are rather inconspicuous, they are observable; their average length is 0.424 mm (range 0.33–0.55 mm; n=8). We examined for this character only the alcohol specimens, however, its uniform appearance in these four bats suggests its general occurrence within the species as well.

We prepared a baculum from the Sinaitic specimen of *B. leucomelas* (NMP 90521; Fig. 59a); it is a dorsoventrally flattened triangular bone 0.79 mm long and 0.51 mm wide, with narrow

Figs. 57, 58. An individual of *Barbastella leucomelas* (Cretzschmar, 1830) from the oasis of El Milga, Sinai (photos by C. Dietz). 57 (left) – overall view on the dorsal pelage and head coloration and the ears shape. 58 (right) – right ear pinna; note a tiny lobule in the centre of the lateral pinna margin (appr. at the level of the top of tragus).

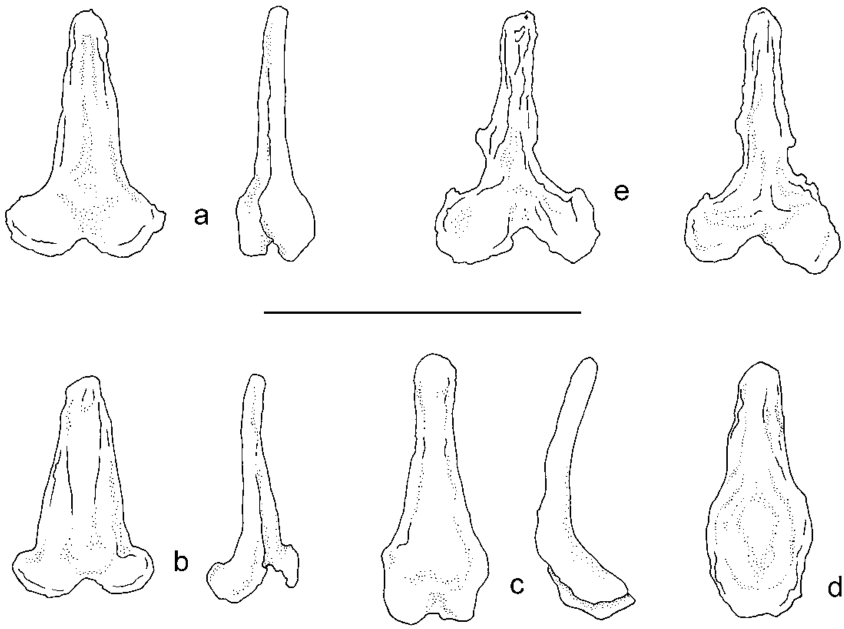



Fig. 59. Baculum preparations of Plecotini bats from Sinai a from comparative samples (distal epiphyses above; in pairs: left – dorsal view, right – lateral view): a – *Barbastella leucomelas* (Cretzschmar, 1830) (NMP 90521, Ain Hudra, Sinai); b – *B. darjelingensis* (Hodgson, 1855) (CUP CT84/253, Oš, Kirghizstan); c, d – *B. barbastellus* (Schreber, 1774) (c – SMM [unnumbered], Čížov, Czech Republic; d – NMP pb428, Čížov, Czech Republic); e, f – *Plecotus christii petraeus* ssp. n. (e – NMP 90499, Feiran, Sinai; f – NMP 92097, Wadi Rum, Jordan). Scale bar = 1 mm.

distal epiphysis and broad wings in the proximal epiphysis. The baculum in *B. leucomelas* has similar size and shape as bacula in the Central Asian populations of *B. darjelingensis* (Fig. 59b; Strelkov 1989), but differs in shape from those of *B. barbastellus*, which are rather narrow, more curved and have a distinct bottle-like shape (Fig. 59c, d; Topál 1958, Hill & Harrison 1987, Strelkov 1989).

To conclude, the genetic and morphologic analyses clearly showed *Barbastella leucomelas* to be an isolated unit within the genus, deserving separate species placement. Such a position was proposed not only by the earliest authors (Cretzschmar 1830, Rüppell 1842, Fitzinger 1866, von Heuglin 1877), but also by Bianki (1917), Ryberg (1947) and Harrison (1964). Since from Eritrea only two old records are available (see above) and from continental Egypt or from Arabian countries other than Israel this bat remains unknown, southern Sinai and the close areas of southern Israel, associated with the Arava Valley, are the only recently confirmed areas of *B. leucomelas* occurrence. Such a geographically limited range belongs to the most restricted ones known among the temperate bat fauna. This highlights the importance of the central mountainous region of the Sinaitic peninsula for the conservation of this species.

Feeding ecology. The diet and foraging behaviour of *Barbastella leucomelas* is unknown, here we present the first data on the diet of this species. Although Sierro & Arlettaz (1997) mentioned the diet of '*B. leucomelas*', they reported material coming from the Tien-Shan and Pamir Mts (Central Asia) and hence from *B. darjelingensis* (see above).

Representatives of the genus *Barbastella* are extremely specialised bats feeding predominantly on Lepidoptera (Beck 1995, Rydell et al. 1996, Sierro & Arlettaz 1997, Andreas 2002). Information regarding its foraging behaviour and flight is rare and partly contradictory, but most of recent authors suppose aerial hawking to be the most important foraging strategy in this genus (Ahlén 1990, Sierro & Arlettaz 1997). The closest relatives of *Barbastella* bats from the tribe Plecotini are foliage gleaners (Anderson & Racey 1991, 1993).

The most data on the *Barbastella* feeding strategies are available from European *B. barbastellus*. This species is predicted to fly rather slowly and its flight to be highly manoeuvrable (Norberg & Rayner 1987); its echolocation calls are different from the calls of typical aerial hawkers (Sierro & Arlettaz 1997, Řehák 1999). Rydell et al. (1996) supposed flexible foraging strategy in *B. barbastellus* including aerial hawking and probably also surface gleaning.

We collected two digestive tracts from *B. leucomelas* in the oasis of Ain Hudra. Both tracts contained fragments of small lepidopterans only (Fig. 16). The analysis of 12 fecal pellets collected from two *B. leucomelas* captured at St. Katherine Research Centre in El Milga consisted of 85% remains of small lepidopterans and 15% of small winged ants (Hymenoptera) (not figured).

An extremely high proportion of Lepidoptera in the results of diet analyses from completely different habitats in mixed mountainous forest (Rydell et al. 1996, Sierro & Arlettaz 1997) and deciduous forest (Andreas 2002) of Central Europe, xeric steppes and semi-deserts of Central Asia (Sierro & Arlettaz 1997) as well as from the deserts of Sinai (i.e. in three separate species, see above) shows unique foraging specialisation within the whole genus *Barbastella*.

Echolocation. Basic parameters of echolocation calls of *Barbastella leucomelas* (Figs. 60–63) are given in Table 8. Since echolocation of this species has not been described so far (only Men-

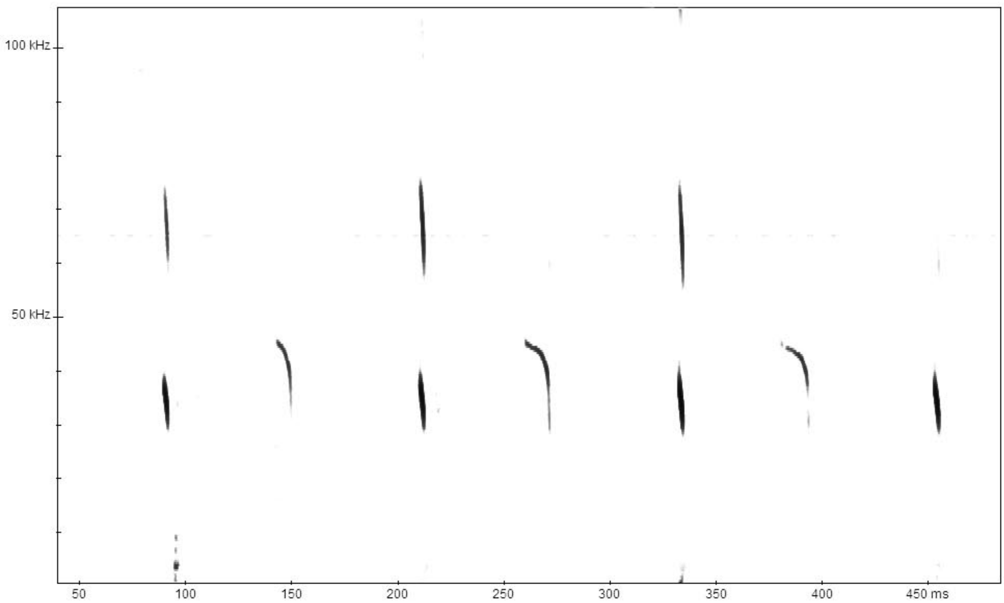



Fig. 60. Spectrogram of echolocation calls of *Barbastella leucomelas* (Cretzschmar, 1830): an individual foraging at St. Katherine Research Centre, a typical sequence with both types of signals (see text for details).

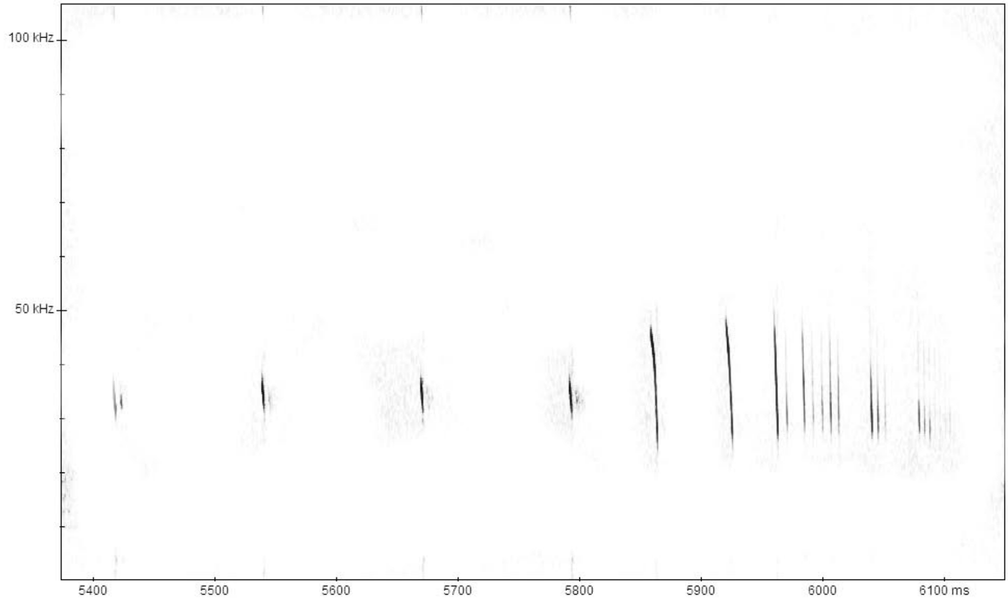



Fig. 61. Spectrogram of echolocation calls of *Barbastella leucomelas* (Cretzschmar, 1830): search phase and terminal buzz of an individual foraging in the Ain Hudra Oasis. Only type A signals are present prior to terminal buzz.

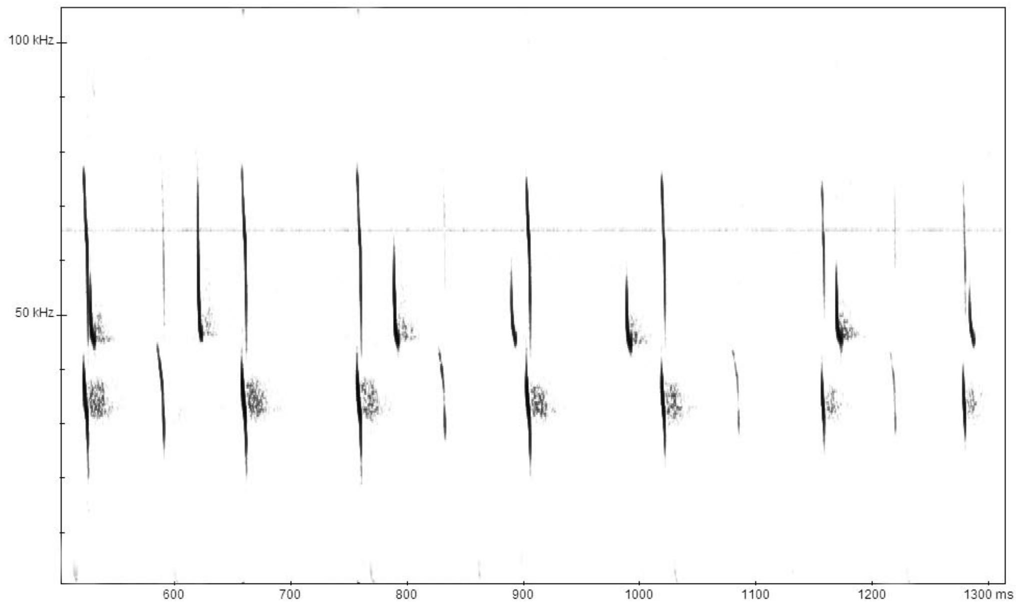



Fig. 62. Spectrogram of echolocation calls of *Barbastella leucomelas* (Cretzschmar, 1830) and *Hypsugo ariel* (Thomas, 1904). Simultaneous foraging of both species at St. Katherine Research Centre, El Milga.

Table 8. Descriptive parameters of echolocation calls of *Barbastella leucomelas* (Cretzschmar, 1830) from Sinai. Published data on echolocation parameters of two other species of the genus *Barbastella* are given for comparison. Explanation: n – number of individual calls analysed (in parentheses number of call sequences from which calls were obtained); SF – start frequency; FMAXE – frequency with maximum energy (peak frequency); EF – end frequency; PDUR – pulse duration; IPI – inter-pulse interval; [a] – IPI from call sequences where type A calls alternate with type B calls; [b] – IPI from call sequences where only type A calls are present; upper lines (in bold) – mean±SD, lower lines – range

| species | call type | n | SF | FMAXE | EF | PDUR | IPI | source |
|---|---|---|---|---|---|---|---|---|
| *B. leucomelas* | A | 128 (16) | **39.4±1.1** | **34.5±1.1** | **29.4±1.2** | **3.1±0.4** | **66.5±23.1**[a] | this paper |
| | | | 35.9–41.9 | 32.4–37.2 | 25.1–31.5 | 2.1–4.4 | 46.7–153 | |
| | | | | | | | **140.3±44.9**[b] | |
| | | | | | | | 57.6–275 | |
| | B | 67 (14) | **45.2±0.9** | **43.0±1.5** | **33.8±4.6** | **9.2±3.2** | **56.6±7.4** | |
| | | | 43.7–46.9 | 38.2–45.1 | 25.9–40.7 | 4.0–18.8 | 40.0–84.0 | |
| *B. barbastellus* | A | 5 | **39.4±4.7** | **33.2±4.4** | **28.0±3.4** | **3.4±0.7** | **108.4±67.0** | Russo & Jones (2002) |
| | | | 35.2–49.0 | 29.2–44.7 | 23.8–36.8 | 2.5–5.1 | 41.8–229.0 | |
| | B | 5 | **43.9±2.8** | **38.9±3.3** | **28.9±1.9** | **4.3±1.3** | **72.4±32.0** | |
| | | | 36.8–47.3 | 32.9–41.3 | 25.4–31.9 | 2.0–6.6 | 43.2–144.9 | |
| *B. barbastellus* | A | 109 (12) | **36.5±1.5** | **32.8±0.9** | **28.1±0.99** | **2.6±0.7** | **92.6±43.0** | Denzinger et al. (2001) |
| | | | 33.4–39.8 | 30.8–34.9 | 25.5–30.0 | 1.3–4.1 | 42.6–287.2 | |
| | B | 83 (11) | **45.2±1.2** | **40.9±3.3** | **30.5±2.8** | **4.9±1.5** | **55.7±5.8** | |
| | | | 42.0–48.0 | 31.9–45.8 | 24.8–37.1 | 1.7–9.1 | 13.4–112.5 | |
| *B. beijingensis* | A | 6 | **39.2±1.6** | **32.1±1.9** | **26.8±0.5** | **5.1±0.8** | **72.2±6.2** | Zhang et al. (2007) |
| | B | 10 | 42.7±1.6 | 39.4±0.7 | 25.1±1.4 | 8.2±1.7 | 99.0±28.0 | |

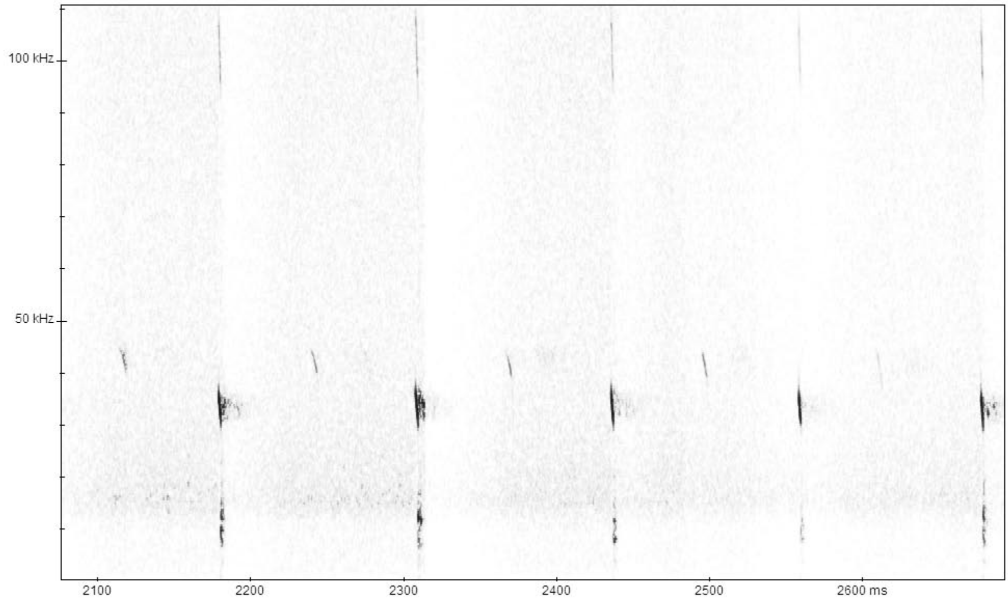



Fig. 63. Spectrogram of echolocation calls of *Barbastella leucomelas* (Cretzschmar, 1830). An individual foraging around acacia trees in the Ain El Furtaga Oasis.

delssohn & Yom-Tov (1999) mentioned the highest pulse intensity at 45 kHz), we give more detailed description of it and comparison with other species of the genus *Barbastella* (Table 8). In basic characters, the echolocation call design of *B. leucomelas* is nearly identical with that of other species of barbastelles. Short, frequency modulated signals (type A) often, though not regularly, alternate with longer signals of convex frequency-time course (type B) of higher peak frequency but a much lower intensity. These longer signals are often omitted; in those cases IPI are about two times longer than where both types of signals alternate (see Table 8 and its caption). Based on comparisons with available data on the echolocation of two of three other species of the genus *Barbastella* (i.e. *B. barbastellus* and *B. beijingensis*) we suggest *B. leucomelas* is the species with the highest known peak frequency of both types of calls (A, B) and most probably also with the highest repetition rate in call sequences (see Table 8).

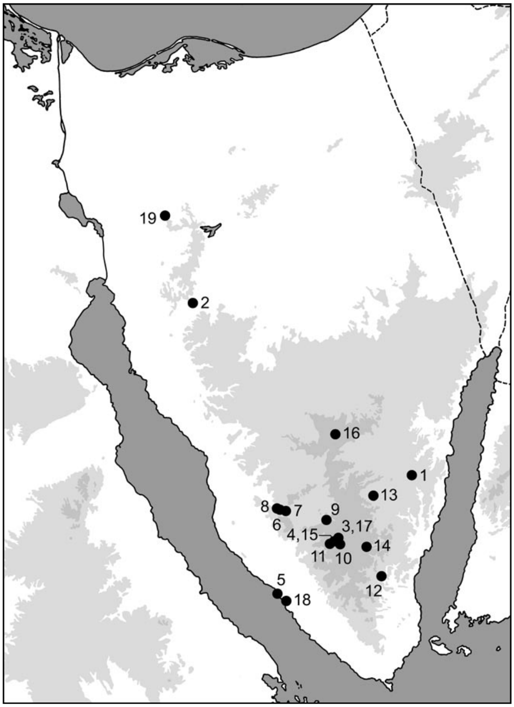
### *Plecotus christii* Gray, 1838

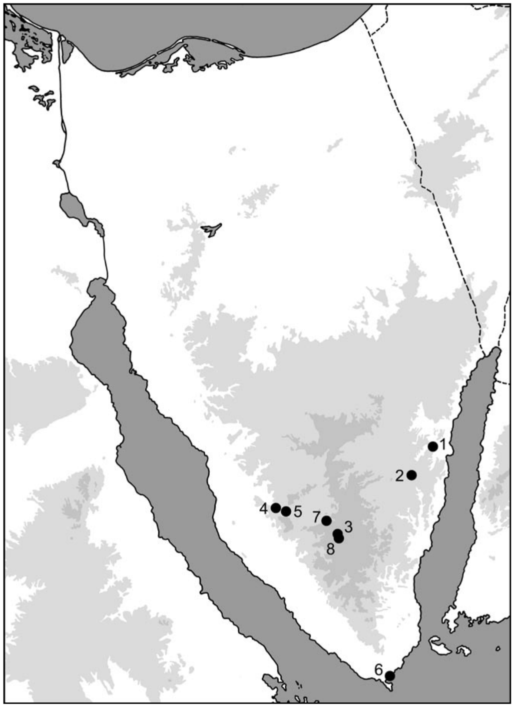
Records. **Original data**: Ain Hudra [1], oasis (Fig. 5), 4 August 2005: net. 1 ma, 5 August 2005: net. 2 ma, 1 ms, 1 fa (coll. 2 ma; CDIS 943, 944 [A]), 13 September 2005: det. & rec. 1 ind., 15 September 2005: net. 1 ma (NMP 90523 [S+A]), 5 July 2007: net. 1 fa; – Ain Sudr [2], oasis (Fig. 19), 18 September 2005: net. 1 fa (NMP 90533 [S+A]); – El Milga [3], garden above the oasis (Fig. 6), 9 September 2005: net. 1 fs (NMP 90497 [S+A]); – El Milga [4], village, Mansour's house, 8 July 2007: 1 ma captured manually (Fig. 68); – El Tur [5], Hammam Musa (Fig. 25), beach resort building, 10 September 2005: found 1 ma (NMP 90518 [A]), above a pool, 11 September 2005: net. 1 fa (NMP 90519 [S+A]); – Feiran [6], El Braga Garden, 10 August 2005: net. 3 ma, 11 August 2005: net. 5 ma, 1 ms; – Feiran [7], a garden in eastern edge of the oasis, 10 September 2005: net. 1 ma (NMP 90499 [S+A]); – Feiran [8], above a pool in western edge of the oasis, 8 September 2005: net. 1 ma (NMP 90496 [S+A]); – Sheikh Awad [9], El Karm Ecolodge (Fig. 49), 17 August 2005:

net. 1 ma, 18 August 2005: net. 1 ma; – Wadi El Arbaein [10], Ramadan's Garden (Fig. 34), 1 August 2005: det. & rec. 1 ind.; – Wadi Gebal [11], Hussein's Garden, 7 August 2005: net. 2 fa; – Wadi Kid [12], garden in a small village, 19 July 2007: net. 1 ma, 1 ind.; – Wadi Marra [13], open area approximately 800 m from the road in a perpendicular direction, 13 July 2006: net. 1 faL; – Wadi Nasb [14], Awad's Garden, 28 June 2006: net. 1 ma; – Wadi Shagg [15], Oder's Garden, 26 July 2006: net. 1 ma, 1 fa. – **Published data**: Jabal El 'Ajmah [16], 5 inds. (HUJ) (Qumsiyeh 1985 [as *P. austriacus christiei*]); – St. Catherine Monastery [17], 1 ind. (HUJ) (Qumsiyeh 1985 [as *P. austriacus christiei*]); – Tor [18], 1 f (BMNH 3.12.8.5. [S+A]) (Anderson 1902, Flower 1932 [as *P. auritus*]; Harrison 1964, Qumsiyeh 1985 [as *P. austriacus christiei*]; Benda et al. 2006 [as *P.* cf. *christii*]; Spitzenberger et al. 2006); El Tur, Sinai, 1 ind. (ZMB) (Spitzenberger et al. 2006); – Um Hashiba [= Umm Khisheib] [19], 1 December 1977: 1 m (TAU M.7160 [S+B]) (Qumsiyeh 1985 [as *P. austriacus christiei*]; Benda et al. 2006 [as *P.* cf. *christii*]); – Northern Sinai (Wassif 1995 [as *P. austriacus*]).

Comments. *Plecotus christii* is reported from eleven areas of Sinai covering the northern, central (Et Tih) and southern parts of the peninsula (Fig. 65); it is the second most frequently recorded bat species in Sinai (after *Hypsugo ariel*). *P. christii* was found both in the oases relatively close to the sea shore (Ain Hudra, Ain Sudr, El Tur, Feiran; Figs. 5, 19, 25) and sites in the continental mountainous inner parts of the peninsula (El Milga, Sheikh Awad, Wadi El Arbaein, Wadi Kid, Wadi Nasb, Wadi Shagg, etc.; Figs. 6, 34, 49, 64). This bat is also widely distributed in continental Egypt, where it occurs in the Nile Valley from Cairo to Aswan (Qumsiyeh 1985, Wassif 1995), in the mountains of the Eastern Desert (Osborn 1988, cf. Frauenfeld 1856) and in the Siwa Oasis of

Fig. 64. View from the top of Gebel Katerin (Mount Katherine, 2642 m a. s. l.) to north-west. In the centre and right side of the picture is a dyke system, along which the foraging of *Plecotus christii* Gray, 1838 and *Tadarida teniotis* (Rafinesque, 1814) was recorded. In the left part of the picture is the Wadi Shagg (ca. 1900 m a. s. l.), where *Rousettus aegyptiacus* (Geoffroy, 1810), *Rhinolophus clivosus* Cretzschmar, 1830 and *Plecotus christii* Gray, 1838 were evidenced (photo by C. Dietz).






Figs. 65, 66. 65 (left) – records of *Plecotus christii* Gray, 1838 in Sinai. 66 (right) – records of *Tadarida teniotis* (Rafinesque, 1814) in Sinai.

the Western Desert (Hayman 1949, Wassif et al. 1984). The Egyptian distribution roughly delineates the whole range of *P. christii* in Africa (Benda et al. 2004), since it is known westernmost from the Oasis of Al Jaghbub (Giarabub) (De Beaux 1928) in NE Libya and southernmost from the Fifth Cataract of the Nile in N Sudan (Flower 1932), in both directions close to the Egyptian border.

However, the Egyptian continental form of *P. christii* differs from that living in Sinai (Qumsiyeh 1985: 70; Benda et al. 2006: 236–239). The Sinaitic form, previously assigned tentatively to *P.* cf. *christii* by Benda et al. (2006, 2007), is also found in the desert and semi-desert areas of the southern Holy Land. In Israel, there are thirteen sites of occurrence listed; most of the records come from the Arava Valley and Negev Desert (Yom-Tov et al. 1992a, Mendelssohn & Yom-Tov 1999). From the central part of the Negev, Korine & Pinshow (2004) mentioned four additional sites around Sede Boqer. Amr (2000) summarised four records (presumably) of this form in southwestern corner of Jordan, from and south of Petra.

TAXONOMY. The Sinaitic and Holy Land *Plecotus* populations had been assigned primarily to *Plecotus auritus* (Linnaeus, 1758), later on to *P. austriacus* (Fischer, 1829) (see the synonymy below), however, mostly to a local form *christii* Gray, 1838 (also spelled *christiei*) in most cases regarded a subspecies of one of the former species. According to the opinion of Harrison & Bates (1991) who provisionally considered all Arabian populations as *P. austriacus christiei*, Spitzenberger et al. (2006) mentioned these populations under *P. christii* (in its present sense), however, with a question. As briefly showed by Benda et al. (2006, 2007), these populations morphologically differ from other congeners inhabiting the eastern Mediterranean area (Benda et al. 2006: 237–238, Figs. 154–156; 2007: 111, Figs. 33, 34). These comparisons actually showed the Sinaitic & Holy Land *Plecotus* to be very similar to *P. christii* from desert parts of continental Egypt and Libya in skull proportions and shape (having very narrow rostrum), although they absolutely differ in size (Fig. 67). The Sinaitic & Holy Land *Plecotus* specimens are in size close to the medium-sized W Palaearctic forms of the genus (*P. austriacus*, *P. m. macrobullaris* Kuzjakin, 1965, *P. gaisleri* Benda, Kiefer, Hanák et Veith, 2004), while the Libyan and Egyptian specimens of *P. christii* rather to the small-sized forms (*P. auritus*, *P. kolombatovici* Đulić, 1980). The principal component analysis of skull measurements performed by Benda et al. (2007: 111) clearly showed clustering of the Sinaitic and Holy Land samples separate from other eastern Mediterranean bats of the genus *Plecotus*.

The comparison of skull dimensions of the Libyan and Egyptian specimens vs. those from Sinai and Holy Land (Tables 9, 10) revealed the largest (and higly significant) differences between these two population groups in size characters, i.e. in largest skull lengths (LCr, LCb, LCc, LMd), the tooth-rows covering molars ($I^1M^3$, $CM^3$, $M^1M^3$, $I_1M_3$, $CM_3$, $M_1M_3$), three widths (LaZ, $P^4P^4$, LBT), dimensions of upper canines and molars, and several other absolute measures, while in most relative dimensions these samples concurred. However, significant distinction was present between the two groups in a relative dimension in the length of rostrum ($CM^3$/LCr, $CM^3$/LCb; Fig. 67; although not present in $I^1M^3$/LCr), suggesting slightly different positions of the visceral part of skull to the neurocranium in both sample groups. The Sinaitic and Holy Land samples also showed absolutely and relatively longer rostra than *P. macrobullaris* from the Middle East,

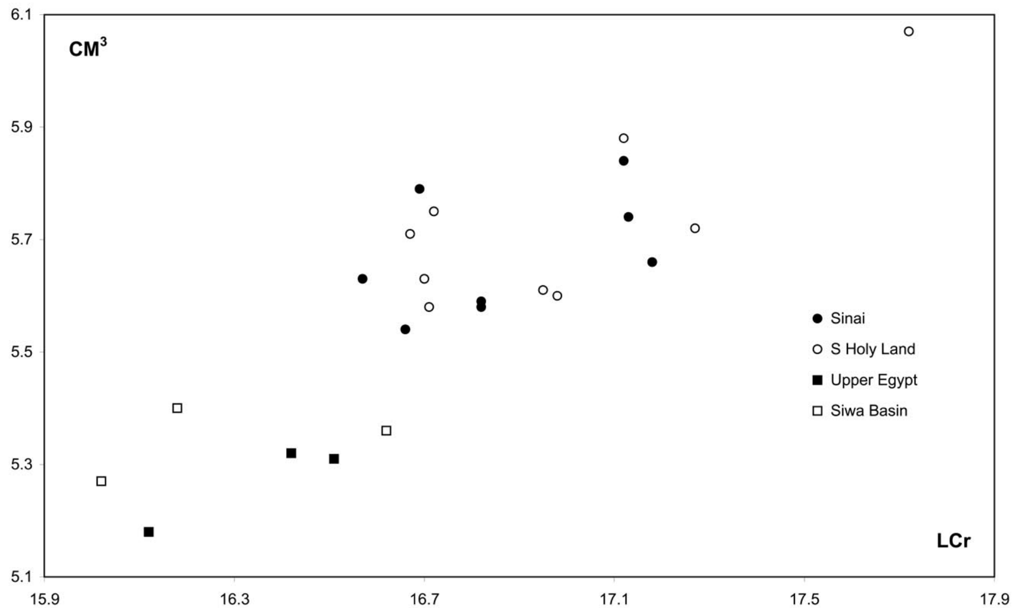



Fig. 67. Bivariate plot of examined samples of *Plecotus christii* Gray, 1838: greatest length of skull (LCr) against the length of upper tooth-row ($CM^3$).

Table 9. Basic biometric data [in mm] on and dimensional ratios of examined samples of *Plecotus christii* Gray, 1838. For details see text, for abbreviations see p. 6

| | Sinai & Holy Land | | | | | Upper Egypt & Siwa Basin | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | **M** | min | max | SD | n | **M** | min | max | SD |
| LAt | 34 | **39.96** | 38.1 | 41.6 | 0.904 | 7 | **38.29** | 36.4 | 40.2 | 1.418 |
| LPol | 15 | **5.47** | 5.0 | 5.7 | 0.219 | 6 | **5.32** | 5.0 | 5.6 | 0.279 |
| LCr | 17 | **16.93** | 16.57 | 17.72 | 0.297 | 6 | **16.31** | 16.02 | 16.62 | 0.239 |
| LCb | 17 | **15.78** | 15.43 | 16.37 | 0.263 | 6 | **15.25** | 14.93 | 15.57 | 0.253 |
| LaZ | 16 | **8.56** | 8.35 | 8.78 | 0.116 | 6 | **8.39** | 8.07 | 8.62 | 0.210 |
| LaI | 18 | **3.24** | 3.02 | 3.38 | 0.098 | 6 | **3.16** | 2.98 | 3.27 | 0.108 |
| LaN | 18 | **8.06** | 7.78 | 8.49 | 0.172 | 6 | **7.90** | 7.49 | 8.22 | 0.262 |
| ANc | 18 | **5.21** | 5.07 | 5.40 | 0.109 | 6 | **5.24** | 5.02 | 5.52 | 0.204 |
| LBT | 18 | **4.70** | 4.48 | 4.90 | 0.109 | 6 | **4.46** | 4.31 | 4.55 | 0.095 |
| CC | 18 | **3.56** | 3.20 | 3.78 | 0.135 | 6 | **3.39** | 3.33 | 3.47 | 0.055 |
| $M^3M^3$ | 18 | **6.00** | 4.96 | 6.35 | 0.311 | 6 | **5.75** | 5.42 | 5.94 | 0.216 |
| $CM^3$ | 18 | **5.70** | 5.54 | 6.07 | 0.133 | 6 | **5.31** | 5.18 | 5.40 | 0.076 |
| LMd | 18 | **10.62** | 10.32 | 11.13 | 0.201 | 6 | **10.19** | 9.98 | 10.41 | 0.171 |
| ACo | 18 | **3.04** | 2.77 | 3.24 | 0.096 | 6 | **2.84** | 2.69 | 2.94 | 0.105 |
| $CM^3$ | 18 | **6.13** | 5.90 | 6.85 | 0.243 | 6 | **5.71** | 5.60 | 5.87 | 0.101 |
| $CM^3$/LCb | 17 | **0.361** | 0.351 | 0.373 | 0.007 | 6 | **0.348** | 0.344 | 0.353 | 0.004 |
| $I^1M^3$/LCr | 16 | **0.384** | 0.374 | 0.396 | 0.006 | 6 | **0.378** | 0.369 | 0.388 | 0.006 |
| CC/$CM^3$ | 18 | **0.624** | 0.568 | 0.655 | 0.021 | 6 | **0.639** | 0.619 | 0.653 | 0.013 |
| $M^3M^3$/$CM^3$ | 18 | **1.063** | 1.020 | 1.126 | 0.028 | 6 | **1.084** | 1.021 | 1.124 | 0.042 |
| LaN/LCr | 17 | **0.477** | 0.453 | 0.496 | 0.011 | 6 | **0.484** | 0.454 | 0.508 | 0.019 |
| ANc/LCr | 18 | **0.309** | 0.291 | 0.323 | 0.010 | 6 | **0.321** | 0.305 | 0.345 | 0.014 |
| ACr/LCr | 16 | **0.447** | 0.426 | 0.470 | 0.013 | 5 | **0.452** | 0.436 | 0.473 | 0.014 |
| LBT/LCr | 18 | **0.279** | 0.266 | 0.289 | 0.006 | 6 | **0.274** | 0.269 | 0.277 | 0.003 |
| ACo/LMd | 19 | **0.287** | 0.267 | 0.301 | 0.008 | 6 | **0.279** | 0.265 | 0.293 | 0.010 |
| LCn/LaCn | 7 | **1.278** | 1.203 | 1.390 | 0.065 | 6 | **1.313** | 1.247 | 1.406 | 0.052 |
| $LM^3$/$LaM^3$ | 7 | **0.382** | 0.333 | 0.407 | 0.026 | 6 | **0.381** | 0.358 | 0.406 | 0.020 |

but on average shorter than *P. austriacus* from Europe (see also Benda et al. 2006: 237, Fig. 154; Benda et al. 2007: 111, Fig. 33).

A genetic comparison of partial cyt *b* sequences (522 bp) of Sinaitic specimens with those from SW Jordan and NE Libya (Table 11) showed rather shallow diversity among these samples (K2P distance 0.6–1.2%). Although rather limited sample sizes and short sequences were used, the results of this genetic comparison confirm parity within the Holy Land, Sinaitic and Libyan populations of *P. christii*.

Since the group of these small-sized bats from NE Libya (the oasis of Jaghbub, a part of the Siwa Basin of Western Desert) concur in their size and morphology with those of the southern Egypt, where the type locality of *Plecotus christii* Gray, 1838 was restricted (Qumsiyeh 1985: 68) to 'the Nile Valley between Qena and Aswan' (betw. 16° 10' N, 32° 43' E and 24° 05' N, 32° 53' E), the bats from the deserts of southern and also of western and central Egypt and eastern Libya belong to the nominotypical form. The populations of *P. christii* from Sinai and southern Holy Land, represent a morphotype clearly distinct from the nominotypical one, geographically limited to eastern portion of the species range. Although the genetic differences were found rather minute in our preliminary comparison, the above morphological analysis showed this morphotype unique in several characters. Therefore, we regard it as constituting a separate subspecies:

## *Plecotus christii petraeus* Benda, subsp. nov.

*Plecotus auritus*: Dobson 1878: 178 [partim]; Tristram 1884: 27 [partim]; Anderson 1902: 114 [partim]; Palacký 1902: 14 [partim]; Aharoni 1930: 342 [partim]; Flower 1932: 380 [partim]; Bodenheimer 1935: 92 [partim]; Ryberg 1947: Map 42 [partim]; Kuzjakin 1950: 299 [partim]; Wassif & Hoogstraal 1954: 66; Lanza 1959: 408 [partim]; Kuzjakin 1965: 98 [partim]; Koopman 1975: 417 [partim]; Makin 1977: 79; etc.
*Plecotus christiei*: Hayman 1949: 39 [partim]; Spitzenberger et al. 2006: 218–219, 228 [partim].
*Plecotus auritus christiei*: Ellerman & Morrison-Scott 1951: 181 [partim]; Theodor & Moscona 1954: 159 [partim]; Harrison 1956: 451 [partim]; Bodenheimer 1958: 174 [partim]; Hoogstraal 1962: 146–160 [partim].
*Plecotus austriacus*: Hanák 1962: 91 [partim]; Gaisler et al. 1972: 28 [partim]; Hufnagl 1972: 33 [partim]; Madkour 1977: 175–182 [partim]; Corbet 1978: 61 [partim]; Strelkov 1981: 40 [partim]; Makin 1987: 76; Strelkov 1988a: 90–101 [partim]; Strelkov 1988b: 288 [partim]; Le Berre 1990: 110 [partim]; Nader 1990: 345 [partim]; Yom-Tov et al. 1992a: 131–135; Shalmon et al. 1993: 65; Yom-Tov 1993: 350–354; Whitaker et al. 1994: 77–79; Borisenko & Pavlinov 1995: 103 [partim]; Wassif 1995: 44; Qumsiyeh et al. 1998: 283; Swift 1998: 5 [partim]; Yom-Tov & Kadmon 1998: 65–68; Disi & Hatough-Bouran 1999: 92; Amr 2000: 37; Feldman et al. 2000: 15–21; Kruskop & Lavrenchenko 2000: 13 [partim]; Horáček et al. 2000: 135 [partim]; Zelenova & Yosef 2003: 57–60; Amr et al. 2004: 443; Horáček et al. 2004: 1001–1025 [partim]; Korine & Pinshow 2004: 191–194; Amr et al. 2006: 236–239; Qumsiyeh et al. 2006: 238; etc.
*Plecotus austriacus christiei*: Harrison 1964: 178–181 [partim]; Kock 1969: 179–183 [partim]; Hayman & Hill 1971: 35 [partim]; Atallah 1977: 309 [partim]; Qumsiyeh 1985: 65–71 [partim]; Nader & Kock 1990b: 319–321 [partim]; Qumsiyeh et al. 1992: 112; Koopman 1994: 110 [partim]; Qumsiyeh 1996: 136 [partim]; Qumsiyeh et al. 1998: 281; Ferguson 2002: 69 [partim]; Hoath 2003: 65 [partim].
*Plecotus austriacus christii*: Harrison & Bates 1991: 103 [partim]; Mendelssohn & Yom-Tov 1999: 150–152 [partim].
*Plecotus* cf. *christii*: Benda et al. 2006: 236–240; Benda et al. 2007: 110–112.

TYPE MATERIAL. **Holotype**: adult male (NMP 90496 [S+A]), Feiran, Sinai, Egypt, 8 September 2005, leg. M. Andreas, P. Benda, J. Hotový & R. Lučan. – **Paratypes** (8): adult male (NMP 90523 [S+A]), Ain Hudra, Sinai, Egypt, 15 September 2005, leg. M. Andreas, P. Benda, J. Hotový & R. Lučan; – adult female (NMP 90533 [S+A]), Ain Sudr, Sinai, 18 September 2005, leg. M. Andreas, P. Benda, J. Hotový & R. Lučan; – subadult female (NMP 90497 [S+A]), El Milga, Sinai, Egypt, 9 September 2005, leg. M. Andreas, P. Benda, J. Hotový & R. Lučan; – adult male and adult female (NMP 90519 [S+A], 90518 [A]), El Tur, Hammam Musa, Sinai, Egypt, 10 & 11 September 2005, leg. M. Andreas, P. Benda, J. Hotový & R. Lučan; – adult male (NMP 90499 [S+A]), Feiran, Sinai, Egypt, 10 September 2005, leg. M. Andreas, P. Benda, J. Hotový & R. Lučan; – adult female (BMNH 3.12.8.5. [S+A]), Tor [= El Tur], Sinai [Egypt], leg. J. Anderson; – adult male (TAU M.7160 [S+B]), Um Hashiba [= Umm Khisheib], Sinai [Egypt], 1 December 1977, collector unlisted.

TYPE LOCALITY. Egypt, Sinai (Governorate of Janub Sina), Wadi Feiran, western edge of the oasis of Feiran, 28° 43’ N, 33° 37’ E, 595 m a. s. l.

DESCRIPTION AND DIAGNOSIS. *Plecotus christii petraeus* subsp. nov. resembles in most respects the nominotypical subspecies, *P. c. christii* Gray, 1838 in the sense of the re-description by Benda et al. (2004: 23–26), from which it differs mainly in its larger body and skull size (Tables 9, 10).

*P. christii petraeus* subsp. nov. is a medium-sized long-eared bat. Forearm is medium-long (LAt 38.1–41.6 mm), thumb short (LPol 5.0–5.7 mm). Skull is medium-sized to large (LCr 16.6–17.7 mm), with large tympanic bullae (LBT 4.5–4.9 mm). Rostral part of skull is relatively short ($I^1M^3$/LCr 0.37–0.40), absolutely and relatively very narrow (CC 3.2–3.8 mm; CC/$CM^3$ 0.57–0.66; $M^3M^3$/$CM^3$ 1.02–1.13). Braincase is absolutely and relatively very narrow (LaN 7.8–8.5 mm; LaN/LCr 0.45–0.50) and relatively medium in height (ANc 5.1–5.4 mm; ANc/LCr 0.29–0.32). Mandible is proportionally short, coronoid process rather low (ACo 2.8–3.2 mm; ACo/LMd 0.27–0.30). First upper incisors are mesiodistally rather long (0.58–0.66 mm). Upper canines are mesiodistally medium in length (LCn 0.95–1.12 mm), relatively medium in width (LCn/LaCn 1.20–1.39) and their height rather medium. First upper premolars ($P^3$) are minute and their crowns are mesiodistally rather short ($LP^3$ 0.41–0.46 mm) and palatolabially narrow. Second upper premolar ($P^4$) bear small to high cusp on the mesiopalatal edge of the cingulum (ACin 0.03–0.15 mm). Third upper premolars ($M^3$) are robust ($LM^3$/$LaM^3$ 0.33–0.41).

Muzzle is in *P. c. petraeus* subsp. nov. rather blunt with larger preorbital glands; the rounded supraorbital glands are small. The coloration of pelage and naked parts is pale (Fig. 68); distal

Table 10. Biometric data [in mm] on the holotype specimen and the type series of *Plecotus christii petraeus* subsp. nov. with results of two statistic tests comparing it with the nominotypical form, *P. c. christii* Gray, 1838 (see text for details). For abbreviations see p. 6

| | holotype | | | type series | | | | ANOVA | | t-test | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | n | **M** | min | max | SD | df | F | p | t-value | p |
| LAt | 41.0 | 8 | **39.98** | 38.7 | 41.3 | 0.924 | 22 | 13.52 | ** | –3.68 | ** |
| LPol | 5.2 | 8 | **5.53** | 5.2 | 5.7 | 0.149 | 21 | 1.51 | | –1.23 | |
| LCr | 17.13 | 8 | **16.87** | 16.57 | 17.18 | 0.238 | 22 | 20.54 | *** | –4.53 | *** |
| LCb | 16.12 | 8 | **15.76** | 15.57 | 16.12 | 0.216 | 22 | 15.94 | ** | –3.99 | ** |
| LCc | 15.61 | 7 | **15.25** | 15.02 | 15.61 | 0.213 | 14 | 20.12 | ** | –4.49 | ** |
| LaZ | 8.67 | 7 | **8.57** | 8.41 | 8.76 | 0.120 | 21 | 6.09 | * | –2.47 | * |
| LaI | 3.19 | 8 | **3.24** | 3.12 | 3.38 | 0.096 | 23 | 2.66 | | –1.63 | |
| LaInf | 4.18 | 8 | **4.10** | 3.65 | 4.28 | 0.192 | 21 | 1.60 | | –1.26 | |
| LaN | 8.49 | 8 | **8.08** | 7.87 | 8.49 | 0.205 | 23 | 3.19 | | –1.79 | |
| ANc | 5.11 | 8 | **5.18** | 5.07 | 5.33 | 0.107 | 23 | 0.12 | | 0.34 | |
| ACr | 7.37 | 8 | **7.48** | 7.32 | 7.62 | 0.102 | 20 | 6.07 | * | –2.46 | * |
| LBT | 4.61 | 8 | **4.68** | 4.53 | 4.78 | 0.090 | 23 | 24.49 | *** | –4.95 | *** |
| CC | 3.58 | 8 | **3.62** | 3.55 | 3.68 | 0.045 | 23 | 8.02 | * | –2.83 | * |
| $P^4P^4$ | 4.83 | 8 | **4.81** | 4.57 | 4.93 | 0.129 | 21 | 20.16 | *** | –4.49 | *** |
| $M^3M^3$ | 6.02 | 8 | **6.11** | 5.92 | 6.24 | 0.131 | 23 | 3.09 | | –1.76 | |
| $I^1M^3$ | 6.58 | 8 | **6.54** | 6.43 | 6.74 | 0.110 | 20 | 19.51 | *** | –4.42 | *** |
| $CM^3$ | 5.74 | 8 | **5.67** | 5.54 | 5.84 | 0.108 | 22 | 46.62 | *** | –6.83 | *** |
| $M^1M^3$ | 3.50 | 7 | **3.56** | 3.47 | 3.68 | 0.086 | 14 | 89.62 | *** | –9.47 | *** |
| $CP^4$ | 2.80 | 7 | **2.60** | 2.09 | 2.80 | 0.240 | 13 | 3.69 | | –1.92 | |
| $LI^1$ | 0.58 | 7 | **0.63** | 0.58 | 0.66 | 0.030 | 11 | 19.35 | ** | –4.40 | * |
| $LaI^1$ | 0.41 | 7 | **0.42** | 0.40 | 0.44 | 0.017 | 11 | 10.49 | * | –3.24 | * |
| $AI^1$ | 0.82 | 7 | **0.84** | 0.75 | 1.01 | 0.080 | 10 | 0.28 | | –0.53 | |
| LCn | 1.12 | 7 | **1.02** | 0.95 | 1.12 | 0.052 | 11 | 7.37 | * | –2.71 | * |
| LaCn | 0.81 | 7 | **0.80** | 0.76 | 0.83 | 0.020 | 11 | 25.95 | *** | –5.09 | *** |
| ACn | 1.30 | 7 | **1.50** | 1.30 | 1.61 | 0.104 | 10 | 3.82 | | –1.95 | |
| $LP^3$ | 0.44 | 7 | **0.43** | 0.41 | 0.46 | 0.017 | 11 | 3.23 | | –1.80 | |
| $LaP^3$ | 0.48 | 7 | **0.49** | 0.46 | 0.52 | 0.023 | 10 | 6.99 | * | –2.64 | * |
| $AP^3$ | 0.38 | 7 | **0.47** | 0.38 | 0.52 | 0.056 | 10 | 1.01 | | –1.01 | |
| $LM^1$ | 1.46 | 7 | **1.43** | 1.37 | 1.52 | 0.053 | 11 | 38.91 | *** | –6.24 | *** |
| $LaM^1$ | 1.62 | 7 | **1.65** | 1.60 | 1.70 | 0.038 | 11 | 66.15 | *** | –8.13 | *** |
| $LM^3$ | 0.60 | 7 | **0.65** | 0.59 | 0.69 | 0.045 | 11 | 7.43 | * | –2.73 | * |
| $LaM^3$ | 1.62 | 7 | **1.70** | 1.62 | 1.76 | 0.049 | 11 | 30.70 | *** | –5.54 | *** |
| ACin | 0.06 | 7 | **0.07** | 0.03 | 0.15 | 0.038 | 10 | 3.79 | | –1.95 | |
| LMd | 10.77 | 8 | **10.56** | 10.36 | 10.77 | 0.172 | 23 | 21.80 | *** | –4.67 | *** |
| ACo | 3.08 | 8 | **3.07** | 2.96 | 3.24 | 0.086 | 23 | 19.44 | *** | –4.41 | *** |
| $I_1M_3$ | 6.78 | 8 | **6.81** | 6.71 | 7.04 | 0.120 | 21 | 24.49 | *** | –4.95 | *** |
| $CM_3$ | 6.14 | 8 | **6.09** | 5.93 | 6.37 | 0.160 | 23 | 25.37 | *** | –5.04 | *** |
| $M_1M_3$ | 4.03 | 7 | **4.05** | 3.95 | 4.24 | 0.098 | 14 | 69.53 | *** | –8.34 | *** |
| $CP_4$ | 2.35 | 7 | **2.28** | 2.20 | 2.37 | 0.069 | 14 | 14.07 | ** | –3.75 | ** |
| $I^1M^3$/LCr | 0.384 | 8 | **0.388** | 0.383 | 0.396 | 0.005 | 20 | 4.02 | | –2.01 | |
| $CM^3$/LCr | 0.335 | 8 | **0.336** | 0.329 | 0.347 | 0.006 | 21 | 18.33 | *** | –4.28 | *** |
| CC/$CM^3$ | 0.624 | 8 | **0.639** | 0.623 | 0.655 | 0.013 | 22 | 2.64 | | 1.62 | |
| $M^3M^3$/$CM^3$ | 1.049 | 8 | **1.078** | 1.049 | 1.126 | 0.028 | 22 | 2.07 | | 1.44 | |
| LaN/LCr | 0.496 | 8 | **0.479** | 0.462 | 0.496 | 0.011 | 22 | 1.50 | | 1.23 | |
| ANc/LCr | 0.298 | 8 | **0.307** | 0.295 | 0.320 | 0.010 | 22 | 5.84 | * | 2.42 | * |
| ACr/LCr | 0.430 | 8 | **0.443** | 0.426 | 0.457 | 0.012 | 19 | 0.51 | | 0.71 | |
| LBT/LCr | 0.269 | 8 | **0.277** | 0.269 | 0.282 | 0.004 | 22 | 5.03 | * | –2.24 | * |
| ACo/LMd | 0.286 | 8 | **0.290** | 0.285 | 0.301 | 0.005 | 23 | 3.52 | | –1.88 | |
| LCn/LaCn | 1.390 | 7 | **1.278** | 1.203 | 1.390 | 0.065 | 11 | 1.16 | | 1.08 | |
| $LM^1$/$LaM^1$ | 0.897 | 7 | **0.864** | 0.829 | 0.897 | 0.025 | 11 | 0.00 | | 0.00 | |
| $LM^3$/$LaM^3$ | 0.368 | 7 | **0.382** | 0.333 | 0.407 | 0.026 | 11 | 0.02 | | –0.14 | |

Fig. 68. An individual of *Plecotus christii petraeus* subsp. nov. from the oasis of El Milga, Sinai (photo by C. Dietz).

parts of the dorsal hairs are very pale brownish-grey or umber, their proximal parts are dark brownish-grey. Distal parts of the ventral hairs are whitish or creamy and their proximal parts are dark brown or grey. Wing membranes are pale greyish brown, their distal parts are paler, ears and tragi are very pale brown but rather unpigmented. Face is pale brownish grey.

Penis is in *P. c. petraeus* subsp. nov. of the same shape as in *P. c. christii* Gray, 1838, i.e. of the '*austriacus & kolombatovici* type' sensu Mucedda et al. (2002). Baculum of *P. c. petraeus* subsp. nov. (Fig. 59e, f) is of similar shape as in the nominotypical form (see Lanza 1960: 11; Qumsiyeh 1985: 70; and Benda et al. 2004: 16), it is small and narrow bone, its proximal epiphysis bears

Table 11. Genetic divergences (corrected distances – Kimura 2-parameter model) among the examined haplotypes of partial sequences (522 bp) of cytochrome *b* mitochondrial gene of *Plecotus* Geoffroy, 1818

| K2P distance | | haplotype | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] |
|---|---|---|---|---|---|---|---|---|---|---|
| [1] | *P. christii* | Sinai | – | | | | | | | |
| [2] | *P. christii* | Jordan | 0.012 | – | | | | | | |
| [3] | *P. christii* | Libya | 0.006 | 0.010 | – | | | | | |
| [4] | *P. balensis* | | 0.097 | 0.092 | 0.090 | – | | | | |
| [5] | *P. austriacus* | | 0.147 | 0.152 | 0.145 | 0.155 | – | | | |
| [6] | *P. auritus* | | 0.211 | 0.217 | 0.208 | 0.205 | 0.208 | – | | |
| [7] | *P. macrobullaris* | | 0.167 | 0.167 | 0.165 | 0.186 | 0.211 | 0.136 | – | |
| [8] | *B. barbastellus* | Morocco 2 | 0.217 | 0.217 | 0.214 | 0.206 | 0.234 | 0.254 | 0.261 | – |

very short and broad lateral arms, and its distal extremity is narrow and blunt. Its dimensions in two examined specimens (NMP 90499, 92097; see Fig. 59e, f) were as follows: length 0.80 and 0.84 mm, maximum width at the proximal epiphysis 0.53 and 0.49 mm, respectively.

For dimensions of the holotype specimen and type series see Table 10 and Appendix V. For details of the differential diagnosis see the comparison above and Tables 9 and 10 as well as the data by Benda et al. (2004).

Partial sequence of the mitochondrial gene for cytochrome *b* obtained from two specimens of *P. c. petraeus* subsp. nov. (holotype and a paratype) coming from western Sinai (NMP 90496 and 90533; 522 bp from the position 159; NCBI Accession Number EU743799):

gca cta tac atc aga tac agc aac agc ttt taa ttc tgt cac tca tat ttg ccg aga tgt aaa tta cgg ctg aat att acg ata tct tca tgc taa tgg agc ttc cat att ttt tat ttg cct cta cct aca cat tgg ccg agg tct tta tta tgg atc cta tat ata taa aga aac ttg aaa cgt ggg aat tat ctt act att tgc agt cat agc aac cgc ctt cat agg ata tgt gct acc atg agg cca aat atc ttt ttg agg agc aac tgt aat cac caa tct act atc cgc aat ccc ata cat tgg aac aac cct ggt aga atg aat ctg agg tgg att ttc cgt aga caa agc tac act gac ccg att ttt cgc act tca ctt tct act ccc ttt tat cat ctc agc tat agt tat aat tca cct tct att tct tca cga gac cgg atc caa taa ccc aat agg aat tcc ctc taa cgc aga cat aat ccc ctt cca ccc cta cta cac aac taa.

Derivatio nominis. The subspecific name refers to Arabia Petraea, a classical name of the arid region (and the former Roman province) in the northwestern part of Arabia, covering Sinai and southern portions of Israel and Jordan, the region of occurrence of the subspecies (see Distribution and Records below). The name *petraeus* is linked with petra, a Latin word meaning rock or boulder, the main features creating the landscape of the region of the new subspecies origin.

Distribution. *P. c. petraeus* subsp. nov. is known to occur in semi-desert and desert areas of southern Israel, southwestern Jordan and the peninsula of Sinai (see Records below). However, its records should be expected also in the northwestern part of Saudi Arabia and in the northeastern desert corner of the continental Egypt.

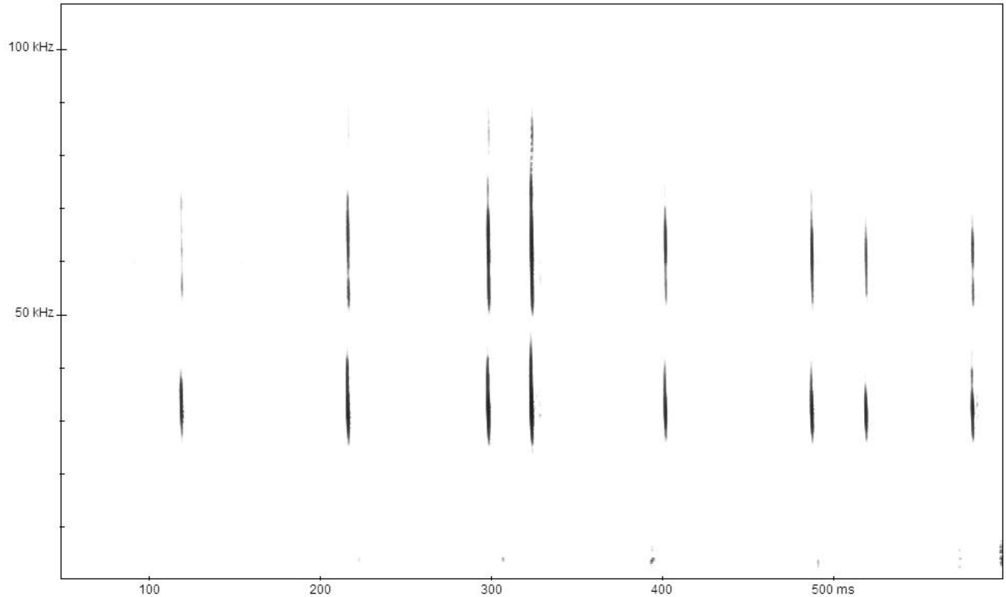
Records. **Sinai**: see Records under *Plecotus christii* above; **Israel**: 'Arad, Avdat / 'Avedat, Ben Gurion grave site, Cave Adullam (10 km SE Jerusalem) (= Mogharet Shureitun / Khureitun), Eilat, En Ziq, Hakrastit Cave (near Revivim), Nakhal Amram (10 km N Eilat), Nakhal Timna, Nakhal Hever / Khaver / Wadi Khabra, Nakhal Zin, Neot HaKikar, Wadi Meneiye (Timna) (Harrison 1964, Atallah 1977, Makin 1977, Qumsiyeh 1985, Yom-Tov et al. 1992a, Mendelssohn & Yom-Tov 1999, Zelenova & Yosef 2003, Korine & Pinshow 2004); **Jordan**: Disa (Wadi Rum), Gharandal (Wadi Araba), Petra, Ra's an Naqb, Wadi Rum (Qumsiyeh et al. 1992, 1998, Disi & Hatough-Bouran 1999, Benda et al. 2006).

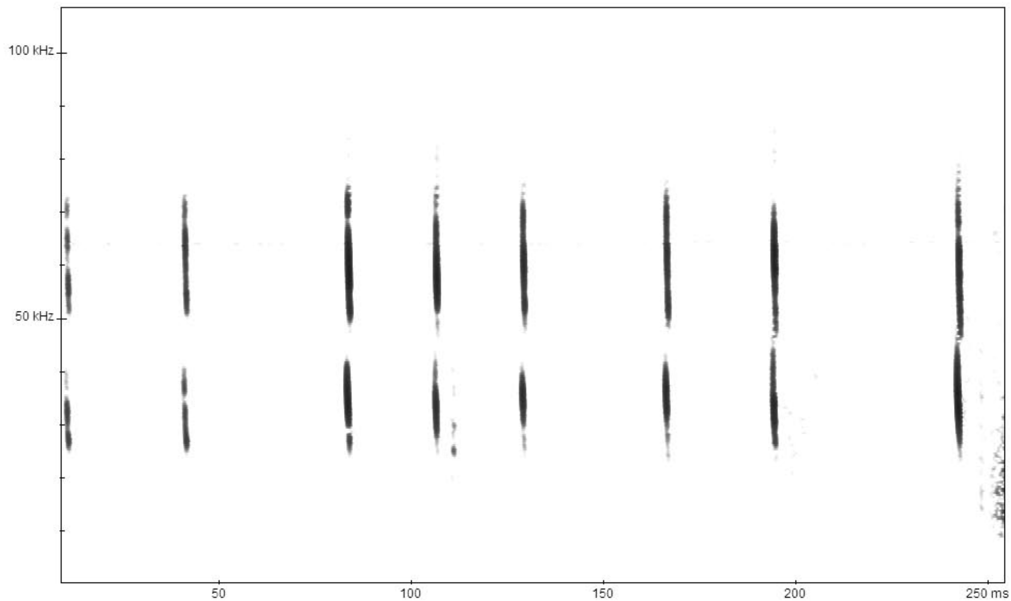
Feeding ecology. Whitaker et al. (1994) analysed five pellets of *Plecotus christii* from Israel, which contained 100% of Lepidoptera and expected the studied species to be a gleaner as other representatives of the genus. Feldman et al. (2000) found 78.5% volume of lepidopterans and small proportions of Trichoptera, Coleoptera and Diptera in the diet of *P. christii* in the Dead Sea area, Israel.

Lepidoptera were also found to be the substantial proportion of the diet of *Plecotus macrobullaris* in the Middle East region (Benda et al. 1999, 2006); all the samples from northwestern Iran contained only Lepidoptera and two samples from Syria contained 100% and 98% volume of Lepidoptera, respectively.

We collected seven bats in different parts of Sinai (see above) and six digestive tracts contained only Lepidoptera. One digestive tract contained 80% volume of Lepidoptera and 20% of Blattodea (Fig. 16). Such a result corresponds well with the previous studies on the *Plecotus* bats from the broader region.

Echolocation. Basic parameters of echolocation calls of *Plecotus christii* from Sinai (Figs. 69, 70) are given in Table 3. To our knowledge, we give the first detailed information on echolocation parameters of this species. Shalmon et al. (1993) and Mendelssohn & Yom-Tov (1999) mentioned range of the call 20–50 kHz, with FMAXE at 35–50 and 35–45 kHz, respectively.




Figs. 69, 70. Spectrograms of echolocation calls of *Plecotus christii* Gray, 1838. 69 (above) – hand-released individual from Feiran. 70 (below) – hand-released individual from Wadi Gebal.

Echolocation of *P. christii* it is almost identical to echolocation of European *Plecotus austriacus* (Fischer, 1829) (Russo & Jones 2002). However, pulse duration and interpulse intervals are in *P. christii* much shorter than in *P. austriacus*, however this is most probably due to the recording conditions: in most fm-species pulse duration is much shorter in release calls than in recordings of free flying bats.

### *Tadarida teniotis* (Rafinesque, 1814)

Records. **Original data**: Ain El Furtaga [1], a pool in a canyon above the oasis (Fig. 4), 16 September 2005: net. 3 ma (NMP 90524 [A], 90525, 90526 [S+A]), 17 September 2005: net. 4 ma (NMP 90529–90532 [S+A]), det. & rec. more inds.; – Ain Hudra [2], oasis (Fig. 5), 5 August 2005: det. & rec. 2 inds.; – El Milga [3] (Fig. 6), Fox Camp, 3 July 2006: many foraging inds.; – Feiran [4], western edge of the oasis, 8 September 2005: det. 1 ind.; – Feiran [5], a garden in eastern edge of the oasis, 9 September 2005: det. min. 1 ind.; – Ras Muhammad National Park, Khashaba Beach [6], 11 September 2005: det. min. 1 ind.; – Shiekh Awad [7], El Karm Ecolodge (Fig. 49), 17 August 2005: det. 1 ind.; – Wadi El Arbaein [8], St. Katherine Research Centre, 29 July – 20 August 2005: obs., det. & rec. 1–5 inds.

Comments. *Tadarida teniotis* is here reported from Sinai for the first time; seven individuals were netted at the oasis of Ain El Furtaga (Fig. 4) and echolocation calls of numerous bats were recorded there and in five other areas in the southern part of the peninsula, both in mountainous rocky wadis and in lowland oases (Fig. 65).

The Sinaitic part of the distribution range of *T. teniotis* represents the southernmost occurrence spot in Egypt, since this bat has been formerly found only in the Cairo region (Qumsiyeh 1985, Wassif 1995) and Wadi El Natrun (Wassif et al. 1984). Only two records are known to come from sites lying further to the south than the Sinaitic ones, one from western Saudi Arabia (Ta'if; Harrison & Bates 1991) and the other from southeastern Iran (Minab; DeBlase 1971). Relatively numerous records of *T. teniotis* in Sinai, however, represent a continuation of the more abundant records in the southern Holy Land rather than in continental Egypt. In Israel, this species is the most widespread and common bat in the arid southern part of the country; Mendelssohn & Yom-Tov (1999) marked in their map 28 records to south of Jerusalem (besides 16 records in northern portion of the country) – this being 1.8 times more than of the second most common bat there, *Eptesicus bottae*; Korine & Pinshow (2004) mentioned fourteen records in a limited area of central Negev around Sede Boqer. On this basis it is likely that *T. teniotis* would also be commonly encountered in the unexplored northern areas of Sinai, as it is in the areas to south and east.

Taxonomy. Although *Tadarida teniotis* in its current species rank (Simmons 2005) is considered monotypic by some authors (Aellen 1966, Corbet 1978, Koopman 1994), most of authors recognise two subspecies in the western Palaearctic; the nominotypical one, living in Europe and Maghreb, and *T. t. rueppellii* (Temminck, 1826), occurring in the Asian range of species plus the populations of the northeastern Africa (see the reviews by Kock & Nader 1984 and Benda et al. 2006). Since the latter form was described from Egypt (the type locality was restricted to 'Cairo' by Qumsiyeh 1985), evaluation of the Sinaitic populations could help in the comprehension of intraspecific taxonomy in this species.

The differences between the two subspecies were restricted to coloration characters only, as the dimensional variation within *T. teniotis* was found rather inconsiderable (see Table 12 and also Table 34 by Benda et al. 2006: 251); the pelage colour in *T. t. rueppellii* is referred to be paler and greyer than in the darker and more brownish nominotypical form (Lewis & Harrison 1962, Harrison 1964, Aellen 1966, von Lehmann 1966, Kock & Nader 1984, Qumsiyeh 1985, Harrison & Bates 1991, Ibáñez & Pérez-Jordá 2004, Benda et al. 2006, etc.). However, in all parts of the species' distribution range the pelage coloration is highly variable; both colour morphs as well as intemediate stages between them were reported from southern Europe as well as from some

Table 12. Basic biometric data on examined Sinaitic and comparative samples of *Tadarida teniotis* (Rafinesque, 1814). For abbreviations see p. 6

| | Sinai | | | | | Middle East | | | | | Lower Egypt (Qumsiyeh 1985) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | **M** | min | max | SD | n | **M** | min | max | SD | n | **M** | min | max | SD |
| LAt | 7 | **61.37** | 59.7 | 64.3 | 1.579 | 23 | **61.27** | 57.9 | 64.0 | 1.578 | 7 | **61.1** | 58 | 63 | 1.7 |
| LCr | 6 | **24.17** | 23.77 | 24.38 | 0.228 | 22 | **23.96** | 23.02 | 24.62 | 0.418 | 7 | **23.9** | 23.2 | 24.3 | 0.4 |
| LCb | 6 | **23.58** | 23.30 | 23.92 | 0.224 | 21 | **23.40** | 22.18 | 24.02 | 0.371 | – | – | – | – | – |
| LaZ | 6 | **14.43** | 14.18 | 15.06 | 0.316 | 22 | **14.14** | 13.24 | 14.47 | 0.308 | 7 | **13.9** | 13.5 | 14.5 | 0.4 |
| LaI | 6 | **4.70** | 4.57 | 4.88 | 0.126 | 23 | **4.68** | 4.39 | 5.12 | 0.169 | 7 | **5.0** | 4.6 | 5.8 | 0.4 |
| LaN | 6 | **11.63** | 11.22 | 12.09 | 0.282 | 22 | **11.87** | 11.24 | 12.37 | 0.300 | – | – | – | – | – |
| ANc | 6 | **7.49** | 7.31 | 7.74 | 0.162 | 20 | **7.34** | 6.93 | 7.74 | 0.199 | 7 | **7.2** | 6.5 | 7.6 | 0. |
| CC | 6 | **5.66** | 5.49 | 6.13 | 0.236 | 23 | **5.71** | 5.39 | 5.93 | 0.154 | – | – | – | – | – |
| $M^3M^3$ | 6 | **9.47** | 9.14 | 10.01 | 0.351 | 23 | **9.43** | 8.86 | 9.75 | 0.228 | – | – | – | – | – |
| $CM^3$ | 6 | **9.07** | 8.91 | 9.26 | 0.125 | 25 | **9.05** | 8.64 | 9.61 | 0.215 | 7 | **8.8** | 8.5 | 9.0 | 0.2 |
| LMd | 6 | **16.97** | 16.71 | 17.56 | 0.305 | 25 | **16.98** | 15.94 | 17.52 | 0.330 | 7 | **16.4** | 15.7 | 16.7 | 0.4 |
| ACo | 6 | **4.10** | 3.91 | 4.29 | 0.138 | 25 | **4.08** | 3.81 | 4.43 | 0.155 | 7 | **4.8** | 4.3 | 5.0 | 0.3 |
| $CM_3$ | 6 | **9.67** | 9.53 | 9.80 | 0.092 | 23 | **9.69** | 9.24 | 10.41 | 0.253 | 7 | **10.0** | 9.6 | 10.2 | 0.2 |

parts of the Middle East and North Africa (Lewis & Harrison 1962, von Lehmann 1966, DeBlase 1980, Arlettaz 1990, Ibáñez & Pérez-Jordá 2004, own observations on materials from Maghreb, Turkey, Cyprus and Iran). Already De Winton (1901) described *Nyctinomus tæniotis* (= *Tadarida teniotis*) from southern Europe and Persia to be mouse-grey coloured.

In our limited series of *T. teniotis* from Sinai, almost a continuum in pelage coloration tinge and richness among specimens was observed; the most dark and brown and the most pale and grey individuals from this set are evidenced in the Figs. 71 and 72. Dorsal pelage in the darkest specimens was dark chestnut brown while in pale bats silverish brown-grey; the ventral pelage was slightly paler brown and very pale brown to creamy, respectively. In both morphs the membranes were similarly dark brown while in the pale morph the ears, legs, arms and forearms were paler or even unpigmented ventrally (Figs. 71, 72). From the eight specimens colected at Ain El Furtaga, three bats were dorsally dark brown, two pale silverish brown-grey and two specimens showed approximately intermediate tinge between those two marginal variations. The dark brown individuals resembled well in their coloration the dark brown individuals known from the European and/or Maghrebian populations.

The existence of brown individuals in the Levantine populations of *T. teniotis* was noted already by Harrison & Bates (1991), who concluded: “Although occasional specimens from Arabia are light brown in tint, these do not approach the warm brown colour of *T. t. teniotis*.” Our records from Sinai population, however, evidenced similar coloration relations which were reported from Europe, where only the nominotypical form was mentioned to occur (see above). The doubts about the justification of the form *rueppellii* on the subspecific level, noted by Aellen (1966), Qumsiyeh (1985), Benda & Horáček (1998), and/or Horáček et al. (2000), seem to appear to be reasonable.

We cannot exclude that the North African or Asian populations of *T. teniotis* differ from the European ones and represent a separate evolution unit within rank of the species, however, such difference should be proved on grounds other than on the pelage coloration differences alone. Although the percentage of pale and/or greyish individuals in Egyptian or Middle Eastern populations could be higher than in the Euro-Mediterranean ones, as they live in more arid regions, such difference could represent marginal stages of a cline shift rather than step distinctions among some of the

Figs. 71, 72. Pelage coloration in two most extreme coloured specimens of *Tadarida teniotis* (Rafinesque, 1814) from the Ain El Furtaga Oasis (photos by P. Benda). 71 (above) – dorsal view. 72 (below) – ventral view.

Mediterranean populations. Therefore, we consider the Asian/Northeast African subspecies *Tadarida teniotis rueppellii* (Temminck, 1826) to be unjustified in its present definition and this name to be a junior synonym of name of the nominotypical subspecies, *T. t. teniotis* (Rafinesque, 1814).

FEEDING ECOLOGY. *Tadarida teniotis* is a fast-flying aerial hawker (Norberg & Rayner 1987, Arlettaz 1990, Feldman et al. 2000), in which the lepidopterans were found to be the most important prey category (Rydell & Arlettaz 1994, Whitaker et al. 1994, Benda et al. 2006).

We collected digestive tracts of seven individuals from eastern Sinai, but one was empty. We found Lepidoptera to be the most important prey item (60% volume), followed by Heteroptera (15%), Orthoptera (11.7%), Neuroptera (5%), Blattodea (5%) and Brachycera (3.3%) (Fig. 16). General pattern of recorded trophic niche is similar to results of previous studies. The record of Brachycera in the diet of this fast flying aerial hawker is a little bit surprising, as diurnal Brachycera are found especially in the diet of foliage gleaning bats. It can perhaps be explained by the early evening start of hunting activity by this bat, when some diurnal insects can be still active. The proportion of Lepidoptera recorded in the Sinaitic samples is the lowest as compared to results of the previous studies (see Benda et al. 2006), but the published number of *T. teniotis* diet analyses is too small and our sample is insufficient for some general conclusion. We can only speculate that moth-eating specialist *T. teniotis* is forced to hunt also other prey categories in extremely adverse conditions of the arid Sinai mountains.

Absence of any detectoring record from winter controls of the localities of regular appearance of *T. teniotis* in summer (El Milga, Ras Muhammad NP; Horáček, ad verb.) suggests a considerable suppression of foraging activity during winter time.

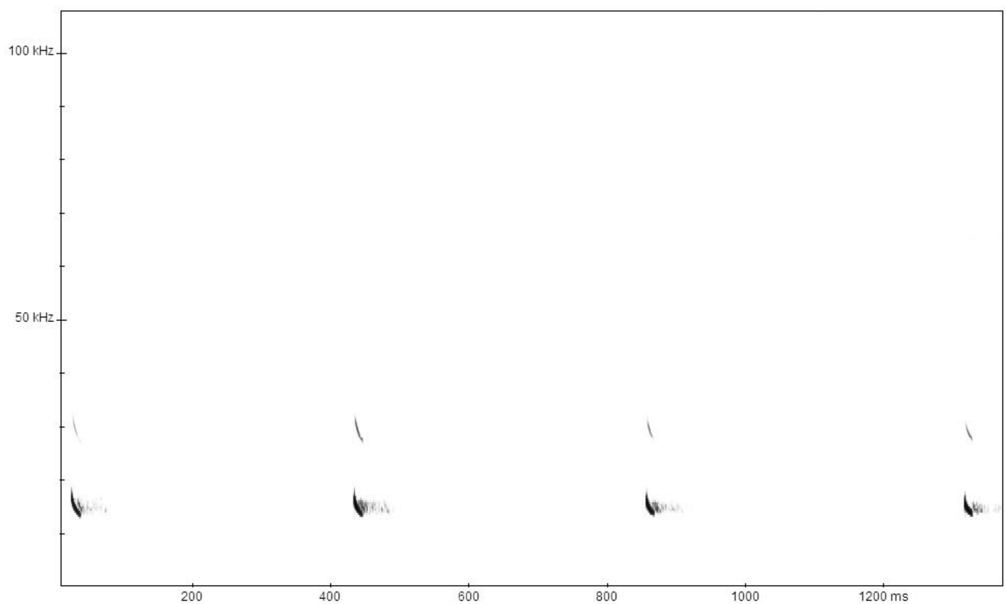



Fig. 73. Spectrogram of echolocation calls of *Tadarida teniotis* (Rafinesque, 1814). An individual flying over St. Katherine Research Center.

ECHOLOCATION. Basic parameters of echolocation calls of *Tadarida teniotis* from Sinai (Fig. 73) are given in Table 3. Echolocation parameters of *T. teniotis* fall within the range described by other authors for European and/or Levantine populations of the species (Shalmon et al. 1993, Mendelssohn & Yom-Tov 1999, Russo & Jones 2002, Obrist et al. 2004, Benda et al. 2006). The only exceptional variable is the interpulse interval, which is, on average, much shorter in calls of Sinaitic *T. teniotis* than in either European or Syrian individuals (Russo & Jones 2002, Obrist et al. 2004, Benda et al. 2006). Calls of this species reported by Benda et al. (2006) from Syria were lower by ca. 3 kHz than those reported here from Sinai.

NOTE. Among many typical sound recordings of *Tadarida teniotis* we also recorded from the broader area of the El Milga Oasis, calls that were higher in their frequencies. We can not exclude that they belong to a species other than *T. teniotis* (as preliminarily suggested by Dietz 2005a), however, since both types of echolocation calls were also recorded in Israel (A. Tsoar, E. Levin & C. Korine, ad verb. and our own data) presumably from *T. teniotis* (perhaps from juveniles?) as there is no suggestion of other candidate species being present, we include these recordings provisionally under *T. teniotis* below. The only other molossid bat known from Egypt (but not Sinai) is *Tadarida aegyptiaca* (Geoffroy, 1818), however this species emits echolocation calls of much higher frequencies than those recorded (although the reference sound recordings are available only from South African populations [Taylor 2000] and may not be representative of Egyptian populations). Besides *T. aegyptiaca*, at least eight Afro-tropical species could be considered; *Tadarida ventralis* (von Heuglin, 1861), *Mops condylurus* (Smith, 1833), *M. demonstrator* (Thomas, 1903), *M. midas* (Sundevall, 1843), *Chaerephon bivittatus* (von Heuglin, 1861), *C. major* (Trouessart, 1897), *C. nigeriae* Thomas, 1913, *C. pumilus* (Cretzschmar, 1830), and possibly others. However, none of these species have been found in Egypt nor northern Arabia although they are known to occur in the closest areas of Saharan and sub-Saharan Africa (central Sudan, Eritrea, northern Ethiopia, and/or southwestern Arabia) (Largen et al. 1974, Koopman 1975, Harrison & Bates 1991). Molossid bats are very strong flyers and it is not unfeasible that these high flying bats have not been recorded before. For other details considering possible bat species in Sinai see Discussion.

RECORDS. **Original data**: El Milga, Deir Sant Katerin, parking ground, 9 August 2005: det. & rec. 1 ind.; – El Milga, St. Katherine Research Centre, 30 July 2005: det. & rec. 1–2 inds., 2 August 2005: det. & rec. 2 inds.; – Wadi El Arbaein, Ramadan's Garden, 1 August 2005: det. & rec. 1 ind.

## DISCUSSION

The present review summarises 106–111 records of 14–15 bat species from the Sinaitic peninsula. The last summaries of the bat fauna of Sinai given by Qumsiyeh (1985) and Harrison & Bates (1991) brought around 15 records of nine species (Table 13). Although it still remains rather brief, the picture of bat fauna composition – at least of the southern portion of the peninsula – is now much more precise, the number of records is now roughly seven times higher than in the last summaries. Six species are reported here for the first time from Sinai; viz. *Rousettus aegyptiacus*, *Rhinopoma cystops*, *Taphozous perforatus*, *Rhinolophus* cf. *mehelyi*, *Eptesicus bottae*, and *Tadarida teniotis*. Of course, in three of them, viz. *R. cystops*, *T. perforatus*, *R.* cf. *mehelyi*, the respective records are based on recordings of echolocation calls, with no individuals captured. We stress this fact especially in connection with those of *Rhinopoma cystops* and *Rhinolophus* cf. *mehelyi*, both recorded by a single sequence only. This species number represents 67–71% of the bat fauna reported from Egypt (Qumsiyeh 1985). Although all species known from Sinai were previously reported from Egypt (Qumsiyeh 1985), at least two bat species occur in Egypt

Table 13. Composition of the bat fauna of Sinai and the number of records of particular species according to subsequent reviews. In parentheses are values not accurately identified geographically and/or specifically

| | Anderson 1902 | Wassif & Hoogstraal 1954 | Qumsiyeh 1985, Harrison & Bates 1991 | present review |
|---|---|---|---|---|
| *Rousettus aegyptiacus* | – | – | – | 10 |
| *Rhinopoma cystops* | – | – | – | 1 |
| *Taphozous perforatus* | – | – | – | 1 |
| *Nycteris thebaica* | 1 | 1 | 1 | 2 |
| *Rhinolophus clivosus* | – | 2 | 3 | 9 |
| *Rhinolophus hipposideros* | – | 1 | 1 | 8 |
| *Rhinolophus mehelyi* | – | – | – | (1) |
| *Asellia tridens* | 1 | 1 | 2 | 4–5 |
| *Eptesicus bottae* | – | – | – | 6 |
| *Hypsugo ariel* | – | – | 1 | 24 |
| *Pipistrellus kuhlii* | (1) | 1 | 2–3 | 3–5 |
| *Otonycteris hemprichii* | – | 1 | 1 | 5 |
| *Barbastella leucomelas* | (1) | – | 1 | 6 |
| *Plecotus christii* | 1 | 1 | 3 | 19–20 |
| *Tadarida teniotis* | – | – | – | 8 |
| total (no. species) | 3–5 | 7 | 9 | 14–15 |
| total (no. records) | 3–5 | 8 | 15–16 | 106–111 |
| records per species | 1 | 1.1 | <2 | 7–7.8 |

only in Sinai; *Rhinolophus hipposideros* and *Barbastella leucomelas*. The latter species was found in Sinai only in the year/s 1822 and/or 1826 (see above), thus, we present its re-discovery there after some 180 years.

All Sinaitic bat species with an exception of *Pipistrellus kuhlii* were recorded in mountainous southern portion of the peninsula. Four species, *Rhinolophus clivosus*, *Asellia tridens*, *Otonycteris hemprichii*, and *Plecotus christii*, were found also in flat deserts of the northern Sinai. *Pipistrellus kuhlii* was recorded in northern Sinai only. The most frequently recorded bat species in the peninsula was *Hypsugo ariel* (24 records), followed by *Plecotus christii* (19–20 records); however, the latter species seems to be more widely distributed throughout the peninsula, while the former occurs mainly in the rocky areas of southern Sinai (comp. Figs. 30, 65). Other Sinaitic species do not exceed ten records, and pictures of their distribution in Sinai can hardly be considered complete or being close to it. Since our research did not cover many potential underground spaces like caves or old mines, certainly the imagines of Sinaitic distribution of spatial underground bats (e.g., genera *Rhinopoma*, *Taphozous*, *Nycteris*, *Rhinolophus*, and/or *Asellia*) is markedly undervalued. On the other hand, a detailed survey with help of nets and bat-detectors could provide evidence of relatively high number of species in one site (e.g., up to 13 in the oasis of Feiran).

The Sinaitic bat fauna resembles by its composition the faunas of the southern part of the Holy Land and the Lower Egypt (in its broader sense, incl. Nile Delta and surrounding deserts), almost the complete Sinaitic species spectrum is also found in these neighbouring regions (Table 14). The only exceptions are represented by *Rhinolophus hipposideros*, *Hypsugo ariel* and *Barbastella leucomelas*, which have not been found to occur in the Lower Egypt but are reported from the Holy Land. The newly described *Plecotus christii petraeus* subsp. nov. also belongs to the latter category.

In contrast, at least three other species live in both these areas neighbouring Sinai, but were not recorded in the peninsula proper, viz. *Rhinopoma microphyllum* (Brünnich, 1782), *Taphozous* *nudiventris* Cretzschmar, 1830, and *Pipistrellus rueppellii* (Fischer, 1829). In all these species, the territory of Sinai represents a gap in their distribution in the arid areas along southeastern corner of the Mediterranean Sea and these bats could be well expected in the peninsula. *Rhinopoma microphyllum* is known to occur in the Holy Land from southern Lebanon to southernmost Arava Valley, incl. the central Negev Desert (Harrison 1963, Mendelssohn & Yom-Tov 1999, Amr 2000, Korine & Pinshow 2004), as well as in the Nile Valley from the Cairo region to Aswan (Qumsiyeh 1985). *Taphozous nudiventris* shows similar pattern of distribution, but in the Holy Land has only been found in the Dead Sea area and the areas to the north (Yom-Tov et al. 1992a, Mendelssohn & Yom-Tov 1999, Darweesh et al. 1997, Amr 2000).

*Pipistrellus rueppellii* was rather scarcely registered in Egypt; Qumsiyeh (1985) summarised only five records from the Nile Valley between Cairo and Luxor. However, two additional reports exist from the close neighbourhood of the Sinaitic territory; Nader & Kock (1983) published a record from Ras Abu Darag (coast of the Gulf of Suez, ca. 70 km S of Suez along the coast) and Harrison & Makin (1988) another one from the Ataka Mts (ca. 10–20 km W of Suez). In the western portion of the Middle East, this bat is known only from Israel; several records were reported mainly from the Dead Sea area, individual published records come also from near of Haifa, central Negev and Eilat (Harrison & Makin 1988, Yom-Tov et al. 1992a, Mendelssohn & Yom-Tov 1999, Korine & Pinshow 2004, cf. Tristram 1884). However, according to unpublished data (E. Levin, A. Tsoar & C. Korine, ad verb.), *P. rueppellii* seems to be a rather common bat in the Negev Desert during the winter time, the evidence from this area suggest that the species is a seasonal vagrant moving north in winter. From the pattern of *P. rueppellii* distribution in the deserts close to the western and eastern Sinai borders, it seems to be dweller of rather lowland deserts and it probably does not occur in the higher situated rocky areas of southern Sinai, where our survey was mostly made. Therefore, its occurrence in Sinai is possible to be expected mainly in its central and northern parts.

In addition, other species that may be expected in Sinai include those which reach their hitherto known margin of distribution range in Upper Egypt, i.e. relatively close to the southern tip of the Sinaitic Peninsula. One vespertilionid bat and two species of molossids belong to this group. The vespertilionid, *Nycticeinops schlieffeni* (Peters, 1859) is an Afrotropic species penetrating into the Palaearctic via Egypt. Although some records are known from Nubia (Koopman 1975), only two records are available from Egypt, both from its northern portion (Qumsiyeh 1985). Beside its type locality Cairo (Peters 1859), an old record of this species was made at Suez (Harrison 1961, cf. Rüppell 1842), i.e. very close to the Sinaitic territory.

Another species which may come in account is *Tadarida aegyptiaca* (Geoffroy, 1818), described (most probably) from and often recorded in the Cairo region (Wassif et al. 1984, Qumsiyeh 1985, cf. Koopman 1975). However, its closest known records to Sinai are from the Red Sea coast (Quseir and 20 km S of Hurghada) and the Red Sea Range (two sites in the Qattar Mts), some 80–150 km as the crow flies to the south and/or southwest of the Sinaitic shore (Klunzinger 1878, Kock 1969, Osborn 1988). This species has not been recorded in the Holy Land, although some authors have predicted its occurrence there (e.g. Qumsiyeh 1996, Darweesh et al. 1997, Qumsiyeh et al. 1998, etc.). Molossids are very strong flyers and it is possible that these high flying bats could be found, albeit as yet unrecorded, in Sinai.

Another free-tailed bat species reported to be found in Nubia is *Chaerephon major* (Trouessart, 1897). This species was described from 'Nilo Super., (ad primam cataract.)' (Trouessart 1897, 1904) on the basis of a specimen from the 'Cataract of the Nile' identified by Dobson (1878: 428) as *Nyctinomus pumilus* [= *Chaerephon pumilus* (Cretzschmar, 1830)] (see also Dobson 1876: 724) and later as *Tadarida aegyptiaca* by Qumsiyeh (1985). Its type locality was interpreted as the 'First Cataract of the Nile' (= Nile at Aswan, Upper Egypt) by De Winton (1901: 40; in Anderson

Table 14. List of bat species per individual regions of the transition between North Africa and the Middle East with marked faunal status (+ = occurrence confirmed; – = occurrence unconfirmed). Based mainly on data summarised by Koopman (1975), Qumsiyeh (1985, 1996), Harrison & Bates (1991), Gaucher (1992, 1993, 1995), Gaucher & Harrison (1995), Mendelssohn & Yom-Tov (1999), Amr (2000), and Benda et al. (2006). Lower Egypt & Nile Delta = the territory of continental Egypt to north of 27° N; Upper Egypt & Nubia = the territory of Egypt and Sudan between 27° and 18° N (at the Fifth Cataract of the Nile); southern Holy Land = the territory of Israel and Jordan to south of 31° 30' N; Mediterranean Levant = Lebanon and the Mediterranean parts of Syria, Israel and Jordan to north of 31° 30' N; Hijaz Range = the western part of Saudi Arabia to north of 18° N and west to 43° W. The status in parentheses is doubtful

| | Sinai | Lower Egypt & Nile Delta | Upper Egypt & Nubia | southern Holy Land | Mediterr. Levant | Hijaz Range |
|---|---|---|---|---|---|---|
| *Rousettus aegyptiacus* | + | + | + | + | + | + |
| *Epomophorus labiatus* | – | – | – | – | – | + |
| *Rhinopoma microphyllum* | – | + | + | + | + | + |
| *Rhinopoma cystops* | + | + | + | + | + | + |
| *Taphozous perforatus* | + | + | + | + | + | + |
| *Taphozous nudiventris* | – | + | + | + | + | + |
| *Coleura afra* | – | – | + | – | – | – |
| *Nycteris thebaica* | + | + | + | + | + | + |
| *Rhinolophus ferrumequinum* | – | – | – | – | + | – |
| *Rhinolophus clivosus* | + | + | + | + | (–) | + |
| *Rhinolophus hipposideros* | + | – | – | + | + | + |
| *Rhinolophus euryale* | – | – | – | – | + | – |
| *Rhinolophus mehelyi* | (+) | + | – | + | + | – |
| *Rhinolophus blasii* | – | – | – | + | + | – |
| *Hipposideros caffer* | – | – | – | – | – | + |
| *Asellia tridens* | + | + | + | + | + | + |
| *Myotis myotis* | – | – | – | – | + | – |
| *Myotis blythii* | – | – | – | – | + | – |
| *Myotis nattereri* | – | – | – | – | + | – |
| *Myotis emargiantus* | – | – | – | – | + | + |
| *Myotis aurascens* | – | – | – | – | + | – |
| *Myotis capaccinii* | – | – | – | – | + | – |
| *Eptesicus serotinus* | – | – | – | – | + | – |
| *Eptesicus bottae* | + | + | – | + | – | + |
| *Eptesicus anatolicus* | – | – | – | – | + | – |
| *Eptesicus nasutus* | – | – | – | – | – | + |
| *Hypsugo savii* | – | – | – | – | + | – |
| *Hypsugo ariel* | + | – | + | + | – | + |
| *Pipistrellus pipistrellus* | – | – | – | – | + | – |
| *Pipistrellus kuhlii* | + | + | – | + | + | + |
| *Pipistrellus deserti* | – | – | + | – | – | – |
| *Pipistrellus rueppellii* | – | + | + | + | + | – |
| *Nyctalus noctula* | – | – | – | – | + | – |
| *Nycticeinops schlieffeni* | – | + | + | – | – | + |
| *Scotophilus dinganii* | – | – | – | – | – | + |
| *Otonycteris hemprichii* | + | + | + | + | + | + |
| *Barbastella leucomelas* | + | – | – | + | – | (+) |
| *Plecotus macrobullaris* | – | – | – | – | + | – |
| *Plecotus christii* | + | + | + | + | + | +* |
| *Miniopterus schreibersii* | – | – | – | – | + | – |
| *Tadarida teniotis* | + | + | – | + | + | + |
| *Tadarida aegyptiaca* | – | + | + | – | – | + |
| *Chaerephon major* | – | – | + | – | – | – |
| *Chaerephon nigeriae* | – | – | – | – | – | + |
| suma per region | 14–15 | 17 | 17 | 20 | 30 | 23–24 |

* the species affiliation is actually unknown (see Nader & Kock 1990b, Benda et al. 2004, and Spitzenberger et al. 2006)

1902: 155). However, this interpretation was doubted by Flower (1932: 386) and Allen (1939: 105) and refuted by Kock (1969: 149); the latter author restricted the type locality to '5. Nil-Katarakt, nördlich Berber, Sudan'. This statement was accepted by subsequent authors (Koopman 1975, 1993, Simmons 2005). Regardless of the exact site of collection of its type specimen, it seems to be clear that *C. major* was recorded in Nubia, the region considered to include southern Egypt. Although it is an area relatively distant from the southern Sinaitic coast, we can suggest a similar situation as in *Tadarida aegyptiaca*; as a fast and high flying bat, *C. major* could possibly reach Sinai, at least as an accidental flyer (see Note under *Tadarida teniotis* above). Such a situation, however, we do not suggest in other Upper Egyptian/Nubian faunal elements, like *Pipistrellus deserti* Thomas, 1902 or *Coleura afra* (Peters, 1852).

The Mediterranean elements composing a considerable bulk of bat fauna in the Levant from ca. 32° N to the north, some 100–150 km from the Sinaitic borders, represent another source of potential candidates for fauna of Sinai (Table 14). Though most of the true Mediterranean bat species, like those of the genera *Myotis* Kaup, 1829 and *Miniopterus* Bonaparte, 1837, would not be expected to visit desert areas of southern Holy Land and Sinai, some others have been reported from similarly arid regions. For example, the nearest record of *Nyctalus noctula* (Schreber, 1774), a tree-dwelling bat in most of its range, is known from Jericho (Ariha) (Festa 1894), a town lying in the arid landscape of the West Bank close to the northern edge of the Dead Sea; another exceptional record of this bat was described from an even more extreme arid area in southeastern Oman (Harrison & Jennings 1980).

Since the peninsula of Sinai lies close to the biogeographical crossroad of the Mediterranean arboreal and Saharo-Sindian eremial biomes in the eastern Mediterranean (Blondel & Aronson 1999), a possible enrichment of the Sinaitic bat fauna could be quite wide, as we indicated above. Nevertheless, it is rather hard to imagine an occurrence in Sinai of any bat species which has not already been recorded from southern Israel, a region which is one of the best explored concerning bat fauna in the Middle East, with hundreds of findings of thirty species throughout the whole of the country (see the review by Makin 1989 and subsequent papers by Yom-Tov et al. 1992a, Mendelssohn & Yom-Tov 1999, Korine & Pinshow 2004, etc.). From this point of view, the bat fauna of Sinai is rather well known, since it now comprises 75% of the fauna of southern Holy Land, a region most similar in its natural features to Sinai (see Introduction), and 88% of the fauna of Upper Egypt (Table 14).

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## REFERENCES


AELLEN V. 1966: Notes sur Tadarida teniotis (Raf.) (Mammalia, Chiroptera) – I. Systématique, paléontologie et peuplement, répartition géographique. *Revue Suisse de Zoologie* **73**: 119–159.

AHARONI J. 1930: Die Säugetiere Palästinas. *Zeitschrift für Säugetierkunde* **5**: 327–343.

AHLÉN I. 1990: *Identification of Bats in Flight*. Stockholm: Swedish Society for Conservation of Nature & The Swedish Youth Association for Enviromental Studies and Conservation, 50 pp.

AL-JUMAILY M. M. 1998: Review of the mammals of the Republic of Yemen. *Fauna of Arabia* **17**: 477–502.

ALFRED J. R. B., SINHA N. K. & CHAKRABORTY S. 2002: Checklist of Mammals of India. *Records of the Zoological Survey of India*, *Occasional Paper* **199**: i–vii+1–289 pp.

ALLEN G. M. 1939: A checklist of African mammals. *Bulletin of the Museum of Comparative Zoölogy at Harvard College* **83**: 1–763.

AL-OMARI K. A., ABU BAKER M. A. & AMR Z. S. 2000: First record of the Egyptian Slit-faced Bat, Nycteris thebaica, from Jordan. *Zoology in the Middle East* **21**: 5–8.

AMR Z. S. 2000: *Mammals of Jordan*. *Jordan Country Study on Biological Diversity*. Amman: United Nations Environment Programme, 100 pp.

AMR Z. S. & DISI A. M. 1988: Jordanian mammals acquired by the Jordan University Natural History Museum. *Dirasat* **15B**: 3–32 (non vidi; ex Qumsiyeh 1996).

AMR Z., ABU BAKER M. & RIFAI L. 2004: Mammals of Jordan. Pp.: 437–465. In: WAITZBAUER W., ALBERT R., PETUTSCHNIG B. & AUBRECHT G. (eds.): *Denisia 14*. *Reise durch die Natur Jordaniens*. Linz: Biologiezentrum/Oberösterreichische Landesmuseen, 508 pp.

AMR Z. S., ABU BAKER M. A. & QUMSIYEH M. B. 2006: Bat diversity and conservation in Jordan. *Turkish Journal of Zoology* **30**: 235–244.

ANDERSEN K. 1907: On Pterocyon, Rousettus, and Myonycteris. *The Annals and Magazine of Natural History* (7)**19**: 501–515.

ANDERSEN K. 1912: *Catalogue of the Chiroptera in the Collection of the British Museum*. *Second Edition*. *Volume I*: *Megachiroptera*. London: British Museum (Natural History), ci+854 pp.

ANDERSON J. 1902: *Zoology of Egypt: Mammalia*. *Revised and completed by W. E. de Winton*, *F. Z. S*. London: Hugh Rees, Ltd., 374 pp.

ANDERSON M. E. & RACEY P. A. 1991: Feeding behaviour of captive brown long-eared bats, Plecotus auritus. *Animal Behaviour* **42**: 489–493.

ANDERSON M. E. & RACEY P. A. 1993: Discrimination between fluttering and non-fluttering moths by brown long-eared bats, Plecotus auritus. *Animal Behaviour* **46**: 1151–1155.

ANDREAS M. 2002: *Potravní ekologie společenstva netopýrů* [*Feeding Ecology in a Bat Community*]. Unpublished Ph.D. Thesis. Praha: Institute of Applied Ecology, Czech Agriculture University, 163 pp (in Czech).

ARLETTAZ R. 1990: Contribution à l'éco-éthologie du molosse de Cestoni, Tadarida teniotis (Chiroptera), dans les Alpes valaisannes (sud-ouest de la Suisse). *Zeitschrift für Säugetierkunde* **55**: 28–42.

ARLETTAZ R., DÄNDLIKER G., KASYBEKOV E., PILLET J.-M., RYBIN S. & ZIMA J. 1995: Feeding habits of the long-eared desert bat, Otonycteris hemprichi (Chiroptera: Vespertilionidae). *Journal of Mammalogy* **76**: 873–876.

ATALLAH S. I. 1977: Mammals of the Eastern Mediterranean Region; their Ecology, Systematics and Zoogeographical Relationships. *Säugetierkundliche Mitteilungen* **25**: 241–319.

AUDOUIN V. 1829: Description sommaire des mammifères carnassiers qui se trouvent en Egypte, publées par Jules-César Savigny. Pp: 205–218. In: *Description de l'Égypte*, *recueil des observations et des recherches qui ont été faites en Égypte pendant l'expedition de l'armée française*. *Seconde edition*. *Tome vingt-troisième*. *Histoire naturelle*. *Zoologie*. [Paris]: C. L. F. Panckoucke, 456 pp.

BATES P. J. J. & HARRISON D. L. 1997: *Bats of the Indian Subcontinent*. Sevenoaks: Harrison Zoological Museum, 258 pp.

BECK A. 1995: Fecal analyses of European bat species. *Myotis* **32–33**: 109–119.

BENDA P. & HORÁČEK I. 1998: Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 1. Review of distribution and taxonomy of bats in Turkey. *Acta Societatis Zoologicae Bohemicae* **62**: 255–313.

BENDA P. & MLÍKOVSKÝ J. 2008: Nomenclatural notes on Asian forms of bats of the genus Barbastella (Mammalia: Chiroptera: Vespertilionidae). *Journal of the National Museum* (*Prague*), *Natural History Series* **177**: in press.

BENDA P. & VALLO P. 2008: Taxonomy of the genus Triaenops (Mammalia: Chiroptera: Hipposideridae). *Zootaxa* (in press).

BENDA P., OBUCH J., ANDREAS M., REITER A. & UHRIN M. 1999: New records of bats from Iran. P.: 6. In: CRUZ M. & KOZAKIEWICZ K. (eds.): *VIIIth European Bat Research Symposium*. *Abstracts*. Kraków: Chiropterological Information Center, Institute of animal Systematics and Evolution PAS, 86 pp.

Benda P., Andreas M. & Reiter A. 2002: Record of Hypsugo arabicus from Baluchistan, Iran, with remarks to its ecology and systematical status. P.: 15. In: Anonymous (ed.): *IXth European Bat Research Symposium. 26–30 Augusty 2002 – Univeristy of Le Havre. Abstracts*. Le Havre: University of Le Havre, [x]+59 pp.

Benda P., Kiefer A., Hanák V. & Veith M. 2004: Systematic status of African populations of long-eared bats, genus Plecotus (Mammalia: Chiroptera). *Folia Zoologica* **53** (Monograph 1): 1–47.

Benda P., Andreas M., Kock D., Lučan R. K., Munclinger P., Nová P., Obuch J., Ochman K., Reiter A., Uhrin M. & Weinfurtová D. 2006: Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 4. Bat fauna of Syria: distribution, systematics, ecology. *Acta Societatis Zoologicae Bohemicae* **70**: 1–329.

Benda P., Hanák V., Horáček I., Hulva P., Lučan R. & Ruedi M. 2007: Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 5. Bat fauna of Cyprus: review of records with confirmation of six species new for the island and description of a new subspecies. *Acta Societatis Zoologicae Bohemicae* **71**: 71–130.

Bergmans W. 1994: Taxonomy and biogeography of African fruit bats (Mammalia, Megachiroptera). 4. The genus Rousettus Gray, 1821. *Beaufortia* **44**(4): 79–126.

Bianki [Bianchi] V. 1917: Predvaritel'nyja zametki o letučih" myšah" (Chiroptera) Rossii [Notes préliminaires sur les chauve-souries ou Chiroptères de la Russie]. *Ežegodnik Zoologičeskago Muzeja Akademii Nauk* **21**[1916]: 73–82 (in Russian, French subtitle).

Blondel J. & Aronson J. 1999: *Biology and Wildlife of the Mediterranean Region*. Oxford: Oxford University Press, 328 pp.

Bobrinskoj N. A. 1925: Materialy dlja fauny letučih myšej Turkestanskogo kraja. (Zapadnyj Turkestan s Semirečenskoj i Zakaspijskoj oblastjami, Hiva i Buhara). [Materials on the fauna of Bats of Turkestan. (Eastern Turkestan with the Regions of Semiretchie and of Transcaspia, Khiva and Bouchara).]. *Bjulleten Moskovskogo Obščestva Ispytatelej Prirody, Novaja Serija* **34**: 330–374 (in Russian, with a summary in English).

Bodenheimer F. S. 1935: *Animal Life in Palestine. An Introduction to the Problems of Animal Ecology and Zoogeography*. L. Mayer, Jerusalem, 506 pp.

Bodenheimer F. S. 1958: The present taxonomic status of the terrestrial mammals of Palestine. *Bulletin of the Research Council of Israel, Section B: Zoology* **7**: 165–190.

Bohnote J. L. 1912: On a further collection of mammals from Egypt and Sinai. *Proceedings of the Zoological Society of London* **1912**(1): 224–231.

Borisenko A. V. & Pavlinov I. Ja. 1995: Podotrjad Microchiroptera [Sub-Order Microchiroptera]. Pp.: 72–120. In: Pavlinov I. Ja., Borisenko A. V., Kruskop S. V. & Jahontov E. L. (eds.): Mlekopitajuščie Evrazii. II. Non-Rodentia. Sistematiko-geografičeskij spravočnik [Mammals of Euroasia. II. Non-Rodentia. Systematical-geographical Review]. *Sbornik Trudov Zoologičeskogo Muzeja MGU* **23**: 1–334 (in Russian).

Bruce J. 1790: *Select Specimens of Natural History Collected in Travels to Discover the Source of the Nile in Egypt, Arabia, Abyssinia, and Nubia. Volume 6*. Dublin: Jackson, xxv+286 pp (non vidi, ex Osborn & Helmy 1980).

Butovskij P. M., Šajmardanov R. T. & Strelkov P. P. 1985: Otrjad Rukokrylye – Chiroptera Blumenbach, 1779 [Order Bats – Chiroptera Blumenbach, 1779]. Pp.: 125–260. In: Bekenov A., Butovskij P. M., Kasabekov B. B., Lankin P. M., Strelkov P. P., Stogov I. I., Fedosenko A. K., Šajmardanov R. T. & Šubin I. G. (eds.): *Mlekopitajuščie Kazahstana v četyreh tomah. Tom četvertyj. Nasekomojadnye i rukokrylye* [*Mammals of Kazakhstan in Four Volumes. Volume Four. Insectivores and Bats*]. Alma-Ata: Nauka Kazahskoj SSR, 280 pp (in Russian, English subtitle).

Churcher C. S. 1991: The Egyptian fruit bat Rousettus aegyptiacus in Dakhleh Oasis, Western Desert of Egypt. *Mammalia* **55**: 139–143.

Corbet G. B. 1978: *The Mammals of the Palaearctic Region: a Taxonomic Review*. London & Ithaca: British Museum (Natural History) & Cornell University Press, 314 pp.

Corbet G. B. & Hill J. E. 1980: *A World List of Mammalian Species. Second Edition*. London & Ithaca: British Museum (Natural History), Comstock Publishing Associates, 226 pp.

Corbet G. B. & Hill J. E. 1992: *The Mammals of the Indomalayan Region: a Systematic Review*. London: Oxford University Press, 488 pp.

Cretzschmar J. 1826: Vorwort. Pp.: i–vi. In: Senkenbergische naturforschende Gesellschaft (ed.): *Atlas zu der Reise im nördlichen Afrika von Eduard Rüppell. Erste Abtheilung. Zoologie*. Frankfurt am Main: Commission bei Heinr. Ludw. Brönner [not continuously paginated].

Cretzschmar J. [1826–]1830: Säugethiere. Pp.: 1–78+30 tbl. In: Senkenbergische naturforschende Gesellschaft (ed.): *Atlas zu der Reise im nördlichen Afrika von Eduard Rüppell. Erste Abtheilung. Zoologie*. Frankfurt am Main: Commission bei Heinr. Ludw. Brönner [not continuously paginated].

Csorba G., Ujhelyi P. & Thomas N. 2003: *Horseshoe Bats of the World (Chiroptera: Rhinolophidae)*. Bishop's Castle, UK: Alana Books, xxxii+160 pp.

Danin A. 1988: Flora and vegetation of Israel and adjacent areas. Pp.: 129–157. In: Yom-Tov Y. & Tchernov E. (eds.): *The Zoogeography of Israel. The Distribution and Abundance at a Zoogeographical Crossroads*. Dordrecht: Dr W. Junk Publishers, 600 pp.

Danin A. & Plitmann U. 1986: Revision of the plant geographical territories of Israel and Sinai. *Plant Systematics and Evolution* **156**: 43–53.

Darweesh N., Al-Melhim W. N., Disi A. M. & Amr Z. S. 1997: First record of the naked-bellied tomb bat, Taphozous nudiventris Cretzschmar, 1830, from Jordan. *Zoology in the Middle East* **15**: 13–14.

DeBlase A. F. 1971: New distributional records of bats from Iran. *Fieldiana Zoology* **58**: 9–14.

DeBlase A. F. 1980: The bats of Iran: systematics, distribution, ecology. *Fieldiana Zoology*, *New Series* **4**: i–xvii+1–424 pp.

De Beaux O. 1928: Risultati zoologici della missione inviata dalla R. Societa Geografica Italiana per l'esplorazione dell'oasi di Giarabub 1926–1927. Mammiferi. *Annali dei Museo Civico di Storia Naturale di Genova* **53**: 39–76.

Denzinger A., Siemers B. M., Schaub A. & Schnitzler H. U. 2001: Echolocation by the barbastelle bat, Barbastella barbastellus. *Journal of Comparative Physiology A* **187**: 521–528.

De Winton W. E. 1901: Notes on bats of the genus Nyctinomus found in Africa, &c. *The Annals and Magazine of Natural History* (7)**7**: 36–42.

Dietz C. 2005a: *Final Report Operation Wallacea*. *Sinai 2005*. 23 pp. URL: www.opwall.com/Library/Egypt/bats.shtml.

Dietz C. 2005b: *Illustrated identification key to the bats of Egypt*. *Version 1.0*. 36 pp. URL: www.uni-tuebingen.de/tierpsych/Kontakt/mitarbeiter_seiten/dietz.htm; www.opwall.com/Library/Egypt/bats.html.

Dietz C. & Maltby A. 2006: *Final Report Operation Wallacea*. *Sinai 2006*. 23 pp. URL: www.opwall.com/Library/Egypt/bats.html

Disi A. M. & Hatough-Bouran A. 1999: Biodiversity of the terrestrial vertebrate fauna of Petra (Jordan). *Časopis Národního Muzea*, *Řada Přírodovědecká* **168**: 83–98.

Dobson G. E. 1876: A monograph of the group Molossi. *Proceedings of the Zoological Society of London* **1876**: 701–735.

Dobson G. E. 1878: *Catalogue of the Chiroptera in the Collection of the British Museum*. London: printed by Order of the Trustees, 567 pp + xxx pl.

Duff A. & Lawson A. 2004: *Mammals of the World*. *A Checklist*. London: A & C Black, 312 pp.

Ehrenberg C. G. 1828[–1833]: *Symbolae physicae seu icones et descriptiones corporum naturalium novorum aut minus cognitorum quae ex itineribus per Libyam Aegyptum Nubiam Dongalam Syriam Arabiam et Habessiniam publico institutis sumptu Friderici Guilelmi Hemprich et Christiani Godofredi Ehrenberg studio annis MDCCCXX–MDCCCXXV redierunt*. *Pars zoologica I*. Berolini: Officina Academica, [82] pp.

Eisentraut M. 1959: Der Rassenkreis Rousettus aegyptiacus E. Geoff. *Bonner Zoologische Beiträge* **10**: 219–235.

Ellerman J. R. & Morrison-Scott T. C. S. 1951: *Checklist of Palaearctic and Indian Mammals 1758 to 1946*. London: Trustees of the British Museum, 810 pp.

Etemad E. 1964: On three new mammals from Iran (one rat and two bats). *Mammalia* **28**: 652–654.

Etemad E. 1967: Notes on bats from Iran. Mammalia **31**: 275–280.

Etemad E. 1969: *Pstandaran airan – khafašha*. *Khafašhai airanu klid tškhis anha* [*The bats of Iran*, *and the keys to identify them*]. Tehran: University of Tehran, 201 pp (in Farsi, with a summary in English paginated separately, 25 pp.).

Feldman R., Whitaker J. O., Jr. & Yom-Tov Y. 2000: Dietary composition and habitat use in a desert insectivorous bat community in Israel. *Acta Chiropterologica* **2**: 15–22.

Fenton M. B., Shalmon B. & Makin D. 1999: Roost switching, foraging behaviour, and diet of the vespertilionid bat, Otonycteris hemprichii. *Israel Journal of Zoology* **45**: 501–506.

Ferguson W. W. 2002: *The Mammals of Israel*. Jerusalem: Gefen Publishing House, 160 pp.

Festa E. 1894: Viaggo del Dr. E. Festa in Palestina, nel Libano e regioni vicine. Parte narrativa. *Bollettino dei Musei di Zoologia ed Anatomia Comparata della R. Università di Torino* **172**(9): 1–38.

Fitzinger L. J. 1866: Systematische Übersicht der Säugethiere Nordost-Afrika's mit Einschluß der arabische Küste, des rothen Meeres, der Somáli- und der Nillquellen-Länder, südwärts bis zum vierten Grade nördlichen Breite. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften*, *I. Abtheilung*, *Mathematische-Naturwissenschaftliche Classe* **54**(December): 1–75.

Flower S. S. 1932: Notes on the recent mammals of Egypt, with a list of the species recorded from that Kingdom. *Proceedings of the Zoological Society of London* **101**: 369–450.

Frauenfeld G. 1856: Über eine neue Fliegengattung: Raymondia aus der Familie der Coriaceen, nebst Beschreibung zweier Arten derselben. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften*, *I. Abtheilung*, *Mathematische-Naturwissenschaftliche Classe* **18**: 320–333 (non vidi, ex Kock 1969).

Gaisler J. 1970: Zoogeographical notes on the bat fauna of Aghanistan (Mammalia: Chiroptera). *Věstník Československé Společnosti Zoologické* **34**: 284–288.

Gaisler J., Madkour G. & Pelikán J. 1972: On the bats (Chiroptera) of Egypt. *Acta Scientiarum Naturalium Academiae Scientiarum Bohemoslovacae Brno*, *Nova Series* **6**(8): 1–40.

Gaucher P. 1992: New record of an Epauleted fruit bat Epomophorus labiatus Temminck, 1837 (Mammalia: Chiroptera: Pteropodidae) in Saudi Arabia. *Mammalia* **56**: 657–659.

Gaucher P. 1993: First record of Scotophilus leucogaster (Cretzschmar, 1826) (Mammalia: Chiroptera: Vespertilionidae) in Saudi Arabia. *Mammalia* **57**: 146–147.

Gaucher P. 1995: First record of Geoffroy bat Myotis emarginatus Geoffroy, 1806 (Mammalia: Chiroptera: Vespertilionidae) in Saudi Arabia. *Mammalia* **59**: 149–151.

Gaucher P. & Harrison D. L. 1995: Occurrence of Bodenheimer's Pipistrelle Pipistrellus bodenheimeri Harrison, 1960 (Mammalia, Chiroptera: Vespertilionidae) in Saudi Arabia. *Mammalia* **59**: 672–673.

Geoffroy Saint-Hilaire [E.] 1818: *Description des mammifères qui se trouvent en Égypte*. Pp.: 99–166. In: *Description de l'Égypte*, *ou recueil des observations et des recherches qui ont été faites en Égypte pendant l'expedition de l'armée française*. *Histoire Naturelle 2*. Paris, 218 pp.

Geoffroy Saint-Hilaire [E.] 1828: *Description des mammifères qui se trouvent en Égypte*. Pp.: 91–204. In: *Description de l'Égypte*, *recueil des observations et des recherches qui ont été faites en Égypte pendant l'expedition de l'armée française*. *Seconde edition*. *Tome vingt-troisième*. *Histoire naturelle*. *Zoologie*. [Paris]: C. L. F. Panckoucke, 456 pp.

Gray J. E. 1838: A revision of the genera of bats (Vespertilionidae), and the description of some new genera and species. *Magazine of Zoology and Botany* **2**: 483–505.

Gray P. A., Fenton M. B. & Van Cakenberghe V. 1999: Nycteris thebaica. *Mammalian Species* **612**: 1–8.

Guichard K. M. 1992: The Insects of Socotra. Pp.: 181–188. In: Doe D. B. (ed.): *Socotra*. *Island of Tranquility*. London: Immel Publishing Ltd., 238 pp.

Gustafson Y. & Schnitzler H. U. 1979: Echolocation and obstacle avoidance in the hipposiderid bat Asellia tridens. *Journal of Comparative Physiology* **131**: 161–167.

Habilov T. K. 1992: *Fauna Respubliki Tadžikistan*. *Tom XX*. *Časť VII*. *Mlekopitajuščie*. *Rukokrylye* [*Fauna of the Republic of Tajikistan*. *Volume XX*. *Part VII*. *Mammals*. *Bats*]. Dušanbe: Izdatel'stvo Doniš, 352 pp (in Russian, with an abstract in English).

Hackethal H., Grimmberger E. & Haensel J. 1988: Untersuchungen zur morphologischen Variabilität der Mopsfledermaus, Barbastella barbastellus (Schreber, 1774) (Chiroptera, Vespertilionidae). *Nyctalus* (*Neue Folge*) **2**(5): 431–444.

Haim A. & Tchernov E. 1974: The distribution of myomorph rodents in the Sinai peninsula. *Mammalia* **38**: 201–223.

Hanák V. 1962: Netopýr dlouhouchý (Plecotus austriacus, Fischer 1829) – nový člen naší savčí fauny [Graues Mausohr (Plecotus austriacus) – neues Mitglied der Fledermausfauna der Tschechoslowakei]. *Časopis Národního Musea*, *Oddíl Přírodovědný* **131**: 87–96 (in Czech, with a summary in German).

Harrison D. L. 1956: A key to the identification of the bats (Chiroptera) of the Arabian Peninsula. *Proceedings of the Zoological Society of London* **127**: 447–452.

Harrison D. L. 1960: A new species of Pipistrelle bat (Chiroptera: Pipistrellus) from south Israel. *Durban Museum Novitates* **5**: 261–267.

Harrison D. L. 1961: On Savi's Pipistrelle, (Pipistrellus savii Bonaparte 1837) in the Middle East, and a second record of Nycticeius schlieffeni Peters 1859 from Egypt. *Senckenbergiana Biologica* **42**: 41–44.

Harrison D. L. 1963: A note of the occurrence of the greater mouse-tailed bat Rhinopoma microphyllum Brunnich, 1782, in Lebanon. *Mammalia* **27**: 305–307.

Harrison D. L. 1964: *The Mammals of Arabia*. *Volume I. Introduction*. *Insectivora – Chiroptera – Primates*. London: Ernest Benn Limited, 192 pp.

Harrison D. L. 1982: Observations on some rare Arabian Pipistrellus (Chiroptera: Vespertilionidae) with special reference to the external male genitalia. *Bonner Zoologische Beiträge* **33**: 187–190.

Harrison D. L. & Bates P. J. J. 1991: *The Mammals of Arabia*. *Second Edition*. Sevenoaks: Harrison Zoological Museum, 354 pp.

Harrison D. L. & Jennings M. C. 1980: Occurrence of the noctule, Nyctalus noctula Schreber, 1774 (Chiroptera: Vespertilionidae) in Oman, Arabia. *Mammalia* **44**: 409–410.

Harrison D. L. & Makin D. 1988: Significant new records of Vespertilionid bats (Chiroptera: Vespertilionidae) from Israel. *Mammalia* **52**: 593–596.

Hayman R. W. 1949: The Armstrong College Zoological Expedition to Siwa Oasis (Libyan Desert) 1935. Mammals. *Proceedings of the Egyptian Academy of Sciences* **4**: 38–42.

Hayman R. W. & Hill J. E. 1971: Part 2. Order Chiroptera. Pp.: 1–73. In: Meester J. & Setzer H. W. (eds.): *The Mammals of Africa*. *An Identification Manual*. Washington: Smithsonian Institution Press.

von Heuglin T. 1877: *Reise in Nordost-Afrika*. *Schilderungen aus dem Gebiete der Beni Amer und Habab nebst zoologischen Skizzen und einem Führer für Jagdreisende*. *Zweiter Band*. Braunschweig: George Westermann, 304 pp.

Hill J. E. & Harrison D. L. 1987: The baculum in the Vespertilionidae (Chiroptera: Vespertilionidae) with a systematic review, a synopsis of Pipistrellus and Eptesicus, and the descriptions of a new genus and subgenus. *Bulletin of British Museum* (*Natural History*), *Zoology* **52**(7): 225–305.

HOATH R. 2003: *A Field Guide to the Mammals of Egypt*. Cairo & New York: The American University in Cairo Press, xvi+236 pp.
HOLDERIED M. W., KORINE C., FENTON M. B., PARSONS S., ROBSON S. & JONES G. 2005: Echolocation call intensity in aerial hawking bat Eptesicus bottae (Vespertilionidae) studied using stereo videogrammetry. *The Journal of Experimental Biology* **208**: 1321–1327.
HORÁČEK I. 1991: Enigma of Otonycteris: ecology, relationship, classification. *Myotis* **29**: 17–30.
HORÁČEK I. & HANÁK V. 1986: Generic status of Pipistrellus savii and comments on classification of the genus Pipistrellus (Chiroptera, Vespertilionidae). *Myotis* **23–24**: 9–16.
HORÁČEK I., HANÁK V. & GAISLER J. 2000: Bats of the Palearctic region: a taxonomic and biogeographic review. Pp.: 11–157. In: WOŁOSZYN B. W. (ed.): *Proceedings of the VIIIth European Bat Research Symposium. Vol. I. Approaches to Biogeography and Ecology of Bats*. Kraków: Chiropterological Information Center, Institute of Systematics and Evolution of Animals PAS, 280 pp.
HORÁČEK I., BOGDANOWICZ W. & ĐULIĆ B. 2004: Plecotus austriacus (Fischer, 1829) – Graues Langohr. Pp.: 1001–1049. In: KRAPP F. (ed.): *Handbuch der Säugetiere Europas. Band 4: Fledertiere. Teil II: Chiroptera II. Vespertilionidae 2, Molossidae, Nycteridae*. Wiebelsheim: Aula-Verlag, x+605–1186 pp.
HOOGSTRAAL H. 1962: A brief review of the contemporary land mammals of Egypt (including Sinai). 1. Insectivora and Chiroptera. *The Journal of the Egyptian Public Health Association* **37**: 143–162.
HUFNAGL E. 1972: *Libyan Mammals*. Stoughton (USA) & Harrow (UK): The Oleander Press, 85 pp.
HULVA P., HORÁČEK I. & BENDA P. 2007: Molecules, morphometrics and new fossils provide an integrated view of the evolutionary history of Rhinopomatidae (Mammalia: Chiroptera). *BioMed Central Evolutionary Biology* **7**(165): 1–15.
JENTINK F. A. 1887: Tome IX. Catalogue ostéologique des mammifères. In: SCHLEGEL H. & JENTINK F. A. (eds.): *Revue méthodique et critique des Collections déposées dans cet Établissement*. Leiden: E. J. Brill, 360 pp + xii tabs.
JONES G., MORTON M., HUGHES P. M. & BUDDEN R. M. 1993: Echolocation, flight morphology and foraging strategies of some West African hipposiderid bats. *Journal of Zoology, London* **230**: 385–400.
JUSTE J. & IBAÑEZ C. 1993: Geographic variation and taxonomy of Rousettus aegyptiacus (Mammalia: Megachiroptera) in the islands of the Gulf of Guinea. *Zoological Journal of the Linnean Society* **107**: 117–129.
JUSTE J., IBÁÑEZ C., TRUJILLO D., MUÑOZ J. & RUEDI M. 2003: Phylogeography of Barbastelle bats (Barbastella barbastellus) in the western Mediterranean and the Canary Islands. *Acta Chiropterologica* **5**: 165–175.
JUSTE J., IBÁÑEZ C., MUÑOZ J., TRUJILLO D., BENDA P., KARATAŞ A. & RUEDI M. 2004: Mitochondrial phylogeography of the long-eared bats (Plecotus) in the Mediterranean Palaearctic and Atlantic Islands. *Molecular Phylogenetics and Evolution* **31**: 1114–1126.
IBÁÑEZ C. & PÉREZ-JORDÁ J. L. 2004: Tadarida teniotis (Rafinesque, 1814) – Europäische Bulldoggfledermaus. Pp.: 1125–1143. In: KRAPP F. (ed.): *Handbuch der Säugetiere Europas. Band 4: Fledertiere. Teil II: Chiroptera II. Vespertilionidae 2, Molossidae, Nycteridae*. Wiebelsheim: Aula-Verlag, x+605–1186 pp.
KLAUSEWITZ W. 2002: Frankfurt versus Berlin: The Red Sea explorers Wilhelm Hemprich, Christian Ehrenberg and Eduard Rüppell. *Zoology in the Middle East* **27**: 7–12.
KLUNZINGER C. B. 1878: Zur Wirbelthierfauna im und am Rothen Meer. *Zeitschrift der Gesellschaft für Erdkunde zu Berlin, Neue Folge* **13**: 61–96 (non vidi, ex Kock 1969).
KOCK D. 1969: Die Fledermaus-Fauna des Sudan. *Abhandlungen der Senckenbergische Naturforschende Gesellschaft* **521**: 1–238.
KOCK D. & NADER I. A. 1984: Tadarida teniotis (Rafinesque, 1814) in the W-Palaearctic and a lectotype for Dysopes rupelii Temminck, 1826 (Chiroptera: Molossidae). *Zeitschrift für Säugetierkunde* **49**: 129–135.
KOOPMAN K. F. 1975: Bats of the Sudan. *Bulletin of the American Museum of Natural History* **154**: 353–444.
KOOPMAN K. F. 1993: Order Chiroptera. Pp.: 137–241. In: WILSON D. E. & REEDER D. M. (eds.): *Mammal Species of the World. A Taxonomic and Geographic Reference*. Washington and London: Smithsonian Institution Press, 1206 pp.
KOOPMAN K. F. 1994: Chiroptera: Systematics. Pp.: 1–217. In: NIETHAMMER J., SCHLIEMANN H. & STARCK D. (eds.): *Handbuch der Zoologie. Band VIII. Mammalia. Teilband 60*. Berlin and New York: Walter de Gruyter, vii+224 pp.
KORINE C. & PINSHOW B. 2004: Guild structure, foraging space use, and distribution in a community of insectivorous bats in the Negev Desert. *Journal of Zoology, London* **262**: 187–196.
KRUSKOP S. V. & LAVRENCHENKO L. A. 2000: A new species of long-eared bat (Plecotus; Vespertilionidae, Mammalia) from Ethiopia. *Myotis* **38**: 5–17.
KUZJAKIN A. P. 1934: Letučie myši g. Taškenta i sistematičeskoe zametki o nekotorih formah Chiroptera s Kavkaza, Buhary i Turkmenii [The bats from Tashkent and systematical remarks on some Chiroptera from Caucasus, Bucharia and Turkmenia]. *Bjulleten' Moskovskogo Obščestva Ispytatelej Prirody, Otdel Biologičeskij* **43**: 316–330 (in Russian, with a summary in English).
KUZJAKIN A. P. 1950: *Letučie myši* (*Sistematika, obraz žizni i pol'za dlja sel'skogo i lesnogo hozjajstva*) [*Bats* (*Systematics, Life History and Utility in Agriculture and Forestry*)]. Moskva: Sovetskaja Nauka, 444 pp (in Russian).

Kuzjakin A. P. 1965: Otrjad Rukokrylye. Ordo Chiroptera [Order Bats. Ordo Chiroptera]. Pp.: 79–116. In: Bobrinskij N. A., Kuznecov B. A. & Kuzjakin A. P. (eds.): *Opredelitel' mlekopitajuščih SSSR* [*Key to Identification of Mammals of the USSR*]. Moskva: Prosveščenie, 384 pp (in Russian).

Kwiecinski G. G. & Griffits T. A. 1999: Rousettus egyptiacus. *Mammalian Species* **611**: 1–9.

Lanza B. 1959: III. Chiroptera Blumenbach, 1774. Pp.: 187–432. In: Toschi A. & Lanza B. (eds.): *Fauna d'Italia. Mammalia. Generalità – Insectivora – Chiroptera*. Bologna: Calderini, 488 pp.

Lanza B. 1960: Su due species criptiche di Orecchione: «Plecotus auritus» (L.) e «P. wardi» Thomas («Mamm.; Chiroptera»). *Monitore Zoologico Italiano* **68**: 7–23.

Largen M. J., Kock D. & Yalden D. W. 1974: Catalogue of the mammals of Ethiopia. 1. Chiroptera. *Monitore Zoologico Italiano* **16**: 221–298.

Lay D. M. 1967: A study of the mammals of Iran. Resulting from the Street Expedition of 1962–63. *Fieldiana*: *Zoology* **54**: 1–282.

Le Berre M. 1990: *Faune du Sahara 2*. *Mammiferes*. Paris: Lechevallier & R. Chabaud, 360 pp.

Lin L.-K., Motokawa M., Harada M. & Cheng H.-C. 2002: New record of Barbastella leucomelas (Chiroptera: Vespertilionidae) from Taiwan. *Mammalian Biology* **67**: 315–319.

von Lehmann E. 1966: Taxonomische Bemerkungen zur Säugerausbeute der Kumerloevschen Orientreisen 1953–1965. *Zoologische Beiträge* (*Neue Folge*) (Berlin) **12**: 251–317.

Lewis R. E. & Harrison D. L. 1962: Notes on bats from the Republic of Lebanon. *Proceedings of the Zoological Society of London* **138**: 473–486.

Madkour G. 1977: Further observations on bats (Chiroptera) of Egypt. *Agricultural Research Review* **55**: 173–184.

Makin D. 1976: Preliminary report of a survey of Microchiroptera in Israel. *Israel Journal of Zoology* **25**: 211.

Makin D. 1977: Atalefim afufe hidot [Riddle-shrouded bats]. *Teva va Aretz* **18**(2): 74–80 (in Hebrew).

Makin D. 1987: Tefuca uvezoologija shel 'tlafi haraqim be'erec Jisrael [The insectivorous bats (Microchiroptera) of Israel, distribution and biology]. *Re'em* (*Oryx*), *Journal of the Israel Mammal Information Center* **6**: 12–76 (in Hebrew, with a subtitle in English).

Makin D. 1989: The status of bats in Israel. Pp.: 403–408. In: Hanák V., Horáček I. & Gaisler J. (eds.): *European Bat Research 1987*. Praha: Charles University Press, xx+718 pp.

Makin D. & Harrison D. L. 1988: Occurrence of Pipistrellus ariel Thomas, 1904 (Chiroptera: Vespertilionidae) in Israel. *Mammalia* **52**: 419–422.

Marsh E. J. 1994: The Sand of Yesteryear. Arabia Petraea. *Transactions of the Connecticut Academy of Arts and Sciences* **52**: 1–103.

Mayer F., Dietz C. & Kiefer A. 2007: Molecular species identification boosts bat diversity. *Frontiers in Zoology* **4**: 4.

Meakin K., de Kort S. R., Gilbert F., Zalat S., Mohi L., Ibrahim S., Griffin J. & the Volunteers of Operation Wallacea in Egypt 2005: Monitoring birds, reptiles and butterflies in the St Katherine Protectorate, Egypt. *Egyptian Journal of Biology* **7**: 66–95.

Mendelssohn H. & Yom-Tov Y. 1999: *Fauna Palestina*. *Mammalia of Israel*. Jerusalem: The Israel Academy of Sciences and Humanities, 439 pp + xxxvii pl.

Menu H. 1987: Morphotypes dentaires actuels et fossiles des chiroptères vespertilioninés. 2ème partie: Implications systématiques et phylogeniques. *Palaeovertebrata* **17**(3): 77–150.

Mertens R. 1925: Verzeichnis der Säugetier-Typen des Senckenbergischen Museums. *Senckenbergiana* **7**: 18–37.

Meyer-Oehme D. 1968: Zur Kenntnis der Chiropteren-Fauna Afghanistans. *Bonner Zoologische Beiträge* **19**: 97–103.

Miller G. S. 1907: The families and genera of bats. *Bulletin of the United States National Museum* **57**: i–xvii+1–282.

Möhres F. P. & Kulzer E. 1955a: Ein neuer, kombinierter Type der Ultraschallorientierung bei Fledermäusen. *Natuwissenschaften* **42**: 131–132.

Möhres F. P. & Kulzer E. 1955b: Untersuchungen über die Ultraschallorientierung von vier afrikanischen Fledermäusfamilien. *Zoologischer Anzeiger* (Supplementum) **19**: 59–65.

Mucedda M., Kiefer A., Pidinchedda E. & Veith M. 2002: A new species of long-eared bat (Chiroptera, Vespertilionidae) from Sardinia (Italy). *Acta Chiropterologica* **4**: 121–135.

Nader I. A. 1975: On the bats (Chiroptera) of the Kingdom of Saudi Arabia. *Journal of Zoology*, *London* **176**: 331–340.

Nader I. A. 1990: Checklist of the Mammals of Arabia. *Fauna of Saudi Arabia* **11**: 329–381.

Nader I. A. & Kock D. 1983: Notes on some bats from the Near East (Mammalia: Chiroptera). *Zeitschrift für Säugetierkunde* **48**: 1–9.

Nader I. A. & Kock D. 1990a: Eptesicus (Eptesicus) bottae (Peters 1869) in Saudi Arabia with notes on its subspecies and distribution (Mammalia: Chiroptera: Vespertilionidae). *Senckenbergiana Biologica* **70**: 1–13.

Nader I. A. & Kock D. 1990b: Plecotus austriacus (Fischer, 1829) new to Saudi Arabia, with remarks on taxonomy and zoogeography. *Fauna of Saudi Arabia* **11**: 318–322.

Neuhauser H. N. & DeBlase A. F. 1974: Notes on the bats new to the faunal lists of Afghanistan and Iran. *Fieldiana Zoology* **62**(5): 85–96.

NORBERG U. M. & RAYNER J. M. V. 1987: Ecological morphology and flight in bats (Mammalia; Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. *Philosophical Transactions of the Royal Society B, Biological Sciences* **316**: 335-427.

NOWAK R. M. 1994: *Walker's Bats of the World*. Baltimore & London: The Johns Hopkins University Press, 288 pp.

OBRIST M. K., BOESCH M. & FLÜCKIGER P. 2004: Variability in echolocation call design of 26 Swiss bat species: consequences, limits and options for automated field identification with a synergic pattern recognition approach. *Mammalia* **68**: 307–322.

OGNEV S. I. 1927: A synopsis of the Russian bats. *Journal of Mammalogy* **8**: 140–157.

OGNEV S. I. 1928: *Zveri vostočnoj Evropy i severnoj Azii. Tom I* [*The Mammals of the Eastern Europe and of the Northern Asia. Vol. I*]. Moskva-Leningrad: Gosudarstvennoe Izdatel'stvo, 631 pp (in Russian, with a subtitle in English).

OSBORN D. J. 1988: New bat records from the Red Sea Mountains of Egypt. *Mammalia* **52**: 596–598.

OSBORN D. J. & HELMY I. 1980: The contemporary land mammals of Egypt (including Sinai). *Fieldiana Zoology, New Series* **5**: i–xix+1–579.

OWEN R. D. & QUMSIYEH M. B. 1987: The subspecies problem in the Trident leaf-nosed bat, Asellia tridens: homomorphism in widely separated populations. *Zeitschrift für Säugetierkunde* **52**: 329–337.

PALACKÝ J. 1902: Die Verbreitung der Mikrochiropteren. *Věstník Královské České Společnosti Náuk, Třída Mathematicko-Přírodovědecká* [*Sitzungsberichte der Königl. Böhmischen Gesellschaft der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe*] **1901**(34): 1–23.

PETERS W. 1859: Neue Beiträge zur Kenntnis der Chiropteren. *Monatsbericht der Königliche Preussische Akademie der Wissenschaften zu Berlin* **1859**: 222–225.

PYE J. D. 1972: Bimodal distribution of constant frequencies in some hipposiderid bats (Mamalia: Hipposideridae). *Journal of Zoology, London* **166**: 323–335.

QUMSIYEH M. B. 1985: The bats of Egypt. *Special Publication of the Museum of Texas Tech University* **23**: 1–101.

QUMSIYEH M. B. 1996: *Mammals of the Holy Land*. Lubbock: Texas Tech University Press, x+389 pp.

QUMSIYEH M. B. & KNOX JONES J. Jr. 1986: Rhinopoma hardwickii and Rhinopoma muscatellum. *Mammalian Species* **263**: 1–5.

QUMSIYEH M. B., DISI A. M. & AMR Z. S. 1992: Systematics and distribution of the bats (Mammalia: Chiroptera) of Jordan. *Dirasat* **19B**: 101–118.

QUMSIYEH M. B., AMR Z. S. & AL-ORAN R. M. 1998: Further records of bats from Jordan and a synopsis. *Turkish Journal of Zoology* **22**: 277–284.

RAHMATULINA I. K. 2005: *Rukokrylye Azerbajdžana* (*Fauna, ekologija, zoogeografija*) [*Bats of Azerbaijan* (*Fauna, Ecology, Zoogeography*)]. Baku: Nacional'naja Akademija Nauk Azerbajdžana, 476 pp (in Russian).

ŘEHÁK Z. 1999: Central European bat sounds. *Nietopierze* **1**: 29–37.

RISKIN D. K. 2001: Pipistrellus bodenheimeri. *Mammalian Species* **651**: 1–3.

RYDELL J. & ARLETTAZ R. 1994: Low-frequency echolocation enables the bat Tadarida teniotis to feed on tympanate insects. *Proceedings of the Royal Society of London B* **257**: 175–178.

RYDELL J. & BOGDANOWICZ W. 1997: Barbastella barbastellus. *Mammalian Species* **557**: 1–8.

RYDELL J., NATUSCHKE G., THEILER A. & ZINGG P. E. 1996: Food habits of the barbastelle bat, Barbastella barbastellus. *Ecography* **19**: 62–66.

RÜPPELL E. 1829: *Reisen in Nubien, Kordofan und dem peträischen Arabien vorzüglich in geographisch-statistischer Hinsicht*. Frankfurt am Main: Friedrich Wilmans, 390 pp.

RÜPPELL E. 1842: Verzeichniss der in dem Museum der senckenbergischen naturforschenden Gesellschaft aufgestellten Sammlungen. Erste Abtheilung: Säugethiere und deren Skelette. *Museum Senckenberg* **3**: 145–196.

RUSSO D. & JONES G. 2002: Identification of twenty-two bat species (Mammalia: Chiroptera) from Italy by analysis of time-expanded recordings of echolocation calls. *Journal of Zoology, London* **258**: 91–103.

RYBERG O. 1947: *Studies on Bats and Bat Parasites Especially with Regard to Sweden and Other Neighbouring Countries of the North. I*. Stockholm: Bokförlaget Svensk Natur, 319 pp.

SALEH M. A. & BASUONY M. I. 1998: A contribution to the mammalogy of the Sinai Peninsula. *Mammalia* **62**: 557–575.

SALSAMEDI E., AIHARTZA J., GOITI U., ALMENAR D. & GARIN I. 2005: Echolocation calls and morphology in the Mehelyi's (Rhinolophus mehelyi) and Mediterranean (R. euryale) horseshoe bats: implications for resource partitioning. *Hystrix, Italian Journal of Mammalogy* (*New Series*) **16**: 145–158.

SANBORN C. C. & HOOGSTRAAL H. 1955: The identification of Egyptian bats. *The Journal of the Egyptian Public Health Association* **30**: 103–119.

SATUNIN K. A. 1909: Materialy k" poznaniju mlekopitajuščih" Kavkazskago kraja i Zakaspijskoj oblasti. VIII. Ekskursija Kavkazskago Muzeja v" stepi i predgor'ja vostočnago Zakavkaz'ja vesnoju 1907 g. [Beiträge zur Kenntnis der Säugetierfauna Kaukasiens und Transkaspiens. VIII. Exkursion des Kaukasischen Museums in die Steppen und Vorberge Ost-Transkaukasiens im Frühling 1907]. *Izvestija Kavkazskago Muzeja* [*Mitteilungen des Kaukasischen Museums*] **4**: 41–67 (in Russian, with a summary in German, pp. 102–117).

SATUNIN' K. A. 1914: *Opredelitel' mlekopitajuščih" Rossijskoj Imperii. Vypusk" pervyj*. (*Rukokrylyja*, *Nasekomojadnyja i Hiščnyja*) [*Key of the Mammals of Russian Empire. First Volume*. (*Bats*, *Insectivors and Carnivors*)]. Tiflis: Kanceljarija Namestnika E. I. V. na Kavkaze, 148 pp (in Russian).
SATUNIN' K. A. 1915: Mlekopitajuščija Kavkazkago Kraja. Tom" I. (Chiroptera, Insectivora i Carnivora) [Mammalia Caucasica. Tome I., (Chiroptera, Insectivora et Carnivora)]. *Zapiski Kavkazkago Muzeja*, *Serija A* [*Memoires du Musée du Caucase*, *Serie A*] **1**: 1–410 (in Russian, with a subtitle in French).
SENNA A. 1905: Contributo alla conoscenza dei chirotteri Eritrei. *Archivio Zoologico Italiano* **2**(3): 249–308 (non vidi, ex Kock 1969).
SCHLITTER D. A. & QUMSIYEH M. B. 1996: Rhinopoma microphyllum. *Mammalian Species* **542**: 1–5.
SCHOBER W. 2004: Barbastella barbastellus (Schreber, 1774) – Mopsfledermaus (Breitohrige Fledermaus). Pp.: 1071–1091. In: KRAPP F. (ed.): *Handbuch der Säugetiere Europas*. *Band 4: Fledertiere*. *Teil II: Chiroptera II*. *Vespertilionidae 2*, *Molossidae*, *Nycteridae*. Wiebelsheim: Aula-Verlag, x+605–1186 pp.
SHALMON B., KOFYAN T. & HADAD E. 1993: *A Field Guide to the Land Mammals of Israel*. *Their Tracks and Signs*. Jerusalem: Kater Publishing House, 216 pp (in Hebrew, with a subtitle in English).
SIERRO A. & ARLETTAZ R. 1997: Barbastelle bats (Barbastella spp.) specialize in the predation of moths: implication for foraging tactics and conservation. *Acta Oecologica* **18**: 91–106.
SIMMONS N. B. 2005: Order Chiroptera. Pp.: 312–529. In: WILSON D. E. & REEDER D. M. (eds.): *Mammal Species of the World*. *A Taxonomic and Geographic Reference*. *Third Edition*. *Volume 1*. Baltimore: The John Hopkins University Press, xxxviii+743 pp.
SIMMONS J. A., KICK S. A. & LAWRENCE B. D. 1984: Echolocation and hearing in the mouse-tailed bat, Rhinopoma hardwickei: Acoustic evolution of echolocation in bats. *Journal of Comparative Physiology A* **154**: 347–356.
SNOWDEN P., BATES P. J. J., HARRISON D. L. & BROWN M. R. 2000: Recent records of bats and rodents from Oman including three species new to the country. *Fauna of Arabia* **18**: 397–407.
SPITZENBERGER F., STRELKOV P. P., WINKLER H. & HARING E. 2006: A preliminary revision of the genus Plecotus (Chiroptera, Vespertilionidae) based on genetic and morphological results. *Zoologica Scripta* **35**: 187–230.
STRELKOV P. P. 1963: II. Otrjad Chiroptera – Rukokrylye [II. Order Chiroptera – bats]. Pp.: 122–218. In: SOKOLOV I. I. (ed.): *Mlekopitajuščie fauny SSSR*. *Časť 1* [*Mammals of the fauna of the USSR*. *Part 1*]. Moskva & Leningrad: Izdatel'stvo Akademii nauk SSSR, 640 pp (in Russian).
STRELKOV P. P. 1981: Otrjad Chiroptera Blumenbach, 1779 – Rukokrylye [Order Chiroptera Blumenbach, 1779 – Bats]. Pp.: 31–53. In: GROMOV I. M. & BARANOVA G. I. (eds.): *Katalog mlekopitajuščih SSSR*. *Pliocen–Sovremennosť* [*Catalogue of Mammals of the USSR*. *Pliocene–Recent*]. Leningrad: Nauka, 456 pp (in Russian).
STRELKOV P. P. 1988a: Buryj (Plecotus auritus) i seryj (P. austriacus) ušany (Chiroptera, Vespertilionidae) v SSSR. Soobščenie 1 [Brown (Plecotus auritus) and grey (P. austriacus) bats (Chiroptera, Vespertilionidae) in the USSR. Communication 1]. *Zoologičeskij Žurnal* **67**: 90–101 (in Russian, with a summary in English).
STRELKOV P. P. 1988b: Buryj ušan (Plecotus auritus) i seryj ušan (P. austriacus) (Chiroptera, Vespertilionidae) v SSSR. Soobščenie 2 [Brown (Plecotus auritus) and grey (P. austriacus) long-eared bats (Chiroptera, Vespertilionidae) in the USSR. Communication 2]. *Zoologičeskij Žurnal* **67**: 287–292 (in Russian, with a summary in English).
STRELKOV P. P. 1989: New data on the structure of baculum in Palaearctic bats. I. The genera Myotis, Plecotus, and Barbastella. Pp.: 87–94. In: HANÁK V., HORÁČEK I. & GAISLER J. (eds.): *European Bat Research 1987*. Praha: Charles University Press, xx+718 pp.
STRELKOV P. P., SOSNOVCEVA V. P. & BABAEV N. V. 1978: Letučie myši (Chiroptera) Turkmenii [The bats of Turkmenia]. *Trudy Zoologičeskogo Instituta Akademii Nauk SSSR* **79**: 3–71 (in Russian, with a subtitle in English).
STRESEMANN E. 1954: Hemprich und Ehrenberg. Reisen zweier naturforschender Freunde im Orient geschildert in ihren Briefen aus den Jahren 1819–1826. *Abhandlungen der Deutsche Akademie der Wissenschaften zu Berlin*, *Klasse für Mathematik und allgemeine Naturwissenschaften* **1954**(1): 1–178.
SWIFT S. M. 1998: *Long-Eared Bats*. London: T & A D Poyser Ltd, x+182 pp.
TATE G. H. H. 1942: Results of the Archbold Expeditions. No. 47. Review of the Vespertilionine bats, with special attention to genera and species of the Archbold collections. *Bulletin of the American Museum of Natural History* **80**: 221–297.
TAYLOR P. J. 2000: *Bats of Southern Africa*. *Guide to Biology*, *Identification*, *and Conservation*. Pietermaritzburg: University of Natal Press, 206 pp.
THEODOR O. & MOSCONA A. 1954: On bat parasites in Palestine. I. Nycteribiidae, Streblidae, Hemiptera, Siphonaptera. *Parasitology* **44**: 157–245.
THOMAS O. 1904: On some small mammals collected by mr. A. M. Mackilligin in the Eastern Desert of Egypt. *The Annals and Magazine of Natural History* (7)**14**: 155–159.
TOPÁL G. 1958: Morphological studies on the os penis of bats in the Carpathian Basin. *Annales Historico-Naturales Musei Nationalis Hungarici* **50**: 331–340.
TRISTRAM H. B. 1884: *The Survey of Western Palestine*. *The Fauna and Flora of Palestine*. London: The Committee of the Palestine Exploration Fund, xxii+455 pp.

Trouessart E.-L. 1897: *Catalogus mammalium tam viventium quam fossilium*. *Nova editio* (*prima completa*). *Fasciculus I. Primates*, *Prosimiae*, *Chiroptera*, *Insectivora*. Berolini: R. Friedländer & Sohn, 218 pp.
Trouessart E.-L. 1904: *Catalogus mammalium tam viventium quam fossilium*. *Quinquennale Supplementum*. Berolini: R. Friedländer & Sohn, iv+929 pp.
Trujillo D., Ibáñez C. & Juste J. 2002: A new subspecies of Barbastella barbastellus (Mammalia: Chiroptera: Vespertilionidae) from the Canary islands. *Revue Suisse de Zoologie* **109**: 543–550.
Ulanovsky N., Fenton M. B., Tsoar A. & Korine C. 2004. Dynamics of jamming avoidance in echolocating bats. *Proceedings of the Royal Society of London B* **271**: 1467–1475.
Van Cakenberghe V. & De Vree F. 1994: A revision of the Rhinopomatidae Dobson 1872, with the description of a new subspecies (Mammalia: Chiroptera). *Senckenbergiana Biologica* **73**: 1–24.
Wallin L. 1969: The Japanese bat fauna. A comparative study of chorology, species diversity and ecological differentiation. *Zoologiska Bidrag från Uppsala* **37**: 224–440.
Wassif K. 1953: On a collection of mammals from northern Sinai. *Bulletin de l'Institut du Désert d'Egypte* **3**: 107–118.
Wassif K. 1959: Mammals from the Egyptian oases of Kharga, Dakhla, Bahariya and Farafra (Al-Wadi Al-Gadid). *Bulletin of the Zoological Society of Egypt* **14**: 15–17 (in English and Arabic [pp. 1–3]).
Wassif K. 1995: *Guide to Mammals of Natural Protecorates in Egypt*. Cairo: Egyptian Environmental Affairs Agency, 172 pp (in Arabic, with a title in English).
Wassif K. & Hoogstraal H. 1954: The mammals of South Sinai, Egypt. *Proceedings of the Egyptian Academy of Sciences* **9**: 63–79.
Wassif K., Madkour G. & Soliman S. 1984: *Fauna and Flora of Egypt*. *1*. *On a collection of bats from Egypt*. Cairo: Natural History Museum of Egypt, 36 pp. + vi plates.
Wang Y.-X. 2003: *A Complete Checklist of Mammal Species and Subspecies in China*. *A Taxonomic and Geographic Reference*. Kunming: China Forestry Publishing House, 394 pp.
Werner Y. L. 1988: Herpetofaunal survey of Israel (1950–85), with comments on Sinai and Jordan and on zoogeographical heterogeneity. Pp.: 355–387. In: Yom-Tov Y. & Tchernov E. (eds.): *The Zoogeography of Israel*. *The Distribution and Abundance at a Zoogeographical Crossroads*. Dordrecht: Dr W. Junk Publishers, 600 pp.
Whitaker J. O. Jr., Shalmon B. & Kunz T. H. 1994: Food and feeding habits of insectivorous bats from Israel. *Zeitschrift für Säugetierkunde* **59**: 74–81.
Wranik W., Rösler H. & Al-Mahdy S. 1999: *Faunistic Survey*. *Socotra Archipelago*. *Provisional Report*. Rostock & Dresden: Universität Rostock and Museum für Tierkunde Dresden, 105 pp.
Yom-Tov Y. 1993: Character displacement among the insectivorous bats of the Dead Sea area. *Journal of Zoology*, *London* **230**: 347–356.
Yom-Tov Y. & Kadmon R. 1998: Analysis of the distribution of insectivorous bats in Israel. *Diversity and Distribution* **4**: 63–70.
Yom-Tov Y. & Shalmon B. 1989: First record of Taphozous perforatus in Israel. *Mammalia* **53**: 661–662.
Yom-Tov Y., Makin D. & Shalmon B. 1992a: The insectivorous bats (Microchiroptera) of the Dead Sea area, Israel. *Israel Journal of Zoology* **38**: 125–137.
Yom-Tov Y., Makin D. & Shalmon B. 1992b: The biology of Pipistrellus bodenheimeri (Microchiroptera) in the Dead Sea area of Israel. *Zeitschrift für Säugetierkunde* **57**: 65–69.
Yoshiyuki M. 1989: *A Systematic Study of the Japanese Chiroptera*. Tokyo: National Science Museum, vi+242 pp.
Zalat S. & Gilbert F. 2006: *Gardens in a Sacred Landscape*. *Natural History and Bedouin Heritage in the High Mountains of Sinai*. Electronic Publication, 263 pp.
Zein Ad Din H. F. & Hafiz H. A. M. 1959: *Al Khfashiat* [*Bats*]. Cairo: Dar Al Fkr Al Arbi, 128 pp (in Arabic).
Zelenova N. & Yosef R. 2003: Bats in the Eilat region (Israel), spring 2002. *Nyctalus* (*Neue Folge*) **9**(1): 57–60.
Zhang Y., Jin S., Quan G., Li S., Ye Z., Wang F. & Zhang M. 1997: *Distribution of Mammalian Species in China*. Beijing: China Forestry Publishing House, xiv+281 pp.
Zhang J.-S., Han N.-J., Jones G., Lin L.-K., Zhang J.-P., Zhu G.-J., Huang D.-W. & Zhang S.-Y. 2007: A new species of Barbastella (Chiroptera: Vespertilionidae) from North China. *Journal of Mammalogy* **88**: 1393–1403.
Zohary M. 1973: *Geobotanical Foundations of the Middle East*. Stuttgart & Amsterdam: Gustav Fischer Verlag & Swets & Zeitlinger, xii+739 pp.

APPENDIX I

# Gazetteer

| site | coordinates | altitude [m a. s. l.] |
|---|---|---|
| Ain El Furtaga, canyon above the oasis (Fig. 4, p. 8) | 29° 03' N, 34° 33' E | 240 |
| Ain Hudra, oasis (Fig. 5, p. 9) | 28° 54' N, 34° 25' E | 680 |
| Ain Sudr, oasis (Fig. 19, p. 22) | 29° 49' N, 33° 07' E | 443 |
| Bir El Abed | 28° 32' N, 33° 56' E | – |
| El Milga, Deir Sant Katerin | 28° 33' N, 33° 59' E | 1490 |
| El Milga, Fox Camp, Bedouin garden | 28° 34' N, 33° 58' E | 1570 |
| El Milga, garden above the oasis (Fig. 6, p. 10) | 28° 34' N, 33° 58' E | 1585 |
| El Milga, Rotog | 28° 28' N, 34° 00' E | 1685 |
| El Milga, St. Katherine Research Centre | 28° 33' N, 33° 57' E | 1590 |
| El Milga, village | 28° 33' N, 33° 57' E | 1550 |
| El Tur, Hammam Musa (Fig. 25, p. 27) | 28° 16' N, 33° 36' E | 7 |
| Farsh El Romana, Abu Hamat Garden (Fig. 20, p. 23) | 28° 32' N, 33° 53' E | 1810 |
| Feiran, El Braga Garden | 28° 42' N, 33° 39' E | 670 |
| Feiran, garden in the eastern edge of the oasis | 28° 42' N, 33° 40' E | 715 |
| Feiran, western edge of the oasis | 28° 43' N, 33° 37' E | 595 |
| Ras Muhammad National Park, Khashaba Beach | 27° 47' N, 34° 13' E | 12 |
| Sheikh Awad, Awad Garden | 28° 38' N, 33° 54' E | 1181 |
| Sheikh Awad, El Karm Ecolodge (Fig. 49, p. 49) | 28° 39' N, 33° 53' E | 1130 |
| Sheikh Awad, Mohammed's Garden | 28° 38' N, 33° 53' E | 1140 |
| Sheikh Awad, Oder's Garden | 28° 38' N, 33° 53' E | 1140 |
| Sheikh Awad, Sulliman's Garden | 28° 38' N, 33° 54' E | 1140 |
| Wadi El Arbaein, Ramadan's Garden (Fig. 34, p. 34) | 28° 32' N, 33° 58' E | 1780 |
| Wadi Gebal (= Wadi Gibal), Hussein's Garden | 28° 32' N, 33° 54' E | 1910 |
| Wadi Hibran, Bedouin village | 28° 27' N, 33° 41' E | 247 |
| Wadi Hibran, camp at the pass to Wadi Sulaf | 28° 37' N, 33° 44' E | 945 |
| Wadi Itfah, Hamid's Garden | 28° 35' N, 33° 55' E | 1460 |
| Wadi Kharba, village | 28° 39' N, 33° 55' E | – |
| Wadi Kid, hill top garden | 28° 21' N, 34° 10' E | ca. 1000 |
| Wadi Kid, small village | 28° 20' N, 34° 12' E | 580 |
| Wadi Klar, Abu Dagash, a cave | 28° 35' N, 33° 55' E | ca. 1455 |
| Wadi Klar, a deserted house west of the Hajsalem's Garden | 28° 35' N, 33° 55' E | ca. 1455 |
| Wadi Klar, Hamid's Garden | 28° 35' N, 33° 55' E | ca. 1455 |
| Wadi Klar, house and pit of a church | 28° 35' N, 33° 55' E | ca. 1455 |
| Wadi Marra | 28° 46' N, 34° 11' E | ca. 980 |
| Wadi Nasb, Awad's Garden | 28° 30' N, 34° 08' E | ca. 1260 |
| Wadi Nasb, Mousa's Garden | 28° 30' N, 34° 08' E | ca. 1260 |
| Wadi Shagg, near the start | 28° 32' N, 33° 56' E | ca. 1890 |
| Wadi Shagg, Oder's Garden (cf. Fig. 64, p. 67) | 28° 32' N, 33° 56' E | ca. 1890 |
| Wadi Sulaf, Wadi El Braga Camp | 28° 38' N, 33° 49' E | 1105 |

## APPENDIX II
# List of comparative material

### *Rousettus aegyptiacus* (Geoffroy, 1810)

**Cyprus**: 1 m (NMP 90435 [S+A]), 2 km SW Prodromi, Androlikou Gorge, 20 April 2005, leg. P. Benda & V. Hanák; – 1 ind. (NMP 90399 [S]), Akamas Pen., Baths of Aphrodite, 10 April 2005, leg. P. Benda & V. Hanák; – 1 m (NMP 91274 [S+A]), Akamas Pen., Smigies Trail, Magnesia Mine, 27 March 2005, leg. I. Horáček, P. Hulva & R. Lučan. – **Egypt**: 8 m, 6 f, 1 ind. (IVB 1–3, 5–10, 13–16, 18 [S+B], IVB UJEP1.1.106 [S]), Cairo, Sultan Hamid Mosque, 23 April 1969, June 1971, leg. J. Gaisler & J. Groschaft; – 3 m, 7 f (ZFMK 63.267–63.272, 63.274 [S+B], 63.275–63.277 [S]), Cairo, Sultan Hassan Mosque, 11 May 1951, leg. H. Hoogstraal; – 2 m, 1 f (ZFMK 94.499, 94.501 [S+B], 94.502 [S+Sk]), Egypt (undef.), 17 August 1994, coll. Airport Düsseldorf; – 2 inds. (ZFMK 62.199, 62.200 [S]), Egypt (undef.), coll. F. P. Möhres. – **Ethiopia**: 3 m, 5 f (NMP pb2524–pb2527, pb2529–pb2531 [S+A], NMP pb2528 [A]), Gilo River bridge, 5 km S of Tepi, 8 May 2003, leg. P. Benda & J. Obuch. – **Iran**: 5 m, 5 f (NMP 48377–48386 [S+A]), Espakeh (Baluchestan), 10 April 2000, leg. P. Benda & A. Reiter; – 3 m, 6 f (NMP 40467/1, 40467/3–10 [S+B]), Isin (Hormozgan), 29 April and 2 May 1977, leg. B. Pražan. – **Lebanon**: 1 m (AUB M021 [S]), Antelias, 19 March 1960, leg. J. E. Stencel; – 1 m, 1 f (NMP 91799, 91910 [S+A]), Antelias, Kassarat Cave, 25 January 2007 & 25 January 2008, leg. P. Benda, R. Černý, I. Horáček, R. Lučan & M. Uhrin; – 1 f (AUB M006 [S]), cave 4 km SE of Beit Meri, 4 October 1959, leg. R. E. Lewis; – 1 m, 1 f (NMP 91904, 91905 [S+A]), Dahr el Mghara, Mgharet el Aaonamie cave, 19 January 2008, leg. P. Benda, I. Horáček, R. Lučan & M. Uhrin; – 2 m, 1 f (NMP 91765, 91766, 91899 [S+A]), Tarabulus, Mtal al Azraq Cave, 21 January 2007 & 18 January 2008, leg. P. Benda, R. Černý, I. Horáček, R. Lučan & M. Uhrin. – **Syria**: 1 m, 1 f (NMP 48865, 48866 [S+A]), Talsh'hab (Der'a), 25 May 2001, leg. M. Andreas, P. Benda, A. Reiter & D. Weinfurtová; – 1 m, 1 f (NMP 48264, 48265 [S+A]), Ya'ar Oden forest (Quneitra/Golan H.), 18 July 1999, leg. P. Benda. – **Turkey**: 1 m (ZFMK 65.205 [S+B]), Dermustlu Köy, Höhle bei Antakya, 2 January 1952, leg. H. Kumerloeve. – **Yemen**: 3 m, 2 f (NMP pb3112–pb3116 [S+A]), 5 km W of Hammam Ali, 27 October 2005, leg. P. Benda; – 2 f (NMP pb3056, pb3057 [S+A]), Al Khuraybah, Wadi Daw'an, 19 October 2005, leg. P. Benda; – 4 m, 2 f (NMP pb3628–3630, 3632, 3633 [S+A], pb3631 [A]), Assala at Mashgab, S of Taiz, 26 October 2007, leg. P. Benda & A. Reiter; – 1 m (NMP pb3758 [S+A]), Halhal, 10 km NE Hajja, 2 November 2007, leg. P. Benda & A. Reiter; – 2 m, 1 f (NMP pb2959–pb2961 [S+B]), Hawf, 12 October 2005, leg. P. Benda; – 2 f (NMP pb3118, pb3119 [S+B]), Jebel Bura, W of Riqab, 30 October 2005, leg. P. Benda; – 2 m (NMP pb2943, pb2944 [S+A]), Ma'arib, 9 October 2005, leg. P. Benda; – 1 m (NMP pb2956 [S+A]), Sah, Wadi Haramawt, 11 October 2005, leg. P. Benda; – 1 f (NMP pb3159 [S+A]), Wadi Al Lahm, W of Al Mahwit, 1 October 2005, leg. P. Benda; – 1 m (NMP pb2917 [S+A]), Wadi Dhahr, 15 km N of Sana'a, 6 October 2005, leg. P. Benda; – 2 f (NMP pb3089, pb3090 [S+A]), Wadi Maytam, 12 km SE of Ibb, 26 October 2005, leg. P. Benda; – 1 m (NMP pb3728 [S+A]), Wadi Zabid, SE of Al Mawkir, 30 October 2007, leg. P. Benda & A. Reiter.

### *Hypsugo ariel* (Thomas, 1904)

**Israel**: 1 m, 2 f (HUJ M.6182 [S+A], M.8054 [A], M.6866 [B]), En Gedi, May 1975, 11 April 1976, 19 October 1987, leg. Y. Barak, Z. Greenberger, H. Mendelssohn & Y. Yom-Tov; – 1 m, 1 f (BMNH 67.1229. [S+B], the holotype of *Pipistrellus bodenheimeri* Harrison, 1960, TAU M.8639 [S]), Yotvata, Wadi Araba, 40 kms. N of Eilat, 13 October 1959, August 1989, leg. D. L. Harrison & D. Makin. – **Jordan**: 1 m (NMP 92095 [S+A]), Wadi Rum, 24 October 2004, leg. R. Lučan. – **Sudan**: 1 m, 1 f (BMNH 4.11.4.7., 4.11.4.6. [S+B], incl. the holotype of *Pipistrellus ariel* Thomas, 1904), 'E Desert of Egypt, 22° N, 35° E, 2000 ft., Wadi Alagy', 12 August 1903, leg. A. M. Mackilligin. – **Yemen**: 1 m (NMP pb3058 [S+A]), Al Nueimah, 20 October 2005, leg. P. Benda; – 2 m, 1 f (NMP pb3050, pb3051 [S+A], pb3052 [A]), Damqawt, 16 October 2005, leg. P. Benda; – 5 m, 4 f (NMP pb3022–pb3025, pb3027–pb3030 [S+A], pb3026 [A]), Hawf, 14 October 2005, leg. P. Benda; – 1 m, 1 f (NMP pb3054 [S+A], pb3055 [A]), 25 km WSW Sayhut, 17 October 2005, leg. P. Benda; – 1 m, 1 f (BMNH 54.423., 54.424. [B]), Seiyun, E. Aden Prot., 2000 ft, 21 June 1956, leg. J. Greathead; – 1 ind. (BMNH 54.1031. [S]), Socotra, Ghadeb, leg. G. B. Popov; – 1 m (BMNH 67.1255 [S+B]), Socotra, Suk, 16 April 1967, leg. K. M. Guichard; – 1 m (NMP 92106 [S+A]), Socotra, Wadi Erher, 24 November 2002, leg. A. K. Nasher & B. Pražan; – 1 f (NMP 90587 [S+A]), Socotra, Wadi Es Gego, 12 May 2004, leg. A. Reiter.

### *Hypsugo arabicus* (Harrison, 1979)

**Iran**: 4 m, 8 f (NMP 48409, 48410, 48414–48420 [S+A], 48411–48413 [S]), Pir Sohrab, 12 April 2000, leg. P. Benda & A. Reiter. – **Oman**: 1 m (BMNH 80.393. [S+B], holotype of *Pipistrellus arabicus* Harrison, 1979), Wadi Sahtan, 23° 22' N, 57° 18' E, 18 March 1979, leg. M. D. Gallagher.

### *Barbastella barbastellus* (Schreber, 1774)

**Azerbaijan**: 1 f (NMP 91699 [S+B]), Doslug, Hačmas Dist., 17 October 1975, leg. I. Rahmatulina. – **Czech Republic**: 5 m, 1 f (NMP 92054–92059 [S+B]), Bechyně, castle cellars, 18 March 1964, leg. V. Hanák; – 1 f (NMP 92021 [S]), Černý Důl u Hostinného, mine, 19 March 1959, leg. V. Hanák; – 3 m (NMP 92063–92065 [S+B]), Český Šternberk, castle cellar, 11 January 1967, leg. V. Hanák; – 2 m, 1 f (NMP pb428 [A], SMZ 6793, [unnumbered] [S+A]), Čížov, Ledové sluje Cave, 19 June 1994, 17 August 2002, 1 September 2006, leg. P. Benda & A. Reiter; – 1 f (NMP 92030 [K]), Hrubý Rohozec, castle cellar, 12 February 1962, leg. V. Hanák; – 1 f (NMP 92027 [S+B]), Kašperské Hory, old mine, 11 February 1960, leg. V. Hanák; – 1 m (NMP 92016 [S]), Křivoklát, castle cellars, 14 January 1959, leg. F. Dusbábek; – 1 m (NMP 92019 [S]), Mladeč, Podkova Cave, 26 January 1959, leg. V. Hanák; – 6 m, 1 f (NMP 92066, 92067, 92078, 92079, 92084, 92085 [S], 92069 [S+B]), Mořina, Amerika mine, 31 January 1956, leg. V. Hanák, 15 February 1957, leg. V. Hanák, 27 October 1957, leg. V. Hanák & J. Figala; – 1 m, 2 f (NMP 92008–92010 [S]), Mšeno near Jablonec nad Nisou, 26 February 1958, leg. K. Hůrka & M. Nevrlý; – 1 m (NMP 92070 [S]), Podrážnice near Horšovský Týn, 9 April 1957, leg. V. Hanák; – 1 f (NMP 92011 [B]), Rabí, castle cellars, 16 December 1958, leg. V. Hanák & K. Hůrka; – 2 m, 1 ind. (NMP 92004, 92088 [S], 92087 [B]), Srbsko, mines, 24 November 1956, leg. K. Hůrka, 24 January 1957, leg. K. Hůrka; – 1 m, 1 f (NMP 92060, 92061 [S+B]), Stříbro, mines, 9 March 1965, leg. V. Hanák; – 1 m (NMP 92062 [S]), Trněný Újezd, Kájův kaňon Quarry, mine, 19 November 1965, leg. V. Hanák; – 7 m, 13 f (NMP 92032, 92033, 92036, 92037, 92040, 92042–92046, 92049–92051, 92053 [S+B], 92041 [S], 92034, 92035, 92038, 92047, 92052 [B]), Vilémovice, Macocha Chasm, Erichova jeskyně Cave, 25 February 1963, leg. V. Hanák & J. Gaisler; – 1 m (NMP 92003 [S]), Zbraslav, castle cellar, 1 December 1956, leg. V. Hanák. – **Iran**: 3 f (NMP 90842–90844 [S+A]), 2 km E Tunel-e-Golestan, 26 May 2006, leg. P. Benda & A. Reiter. – **Slovakia**: 1 m (SNM 739 [S]), Bratislava, 29 January 1966, leg. A. Volf; – 1 ind. (SNM 157 [S]), Driny, 11 February 1961, leg. F. Matoušek; – 1 f (ZMM V-1819 [S+B]), Dubník, mines, 19 January 1985, leg. Š. Danko; – 1 m (NMP 92007 [S]), Hačava, Hačavská jaskyňa Cave, 7 February 1958, leg. V. Hanák & K. Hůrka; – 1 ind. (SNM 657 [S]), Plavecké Podhradie, 23 December 1965, leg. M. Lichard; – 1 f (NMP 92029 [S+B]), Tisovec, Kostolík Cave, 15 February 1961, leg. V. Hanák; – 1 f (ZMM ZM-425/75 [S+B]), Vinné, castle, 16 November 1973, leg. Š. Danko.

### *Barbastella leucomelas* (Cretzschmar, 1830)

**Israel**: 2 f (TAU M.8326, M.8327 [S+B]), Elot, 4 April 1970, March 1975, collectors unlisted.

### *Barbastella darjelingensis* (Hodgson, 1855)

**Kirghizstan**: 1 m (SMF 77890 [S+B]), Kanigut, 18 May 1990, leg. J. Červený; – 1 m (SMF 77874 [S+B]), Sasik-Ungur, 30 May 1990, leg. J. Červený; – 1 m, 1 f (IVB UJEP1.2.39, SMF 46551 [S+B]), vicinity of the Frunze village, Alajskij hrebet Range, Oš District, 30 km S of Fergana, 26 February and 24 April 1973, leg. A. P. Kuzjakin; – 2 m (CUP CT84/125, 253 [S+A]), Oš, Dangi, Tuja Mujun, mine, 7 and 19 August 1984, leg. J. Červený & I. Horáček. – **Nepal/India**: 1 ind. (BMNH 54.9.1.13. [S], type of *Plecotus darjelingensis* Hodgson, 1855 [see Benda & Mlíkovský 2008]), 'Nepal', leg. B. H. Hodgson. – **Tajikistan**: 1 m, 1 f (ZIN 69063, 69064 [S]), Isfara, Guzlon Range, vicinity of Dahan, 25 March and 11 November 1978, leg. T. K. Habilov; – 4 inds. (ZIN 32256–32258, 32260 [S]), Tajikistan (no exact loc.), 1943, collector unlisted. – **Turkmenistan**: 1 m (ZIN 56633 [S]), Šarlouk village, Sumbar river, 2 June 1970, leg. P. P. Strelkov; – 2 m, 1 f (ZIN 56634, 56635, 57945 [S]), Arpaklen Canyon, Kara-Kamyk District, W Kopet-Dag Mts, 1 and 22 May 1970, leg. P. P. Strelkov. – **Uzbekistan**: 2 m (NMP 91466 [S+B], 94465 [B]), Tashkent, 30 September 1963, leg. V. Hanák.

### *Plecotus christii christii* Gray, 1838

**Egypt**: 1 m (NMP 90119 [S+B]), Bir Kohila, Qattar Mts, 30 May 1984, leg. D. Osborn; – 1 m (NMP 90118 [S+B]), Bir Nagat, Qattar Mts, 4 June 1984, leg. D. Osborn; – 1 ind. (BMNH 66a [B]), North Africa [= Nile Valley between Qena and Aswan; Qumsiyeh 1985], leg. T. Christie (lectotype of *Plecotus christii* Gray, 1838); – 1 f (BMNH 1936.2.10.18. [S]), Siwa Oasis, leg. O. Cooper; – 1 m (IVB 100 [S+B]), Thebes, Valley of the Kings, 30 April 1969, leg. J. Gaisler. – **Libya**: 1 m, 1 f (NMP 49862, 49863 [S+A]), Al Jaghbub, 13 May 2002, leg. M. Andreas, P. Benda, V. Hanák, A. Reiter & M. Uhrin. – **Sudan**: 1 ind. (BMNH 49.2.8.35. [B]), Fifth Cataract of the Nile, leg. F. Galton.

### *Plecotus christii petraeus* Benda, subsp. nov.

**Israel**: 1 f (TAU M.7541 [S+B]), Amudai Amram, nr. Elat, 19 February 1981; – 1 m (TAU M.6863 [S+B]), Avdat, 17 May 1976; – 1 f, 1 ind. (TAU M.771, M.1343 [S+B]), Elat, resp. Eilath, 27 September 1954, 2 March 1951; – 1 f (TAU M.8455 [S+B]), 20 km N of Elat, 17 November 1988; – 1 ind. (TAU M.9364 [S+mummy]), NE of Elat, 14 May 1995; – 1 m, 1 f (TAU M.8583, M.8584 [S+B]), Neot HaKikar, 2 May & 14 June 1989. – **Jordan**: 2 m (NMP 92096, 92097 [S+A]), Wadi Rum, 25 October 2004, leg. R. Lučan.

*Tadarida teniotis* **(Rafinesque, 1814)**

**Azerbaijan**: 1 m (IVB UJEP1.2.38 [S+B]), Šušinskoe Canyon, Nagornyj Karabah Republic, 17 August 1939, leg. A. Kuzjakin. – **Cyprus**: 1 m (NMP 91831 [S+A]), Paramytha, small cave, 31 March 2005, leg. I. Horáček, P. Hulva & R. Lučan. – **Iran**: 1 m (NMP 90833 [S+A]), 10 km NW of Emam Qoli, 24 May 2006, leg. P. Benda & A. Reiter; – 1 f (NMP 90811 [S+A]), 5 km W of Amir Abad, 21 May 2006, leg. P. Benda & A. Reiter; – 1 m (NMP 48458 [S+A]), Firuz Abad, 21 April 2000, leg. P. Benda & A. Reiter; – 3 m, 3 f (NMP 48449–48454 [S+A]), Khoshangan, 19 April 2000, leg. P. Benda & A. Reiter; – 2 f (NMP 90797, 90798 [S+A]), Shurlaq, 18 May 2006, leg. P. Benda & A. Reiter. – **Lebanon**: 3 m, 4 f (AUB M-75, 78, 79 [S+B], 665, 666, 667/1, 667/2 [S+A]), Natural Bridge, 7 km E Faraya, 25 September 1960, 31 May 1961, 25 May 1962, leg. R. E. Lewis. – **Syria**: 1 ind. (ISEA M/11781, M/11782 [S]), Kisret Mhamadali, 28 June 1998, leg. A. Shehab; – 1 ind. (SMF 90488 [mandible]), Ar Raqqa, ded. C. Becker. – **Turkey**: 5 f (ZFMK 64.699–64.702, ZFMK 72.141 [S+B]), Birecik, 26 May 1964, 11 May 1972, leg. H. Kumerloeve & U. Hirsch.

## APPENDIX III
## GenBank Accessite Numbers of the examined Sinaitic and comparative bat specimens

| species | gene | haplotype | Access. No. | voucher | site [source]* |
|---|---|---|---|---|---|
| *Rousettus aegyptiacus* | cyt *b* | | EU624124 | NMP 90504 | Sinai, Feiran |
| *Eptesicus bottae* | ND1 | | DQ915026 | CDIS 947 | Sinai, Feiran [1] |
| *Hypsugo ariel* [*ariel* morphotype] | ND1 | | DQ915015 | CDIS 945 | Sinai, Wadi El Arbaein [1] |
| *Hypsugo ariel* [*bodenheimeri* morphotype] | ND1 | | DQ915014 | CDIS 946 | Sinai, Ain Hudra [1] |
| *Barbastella leucomelas* | ND1 | | DQ915029 | CDIS 941 | Sinai, El Milga [1] |
| *Barbastella leucomelas* | ND1 | | DQ915030 | CDIS 942 | Sinai, El Milga [1] |
| *Barbastella leucomelas* | cyt *b* | Sinai | EU743795 | NMP 90521, 90522 | Sinai, Ain Hudra |
| *Barbastella barbastelus* | cyt *b* | Morocco 1 | EU743796 | NMP 90025 | Morocco, Souk-Khemis -des-Beni-Arouss |
| *Barbastella barbastellus* | cyt *b* | Morocco 2 | AY254570 | biopsy | Morocco, Tetouan [2] |
| *Barbastella barbastellus* | cyt *b* | Morocco 3 | AF513752 | EBD 25831 | Morocco, Azrou [2] |
| *Barbastella barbastelus* | cyt *b* | Iran | EU743797 | NMP 90842 | Iran, Tunel-e-Golestan |
| *Barbastella barbastellus* | cyt *b* | Eur. Turkey | AF513753 | CUP [unnumbered] | Turkey, Sarpdere [2] |
| *Barbastella barbastelus* | cyt *b* | Czech Rep. | EU743798 | SMZ 6793 | Czech Republic, Čížov, Ledové sluje Cave |
| *Barbastella barbastellus* | cyt *b* | Switzerland | AF513749 | MNHG 1804.94 | Switzerland, Martigny [2] |
| *Barbastella barbastellus* | cyt *b* | Spain 1 | AF513750 | biopsies | Spain (2 inds.) [2] |
| *Barbastella barbastellus* | cyt *b* | Spain 2 | AF513748 | biopsies | Spain (3 inds.) [2] |
| *Barbastella barbastellus* | cyt *b* | Canary Isls. | AF513745 | EBD 16024, 16028, & biopsies | Spain, Canary Islands (5 inds.) [2] |
| *Barbastella darjelingensis* | cyt *b* | Sichuan | EF534766 | IOZ-BRG-FLW007 | China, Sichuan [3] |
| *Barbastella darjelingensis* | cyt *b* | Taiwan | EF534763 | biopsy | Taiwan [3] |
| *Barbastella beijingensis* | cyt *b* | NE China | EF534760 | biopsy | China, San-Liu-Shui [3] |
| *Plecotus christii* | ND1 | | DQ915080 | CDIS 943, 944 | Sinai, Ain Hudra [1] |
| *Plecotus christii* | cyt *b* | Sinai | EU743799 | NMP 90496, 90533 | Sinai, Feiran & Ein Sudr |
| *Plecotus christii* | cyt *b* | Jordan | EU743801 | NMP 92096 | Jordan, Wadi Rum |
| *Plecotus christii* | cyt *b* | Libya | EU743800 | NMP 49863 | Libya, Al Jaghbub |
| *Plecotus balensis* | cyt *b* | | AF513798 | EBD 25842 | Ethiopia, Abune Yusef [4] |
| *Plecotus austriacus* | cyt *b* | | AF513793 | biopsy | Spain, Huélago [4] |
| *Plecotus macrobullaris* | cyt *b* | | AF513803 | NMP 48053 | Syria, Yabroud [4] |
| *Plecotus auritus* | cyt *b* | | AF513759 | MHNG 1806.47 | Switzerland, Verbier [4] |

* [1] Mayer et al. (2007); [2] Juste et al. (2003); [3] Zhang et al. (2007); [4] Juste et al. (2004)

APPENDIX IV

## Catalogue of bats from Egypt (excluding of Sinai) in the collections of the National Museum Prague and of the Institute of Vertebrate Biology, Brno

### *Rousettus aegyptiacus* (Geoffroy, 1810)

5 ma, 3 ms, 5 fa, 4 fs, 1 fj (IVB 1–18, field Nos. EG 60, 62–78 [S+B]), Cairo, Sultan Hamid Mosque, 23 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 2 fa (IVB UJEP1.1.106 [S+B], IVB UJEP1.1.107 [B]), Cairo [undefined], June 1971, leg. J. Groschaft (cf. Benda et al. 2006). – 4 inds. (NMP 91817–91820 [S from mummies]), 1 fa, 1 mj (NMP 92101, 92102 [S+A]), Dakhla Oasis, Al Qasr village, 17 April 2002, leg. P. Muclinger & P. Nová (cf. Benda et al. 2006).

### *Rhinopoma cystops* Thomas, 1903

3 ma, 3 fs, 8 fa, 4 fs (IVB field Nos. EG 21, 23, 24, 29, 31–37 [S+B], 22, 25–28, 30, 38 [S]), Cairo, Bar Kouky mosque, 21 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 ma, 1 ms, 7 fa, 5 fs (IVB EG 139 [S+B], 134–138, 140–147 [S]), Dandara, Temple of Hathor, 27 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 ms, 2 fa, 2 fs (IVB EG 82, 82 [S+B], 81, 84 [S], 83 [B]), Karnak, Great Temple, 26 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 2 inds. (NMP 92103, 92104 [S+A]), Karnak, Eastern Temple of Ramses II, 19 April 2002, leg. P. Muclinger & P. Nová. – 1 fs (IVB EG 156 [S]), Luxor, Luxor Temple, 29 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 2 fa (IVB UJEP1.3.28, 1.3.29 [S+B]), Sakkara, catacombs, 20 June 1971, leg. J. Groschaft. – 5 ma, 4 ms, 7 fa, 3 fs (IVB EG 40–44, 46, 47, 49, 50, 55–57 [S+B], 45, 48, 52–54, 58, 59 [S]), Sakkara, Prison of Joseph, 23 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 m (NMP 92000 [B]), Sheikh Ali, 15–20 km N of Aswan, 29 April 1984, leg. D. Osborn. – 2 ma, 1 fs (IVB field Nos. EG 198, 199 [S+B]), EG 200 [S]), Thebes, Valley of the Kings, a tomb, 30 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 3 inds. (NMP 91982 [S+A], 91991, 91992 [B]), 13 juveniles (NMP [unnumbered] [A]), Egypt [undef.], leg. J. Groschaft.

### *Taphozous nudiventris* Cretzschmar, 1830

2 m, 2 f, 10 inds. (NMP 91965, 91966, 91968, 91971, 91973–91979 [S+A], 91972 [S], 91990, 91993 [S+B]), Abu Rawash, 18 October 1971, leg. B. Ryšavý (cf. Benda et al. 2006). – 1 ind. (NMP 91962 [S+A]), Abu Rawash, 15 June 1971, leg. J. Groschaft (cf. Benda et al. 2006). – 1 m, 1 f (NMP 91963, 91964 [S]), Abu Rawash, 17 June 1971, leg. J. Groschaft (cf. Benda et al. 2006). – 1 m, 1 ind. (NMP 91967, 91969 [S+A]), Abu Rawash, 10 July 1971, leg. J. Groschaft (cf. Benda et al. 2006). – 3 ma, 2 fa (IVB 29–33, field Nos. EG 16–20 [S+B]), Cairo, Sultan Mahmud Mosque, 21 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 4 inds. (NMP 91970, 91980, 91981 [S+A], [unnumbered] [A, without skull]), Giza, Abu Bur, pyramids, 15 September 1971, leg. B. Ryšavý (cf. Benda et al. 2006). – 1 fj (IVB 15, field No. EG 28 [S+K]), Giza, pyramids, 20 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 ma, 1 fa (IVB UJEP1.1.108, UJEP 1.1.109 [S+B]), Giza, pyramids, 22 June 1971, leg. J. Groschaft (cf. Benda et al. 2006). – 3 ma, 3 fa (IVB 22–25, 27, field Nos. EG 85, 87–90 [S+B], IVB 21, field No. 86 [B]), Karnak, the Great Temple, 26 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 fa (IVB 26, field No. EG 243 [S+B]), Karnak, the Great Temple, 1 May 1969, leg. J. Gaisler (cf. Gaisler et al. 1972).

### *Taphozous perforatus* Geoffroy, 1818

18 ma, 1 ms, 16 fa, 2 fs (IVB 1–29, field Nos. EG 160, 161, 164–170, 172–175, 178–184, 187–195 [S+B], IVB 30–37, field Nos. EG 162, 163, 171, 176, 177, 185, 186, 196 [S]), Thebes, Valley of the Qeens, tomb, 30 April 1969, leg. J. Gaisler (Gaisler et al. 1972).

### *Nycteris thebaica* (Geoffroy, 1803)

6 ma, 4 mj, 7 fa, 3 fs, 1 fj (IVB 4–7, field Nos. 114, 127, 130, 132 [S+B], IVB 8–24, field Nos. 113, 115–126, 128, 129, 131, 133 [S]), Dandara, Temple of Hathor, 27 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 2 fa (IVB 2, 3, field Nos. EG 79, 80 [S+B]), Karnak, the Great Temple, 26 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 fs (IVB 1, field No. EG 244 [S+B]), Karnak, the Great Temple, 1 May 1969, leg. J. Gaisler (cf. Gaisler et al. 1972).

### *Rhinolophus clivosus* Cretzschmar, 1830

1 m (NMP 91987 [S+B]), W of Abu Rihal, 90 km E of Idfn Shalatein, date & collector unlisted. – 1 ma (NMP 91994 [S]), Abu Rawash, 15 April 1959, leg. H. Roer. – 2 m, 1 f (IVB UJEP1.1.103–1.1.105 [S+K]), Giza, pyramids, 20 June 1971, leg. J. Groschaft.

### *Asellia tridens* (Geofrroy, 1813)

8 ma, 8 ms, 4 fs (IVB 10–28, field Nos. EG 93–106, 109–112 [S+B], IVB 28, 29, field Nos. EG 107, 108 [S]), Dandara, Temple of Hathor, 27 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 ms, 1 fa, 2 fs (IVB 62–64, field Nos. EG 254–256 [S+B], IVB 65, field No. EG 253 [S]), El Kharga Oasis, Necropolis of El Bagawat (City of Deads), 6 May 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 ma, 1 ms, 8 fa (IVB 52–55, 57–61, field Nos. EG 257–265 [S+B], IVB 56, field No. EG 266 [S]), El Kharga Oasis, Temple of Hibis, 6 May 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 2 fs (IVB 66, 67, field Nos. EG 241, 242 [S+B]), Karnak, the Great Temple, 1 May 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 fa, 3 fs (NMP 90351, 90352, 90354 [S+A], 90353 [A]), Siwa Oasis, Shali, 12 April 2002, leg. P. Munclinger & P. Nová (cf. Benda et al. 2006). – 21 ma, 1 ms (IVB 30–37, 41–50, field Nos. EG 204–221 [S+B], IVB 38–40, 51, field Nos. EG 201–203, 222 [S]), Thebes, Deir El Medina, tomb, 30 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 13 f (NMP [unnumbered] [A]), Egypt [undef.], date & collector unlisted.

### *Pipistrellus kuhlii* (Kuhl, 1817)

2 ma (IVB 2, 3, field Nos. EG 1, 2 [S+B]), Abu Rawash, 19 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 ma (IVB 4, field No. EG 275 [S+B]), Burgh el Arab, 14 May 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 5 fa, 2 ms, 3 fa (NMP 90534–90536 [S+A], 90537–90542 [A], NMP [unnumbered, field No. pb2905] [A]), San El Hagar El Gibiliya (Sharqira Prov.; 30° 57' N, 31° 55' E; 5 m a. s. l.), 20 September 2005, leg. M. Andreas, P. Benda, J. Hotový & R. Lučan.

### *Pipistrellus deserti* Thomas, 1902

2 fa (IVB 15, 16, field Nos. EG 91, 92 [S+B]), Luxor, hotel garden, 26 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 ma, 3 fa, 1 fs (IVB 6–10, field Nos. EG 148–151, 153 [S+B]), Luxor, hotel garden, 27 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 1 fs (IVB 11, field No. EG 152 [S+B]), Luxor, hotel garden, 28 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 3 fa (IVB 12–13, field Nos. EG 157–159 [S+B]), Luxor, hotel garden, 29 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972). – 4 fa, 1 fs (IVB 1–5, field Nos. EG 245–248, 250 [S+B]), Luxor, hotel garden, 1 May 1969, J. Gaisler (cf. Gaisler et al. 1972).

### *Otonycteris hemprichii* Peters, 1859

1 f, 2 inds. (NMP 91983 [S+A], 91989 [S+B], 91988 [B]), 1 mj, 1 fj (NMP [unnumbered] [A]), Abu Rawash, 19 July and 18 October 1971, leg. J. Groschaft & B. Ryšavý (cf. Benda et al. 2006). – 4 f (NMP 91984, 91985, 92109 [S+A], 91986 [S+B]), 5 mj (NMP [unnumbered] [A]), El Faiyum, 25 July 1971, leg. B. Ryšavý (cf. Benda et al. 2006).

### *Plecotus christii* Gray, 1838

1 ma (NMP 90119 [S+B]), Bir Kohila, Qattar Mts, 30 May 1984, leg. D. Osborn (cf. Osborn 1988 [Benda et al. 2004, 2006 mentioned erroneous date of collection, identical with the next specimen]). – 1 m (NMP 90118 [S+B]), Bir Nagat, Qattar Mts, 4 June 1984, leg. D. Osborn (cf. Osborn 1988). – 1 ma (IVB 100, field No. EG 197 [S+B]), Thebes, Valley of the Kings, 30 April 1969, leg. J. Gaisler (cf. Gaisler et al. 1972).

### *Tadarida aegyptiaca* (Geoffroy, 1818)

5 m (NMP 91995–91999 [S+B]), Bir Kohila, Qattar Mts, 30 May 1984, leg. D. Osborn (cf. Osborn 1988). – 1 m (NMP 92001 [S+B]), Bir Nagat, Qattar Mts, 2 June 1984, leg. D. Osborn (cf. Osborn 1988).

## APPENDIX V
## Biometric data on the bats from Sinai

Basic external and cranial measurements of the examined bat individuals recorded in Sinai (pp. 100–103). For collection acronyms and measurement abbreviations see pp. 5, 6. Arranged in alphabetical and numerical orders, according to collection acronym and number and/or record sites name, date, sex and age. Part A (pp. 100, 101) contains the collected specimens, part B (pp. 102, 103) the released bats.

Appendix V. Part A, dimensions of collected specimens

| coll. No. | site | sex | age | LC | LCd | LAt | LA | LT/LaFE | G | LCr | LCb/c | LaZ | LaI | LaN | AN | CC | $M^3M^3$ | $CM^{2/3}$ | LMd | ACo | $CM_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rousettus aegyptiacus* | | | | | | | | | | | | | | | | | | | | | |
| NMP 90492 | Feiran | f | j | 124 | 14 | 84.0 | 19.1 | – | 69.0 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90501 | Feiran | m | a | 146 | 25 | 91.5 | 22.3 | – | 119.0 | 41.92 | 40.10 | 24.46 | 7.78 | 16.47 | 12.44 | 8.29 | 12.36 | 16.37 | 32.75 | 14.91 | 17.74 |
| NMP 90502 | Feiran | m | a | 142 | 16 | 93.2 | 22.2 | – | 114.0 | 41.13 | 39.48 | 24.74 | 7.69 | 16.33 | 12.91 | 8.23 | 12.69 | 16.16 | 32.56 | 15.69 | 17.38 |
| NMP 90503 | Feiran | m | a | 149 | 22 | 94.5 | 22.4 | – | 142.0 | 43.66 | 41.47 | 27.33 | 8.59 | 17.91 | 13.24 | 8.73 | 13.30 | 16.99 | 33.82 | 16.17 | 18.44 |
| NMP 90504 | Feiran | m | a | 138 | 19 | 95.4 | 22.7 | – | 125.0 | 42.57 | 41.02 | 25.48 | 7.82 | 16.98 | 12.61 | 8.08 | 12.42 | 16.74 | 33.49 | 14.73 | 18.18 |
| NMP 90505 | Feiran | m | a | 144 | 18 | 91.0 | 22.7 | – | 117.0 | 40.41 | 38.91 | 25.58 | 8.10 | 16.48 | 12.43 | 8.84 | 12.36 | 15.62 | 31.38 | 15.43 | 16.72 |
| NMP 90506 | Feiran | f | G | 131 | 19 | 89.0 | 20.8 | – | 122.0 | 38.91 | 37.57 | 24.24 | 7.61 | 16.08 | 12.63 | 7.82 | 12.01 | 14.91 | 30.08 | 14.28 | 16.08 |
| NMP 90507 | Feiran | f | G | 129 | 21 | 87.0 | 21.1 | – | 103.0 | 39.42 | 37.53 | 24.24 | 7.34 | 16.02 | 11.91 | 7.98 | 11.92 | 15.61 | 30.71 | 14.27 | 16.32 |
| NMP 90508 | Feiran | f | G | 136 | 20 | 91.7 | 20.7 | – | 116.0 | 40.91 | 39.34 | 23.48 | 7.19 | 16.02 | 11.56 | 8.17 | 11.84 | 16.27 | 32.13 | 14.37 | 17.46 |
| NMP 90509 | Feiran | f | a | 138 | 18 | 93.7 | 20.8 | – | 117.0 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90510 | Feiran | f | G | 135 | 21 | 92.1 | 21.0 | – | 127.0 | 40.31 | 39.10 | 24.44 | 7.68 | 16.15 | 12.29 | 8.07 | 11.84 | 15.16 | 31.24 | 14.78 | 16.64 |
| NMP 90511 | Feiran | f | a | 137 | 24 | 91.5 | 20.5 | – | 103.0 | 42.39 | 40.60 | 25.23 | 8.36 | 16.23 | 12.45 | 8.40 | 12.64 | 16.02 | 32.36 | 14.73 | 17.49 |
| NMP 90512 | Feiran | f | j | 129 | 21 | 87.7 | 20.1 | – | 87.2 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90513 | Feiran | f | j | 132 | 21 | 92.6 | 20.0 | – | 91.3 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90514 | Feiran | f | j | 120 | 18 | 83.2 | 20.2 | – | 68.8 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90515 | Feiran | f | j | 121 | 19 | 82.3 | 19.8 | – | 72.0 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90516 | Feiran | m | j | 119 | 20 | 84.0 | 21.6 | – | 61.0 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90517 | Feiran | f | j | 124 | 20 | 86.7 | 21.9 | – | 74.5 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90520 | Ain Hudra | m | a | 139 | 17 | 89.8 | 20.6 | – | 118.0 | 41.41 | 39.68 | 24.98 | 7.81 | 16.28 | 12.46 | 8.27 | 12.23 | 16.14 | 32.37 | 14.58 | 17.51 |
| NMP 90527 | Ain El Furtaga | m | a | 147 | 20 | 92.9 | 21.4 | – | 123.0 | 42.39 | 40.22 | 25.02 | 8.36 | 16.24 | 13.02 | 8.46 | 12.80 | 16.34 | 32.61 | 15.41 | 17.67 |
| NMP 90528 | Ain El Furtaga | f | G | 131 | 20 | 88.6 | 20.1 | – | 126.0 | 41.11 | 39.17 | 25.07 | 7.93 | 16.93 | 12.91 | 7.97 | 12.54 | 15.97 | 32.07 | 14.18 | 17.17 |
| *Rhinolophus clivosus* | | | | | | | | | | | | | | | | | | | | | |
| CDIS 948 | Feiran | f | s | – | – | 49.4 | – | – | 10.1 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90498 | Feiran | f | a | 57 | 35 | 48.2 | 23.5 | 7.7 | 8.5 | 20.53 | 17.38 | 10.09 | 2.12 | 8.19 | 5.88 | 5.27 | 7.24 | 7.12 | 13.08 | 3.47 | 7.61 |
| *Eptesicus bottae* | | | | | | | | | | | | | | | | | | | | | |
| CDIS 947 | Feiran | m | a | – | – | 41.0 | – | – | 6.3 | – | – | – | – | – | – | – | – | – | – | – | – |
| *Hypsugo ariel* | | | | | | | | | | | | | | | | | | | | | |
| CDIS 945 | El Arbaein | m | a | – | – | 30.6 | – | – | 3.0 | 11.79 | 11.41 | 7.04 | 2.72 | 5.65 | 6.21 | 3.61 | 4.73 | 4.06 | 7.82 | 2.21 | 4.28 |
| CDIS 946 | Ain Hudra | m | a | – | – | 28.8 | – | – | 3.1 | 11.46 | 10.94 | 6.84 | 2.81 | 5.63 | 6.12 | 3.41 | 4.63 | 3.89 | 7.75 | 2.12 | 4.11 |
| NMP 90493 | Feiran | m | s | 39 | 36 | 30.7 | 13.3 | 5.0 | 2.4 | 11.39 | 10.92 | 7.02 | 2.62 | 5.51 | 3.89 | 3.23 | 4.73 | 3.94 | 7.81 | 2.33 | 4.12 |
| NMP 90494 | Feiran | f | a | 42 | 39 | 32.4 | 13.3 | 5.0 | 2.8 | 11.65 | 11.13 | 7.21 | 2.63 | 5.73 | 3.96 | 3.44 | 4.69 | 3.77 | 8.01 | 2.36 | 4.36 |
| *Otonycteris hemprichii* | | | | | | | | | | | | | | | | | | | | | |
| NMP 90495 | Feiran | f | a | 78 | 55 | 62.6 | 45.7 | 19.4 | 18.2 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90500 | Feiran | m | a | 77 | 54 | 60.6 | 43.9 | 18.2 | 19.2 | 22.41 | 21.22 | 13.94 | 4.16 | 9.87 | 7.23 | 5.96 | 9.43 | 8.27 | 15.98 | 7.03 | 9.09 |

Appendix V. (continued) Part A, dimensions of collected specimens

| coll. No. | site | sex | age | LC | LCd | LAt | LA | LT | G | LCr | LCb/c | LaZ | LaI | LaN | AN | CC | $M^3M^3$ | $CM^{2/3}$ | LMd | ACo | $CM_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Barbastella leucomelas* | | | | | | | | | | | | | | | | | | | | | |
| CDIS 941 | El Migla | f | a | – | – | 39.8 | – | – | 6.5 | 13.96 | 13.14 | 7.28 | 3.43 | 3.82 | 6.76 | 3.38 | 5.39 | 4.32 | 8.84 | 2.42 | 4.86 |
| CDIS 942 | El Migla | f | a | – | – | 39.9 | – | – | 6.0 | 14.03 | 13.15 | 7.19 | 3.38 | 3.84 | 6.88 | 3.51 | 5.36 | 4.41 | 8.67 | 2.42 | 4.83 |
| NMP 90521 | Ain Hudra | m | a | 49 | 49 | 38.1 | 19.4 | 8.4 | 6.1 | 13.88 | 12.91 | 7.19 | 3.57 | 6.89 | 5.27 | 3.43 | 5.19 | 4.37 | 8.63 | 2.38 | 4.81 |
| NMP 90522 | Ain Hudra | m | a | 51 | 53 | 38.0 | 19.5 | 8.8 | 7.3 | 14.08 | 13.02 | 7.36 | 3.47 | 6.92 | 5.35 | 3.44 | 5.23 | 4.47 | 8.70 | 2.43 | 4.86 |
| *Plecotus christii* | | | | | | | | | | | | | | | | | | | | | |
| CDIS 943 | Ain Hudra | m | a | – | – | 38.8 | – | – | 5.3 | – | – | – | – | – | – | – | – | – | – | – | – |
| CDIS 944 | Ain Hudra | m | a | – | – | 39.7 | – | – | 6.3 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90496 | Feiran | m | a | 51 | 54 | 41.0 | 39.1 | 18.1 | 6.9 | 17.13 | 16.12 | 8.67 | 3.19 | 8.49 | 5.11 | 3.58 | 4.96 | 5.74 | 10.77 | 3.08 | 6.14 |
| NMP 90497 | Al Migla | f | s | 52 | 53 | 39.5 | 39.2 | 19.6 | 6.4 | 17.12 | 16.02 | 8.76 | 3.27 | 8.26 | 5.09 | 3.64 | 6.20 | 5.84 | 10.75 | 3.24 | 6.37 |
| NMP 90499 | Feiran | m | a | 51 | 50 | 39.5 | 38.9 | 17.8 | 6.3 | 16.82 | 15.66 | 8.41 | 3.19 | 7.98 | 5.10 | 3.59 | 5.92 | 5.59 | 10.52 | 3.08 | 5.93 |
| NMP 90518 | El Tur | m | a | 50 | – | 40.2 | 39.0 | 18.6 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90519 | El Tur | f | a | 50 | 54 | 40.5 | 39.9 | 18.6 | 6.3 | 16.66 | 15.59 | 8.52 | 3.37 | 7.96 | 5.33 | 3.63 | 6.24 | 5.54 | 10.38 | 3.03 | 5.97 |
| NMP 90523 | Ain Khudra | m | a | 51 | 53 | 39.1 | 38.3 | 18.3 | 6.3 | 16.57 | 15.57 | 8.47 | 3.38 | 8.01 | 5.18 | 3.67 | 5.95 | 5.63 | 10.36 | 2.96 | 5.94 |
| NMP 90533 | Ain Sudr | f | a | 52 | 54 | 41.3 | 40.2 | 19.1 | 6.7 | 17.18 | 15.89 | 8.61 | 3.15 | 7.94 | 5.07 | 3.68 | 6.14 | 5.66 | 10.73 | 3.11 | 6.13 |
| *Tadarida teniotis* | | | | | | | | | | | | | | | | | | | | | |
| NMP 90524 | Ain El Furtaga | m | s/a | 94 | 50 | 59.7 | 34.3 | 7.5 | 31.3 | – | – | – | – | – | – | – | – | – | – | – | – |
| NMP 90525 | Ain El Furtaga | m | a | 91 | 49 | 60.2 | 33.8 | 8.2 | 29.8 | 24.04 | 23.53 | 14.18 | 4.57 | 11.54 | 7.31 | 5.62 | 9.23 | 9.12 | 16.89 | 3.97 | 9.53 |
| NMP 90526 | Ain El Furtaga | m | a | 93 | 47 | 60.3 | 33.5 | 8.6 | 33.7 | 24.32 | 23.92 | 14.35 | 4.79 | 11.64 | 7.55 | 5.62 | 9.75 | 9.26 | 17.02 | 4.17 | 9.80 |
| NMP 90529 | Ain El Furtaga | m | a | 94 | 53 | 64.3 | 35.8 | 6.5 | | 24.25 | 23.45 | 14.27 | 4.58 | 11.71 | 7.59 | 5.53 | 9.14 | 8.91 | 16.71 | 4.13 | 9.63 |
| NMP 90530 | Ain El Furtaga | m | a | 95 | 52 | 62.1 | 35.4 | 6.9 | 28.8 | 23.77 | 23.30 | 14.38 | 4.63 | 11.22 | 7.36 | 5.57 | 9.47 | 8.98 | 16.80 | 3.91 | 9.68 |
| NMP 90531 | Ain El Furtaga | m | a | 92 | 53 | 62.0 | 37.0 | 7.7 | 30.9 | 24.38 | 23.76 | 15.06 | 4.75 | 12.09 | 7.74 | 6.13 | 10.01 | 9.12 | 17.56 | 4.29 | 9.73 |
| NMP 90532 | Ain El Furtaga | m | a | 94 | 50 | 61.0 | 35.5 | 6.6 | 30.0 | 24.27 | 23.51 | 14.35 | 4.88 | 11.57 | 7.41 | 5.49 | 9.19 | 9.01 | 16.86 | 4.11 | 9.66 |

Appendix V (continued). Part B. dimensions of released bats

| site | date | sex | age | LAt | G | site | date | sex | age | LAt | G |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rousettus aegyptiacus* | | | | | | | | | | | |
| Ain Hudra | 04/08/2005 | f | a | 90.4 | 108.5 | Ain Hudra | 16/09/2005 | f | G | 88.4 | 131.0 |
| Ain Hudra | 16/09/2005 | f | j | 90.6 | 104.0 | Ain Hudra | 16/09/2005 | f | j | 85.4 | 86.1 |
| Ain Hudra | 16/09/2005 | m | a | 92.6 | 131.0 | Ain Hudra | 16/09/2005 | m | a | 95.3 | 136.0 |
| Ain Hudra | 16/09/2005 | m | a | 93.5 | 121.0 | Ain Hudra | 16/09/2005 | m | a | 90.7 | 118.0 |
| Ain Hudra | 17/09/2005 | f | G | 92.0 | 131.0 | Ain Hudra | 17/09/2005 | f | G | 89.6 | 128.0 |
| Ain Hudra | 17/09/2005 | f | j | 81.3 | 70.3 | Ain Hudra | 17/09/2005 | m | a | 92.3 | 104.0 |
| Ain Hudra | 17/09/2005 | m | a | 92.5 | 92.2 | Ain Hudra | 17/09/2005 | m | a | 93.6 | 131.0 |
| Ain Hudra | 17/09/2005 | m | a | 92.7 | 109.0 | Feiran | 10/08/2005 | f | a | 88.7 | 135.0 |
| Feiran | 10/08/2005 | f | a | 93.4 | 108.0 | Feiran | 10/08/2005 | f | j | 83.9 | 102.0 |
| Feiran | 10/08/2005 | m | a | 92.2 | 108.0 | Feiran | 10/08/2005 | m | a | 95.0 | 118.0 |
| Feiran | 10/08/2005 | m | a | 89.9 | 113.0 | Feiran | 10/08/2005 | m | a | 94.4 | 141.0 |
| Feiran | 10/08/2005 | m | a | 97.8 | 140.0 | Feiran | 10/08/2005 | m | j | 87.7 | 114.0 |
| Feiran | 10/09/2005 | f | a | 89.7 | 91.2 | Feiran | 10/09/2005 | f | G | 91.8 | 114.0 |
| Feiran | 10/09/2005 | f | G | 92.5 | 121.0 | Feiran | 10/09/2005 | f | G | 95.3 | 121.0 |
| Feiran | 10/09/2005 | f | G | 92.3 | 122.0 | Feiran | 10/09/2005 | f | j | 82.5 | 66.2 |
| Feiran | 10/09/2005 | f | j | 79.2 | 60.8 | Feiran | 10/09/2005 | f | j | 79.9 | 55.8 |
| Feiran | 10/09/2005 | f | j | 79.5 | 57.7 | Feiran | 10/09/2005 | f | j | 89.8 | 97.0 |
| Feiran | 10/09/2005 | m | a | 90.3 | 124.0 | Wadi Itfah | 03/08/2006 | f | j | 75.8 | – |
| Wadi Klar | 01/08/2006 | f | j | 81.8 | – | Wadi Klar | 01/08/2006 | f | j | 81.0 | – |
| Wadi Klar | 01/08/2006 | f | j | 73.8 | – | Wadi Shagg | 27/07/2006 | f | a | 76.8 | – |
| *Rhinolophus clivosus* | | | | | | | | | | | |
| Wadi Klar | 29/07/2006 | f | a | 49.1 | 9.8 | Wadi Klar | 29/07/2006 | f | j | 46.6 | 6.3 |
| Wadi Klar | 02/08/2006 | f | a | 48.9 | 9.5 | Wadi Klar | 02/08/2006 | f | j | 49.1 | 7.5 |
| Wadi Klar | 04/08/2006 | f | a | 49.8 | 11.0 | Wadi Klar | 04/08/2006 | f | L | 51.0 | 10.8 |
| *Rhinolophus hipposideros* | | | | | | | | | | | |
| Sheikh Awad | 17/08/2005 | f | s | 36.7 | 3.5 | Sheikh Awad | 17/08/2005 | m | s | 36.0 | 3.4 |
| Sheikh Awad | 12/07/2007 | f | a | 37.5 | 4.5 | Sheikh Awad | 12/07/2007 | m | j | 36.3 | 3.0 |
| Wadi Klar | 02/08/2006 | f | a | 36.7 | 3.8 | Wadi Klar | 02/08/2006 | m | j | 36.1 | 3.5 |
| *Eptesicus bottae* | | | | | | | | | | | |
| El Milga | 03/07/2006 | m | a | 43.9 | 8.8 | Wadi Nasb | 29/06/2006 | m | a | 44.5 | 9.0 |
| Wadi Nasb | 29/06/2006 | m | a | 42.7 | 9.0 | | | | | | |
| *Hypsugo ariel* | | | | | | | | | | | |
| Ain Hudra | 05/08/2005 | f | s | 32.4 | 2.8 | Ain Hudra | 04/07/2006 | m | a | 31.1 | 3.0 |
| Sheikh Awad | 19/07/2006 | f | a | 31.9 | 2.8 | Sheikh Awad | 19/07/2006 | f | j | 30.9 | 2.3 |
| Sheikh Awad | 20/07/2006 | f | L | 32.5 | 4.0 | Wadi Kid | 18/07/2007 | f | j | 30.2 | 2.0 |
| Wadi Kid | 18/07/2007 | f | j | 32.3 | 2.7 | Wadi Kid | 19/07/2007 | m | a | 31.8 | 3.0 |
| Wadi Marrar | 11/07/2006 | m | a | 30.0 | 2.8 | Wadi Nasb | 22/07/2006 | f | a | 31.3 | 3.0 |
| Wadi Sulaf | 10/07/2007 | f | a | 32.0 | 3.5 | | | | | | |
| *Otonycteris hemprichii* | | | | | | | | | | | |
| Wadi Nasb | 29/06/2006 | m | a | 64.0 | 20.0 | Wadi Nasb | 22/07/2006 | m | a | 64.0 | 18.5 |
| Wadi Sulaf | 10/07/2007 | m | s | 61.8 | 20.0 | Wadi Sulaf | 10/07/2007 | m | s | 61.9 | 15.0 |
| Wadi Sulaf | 10/07/2007 | m | s | 60.9 | 15.5 | | | | | | |
| *Barbastella leucomelas* | | | | | | | | | | | |
| El Milga | 08/07/2007 | m | a | 38.9 | 7.3 | | | | | | |

Appendix V (continued). Part B. dimensions of released bats

| site | date | sex | age | LAt | G | site | date | sex | age | LAt | G |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Plecotus christii* | | | | | | | | | | | |
| Ain Hudra | 04/08/2005 | m | a | 38.8 | 5.3 | Ain Hudra | 05/08/2005 | f | a | 40.6 | 6.0 |
| Ain Hudra | 05/08/2005 | m | a | 38.4 | 5.8 | Ain Hudra | 10/08/2005 | m | a | 41.3 | 5.1 |
| Ain Hudra | 10/08/2005 | m | a | 40.5 | 7.4 | Ain Hudra | 10/08/2005 | m | a | 40.2 | 5.8 |
| Ain Hudra | 11/08/2005 | m | s | 39.2 | 6.3 | Ain Hudra | 05/07/2007 | f | a | 40.3 | 7.5 |
| El Milga | 08/07/2007 | m | a | 39.2 | 6.5 | Sheikh Awad | 17/08/2005 | f | a | 40.1 | 5.2 |
| Wadi Gebal | 07/08/2005 | f | a | 40.6 | 6.2 | Wadi Gebal | 07/08/2005 | f | a | 39.7 | 5.8 |
| Wadi Kid | 19/07/2007 | m | a | 40.0 | 6.0 | Wadi Marra | 13/07/2006 | f | L | 39.3 | 6.3 |
| Wadi Nasb | 28/06/2006 | m | a | 41.6 | 6.3 | Wadi Shagg | 26/07/2006 | f | a | 40.8 | 6.3 |
| Wadi Shagg | 26/07/2006 | m | a | 40.2 | 6.8 | | | | | | |