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PRELIMINARY STUDY OF HABITAT-RELATED BAT FAUNA OF MASTOUTA-BISHSHOUK REGION (NORTHWEST TUNISIA)

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Preliminary Study of Habitat-Related Bat Fauna of Mastouta-Bishshouk Region (Northwest Tunisia). Dalhoumi, R., Nefla, A., Bedoui, W., Ouni, R., Aissa, P., Aulagnier, S. — In order to define appropriate conservation measures in northern Tunisia we surveyed the bat fauna of Mastouta-Bishshouk region in both roosting sites and foraging areas. A total of 11 species was recorded. We found only three occupied roosts including a maternity colony of *Rhinolophus ferrumequinum, Miniopterus schreibersii* and *Myotis cappacinii* in a train abandoned tunnel. A tunnel of water channel hosted *Rhinolophus mehelyi*, *M. schreibersii* and *M. punicus*. Echolocation calls were recorded at a bridge over Beja Wadi, at an artificial basin, and in crop fields. Bat activity was the highest at the bridge in late March, and null in the harvested crop fields in late August. *Pipistrellus kuhlii* was the most active bat species in the three sites, *Pipistrellus pipistrellus* was the second most active species, followed by *Eptesicus isabellinus*. *Plecotus gaisleri* and *Myotis punicus* were detected only once at the bridge and the basin respectively. This bat assemblage is representative of the bat fauna of northern Tunisia. Roost and foraging area surveys strongly benefit acoustic recording, even in winter when some bats remain active. The rare local underground roosts should be protected from human disturbance and the water quality of Majerda Wadi should be improved.
Key words. Chiroptera, water, tunnel, Mediterranean, North Africa.

Introduction

Terrestrial organisms live in an environment that is subject to profound rhythmic alteration including a daily alternation of light and darkness that affects their circadian activity (Erkert, 1982). As strictly nocturnal animals, bats need a roost where they can rest during the day, fulfilling their physiological demands and safe from predators (Findley, 1993; Neuweiler, 2000). They also need foraging areas related to their dietary diversity to be visited during the night (Altringham, 2011). Then roosting habits and feeding ecology require different complementary habitats, influencing local and global distribution of bats (Altrigham, 2011). So conservation efforts should target both roosting and foraging habitats. Before the use of ultrasound detection that enabled field identification of foraging bats, most studies relied on identifying and counting bats in their roost in Europe (Racey, 1998), and in all other parts of the World.

In Tunisia, since the first data published by Hartmann (1868), the bat fauna has been sporadically investigated (see Dalhoumi et al., 2011). In northern Tunisia, most data come from direct observations in a small number of roost sites (Blanc, 1935; Cockrum, 1976; Deleuil & Labbe, 1955; Gadeau de Kerville, 1908; Noblet & Nefzi, 1991). Among the most recent studies in northern Tunisia, Zava & Masseti (2007) listed eight bat species in El Feidja National Park during an expedition in late May 2000 and Puechmaille et al. (2012) reported 14 bat species in the northern part of Tunisia as the result of expeditions between May 2008 and July 2012. None of these surveys provide information on habitat use by bats. The first data from acoustic sampling were reported by Rebelo & Brito (2006) who focused on bat activity in Saharan areas. Then, Puechmaille et al. (2012) used acoustic sampling to survey Tunisian bat fauna. More recently, and for the first time, Dalhoumi et al. (2014, 2016, 2017 a, b) studied the seasonal patterns of bat activity and habitat use in central Tunisia. However the later studies have been conducted in arid zones whereas northern Tunisia is mainly an agricultural land occupied by crop fields. Natural vegetation is confined to high hills and mountain regions. During the last decade and particularly after the political turmoil of 2011, natural habitats suffered serious degradations caused by intensification of land use, extensive stockbreeding, cutting and burning of forests that destroyed 2000 ha in 2012 (Chriha & Sghari, 2013). These damages resulted in fragmenting natural habitats which may be detrimental to certain bat species using linear features connecting foraging areas (Russ & Montgomery 2002). They might have altered the trophic organization of communities (Hill et al., 2011), affected the activity level of many bats species (Bright, 1993), and even led to a decline of other ones (Castro & Michalski, 2014; Wickramasinghe et al., 2003).

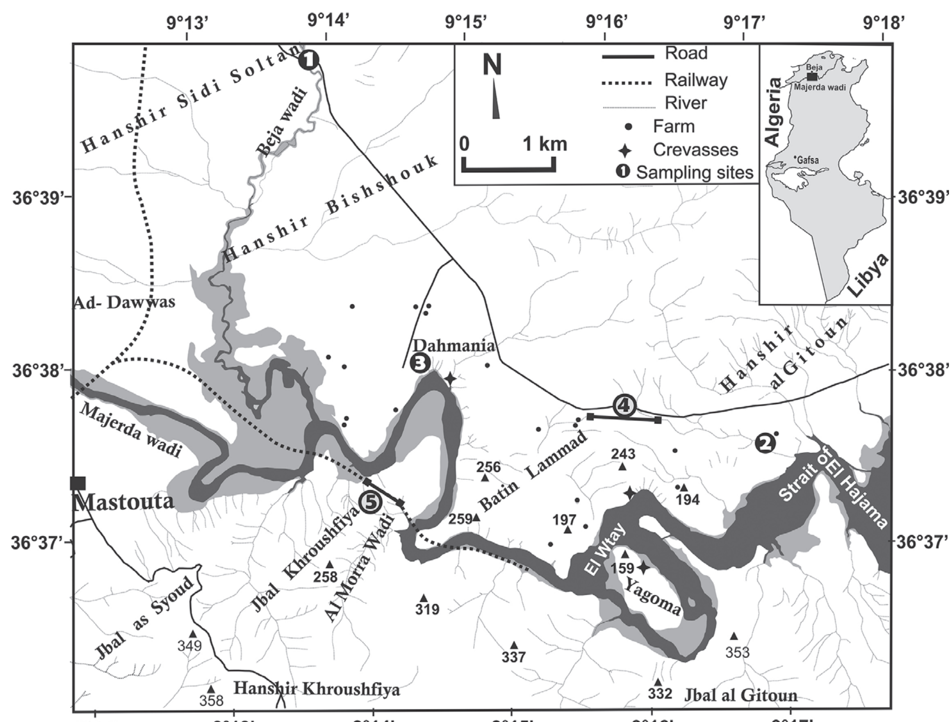

Fig. 1. Bat sampling sites in the Mastouta-Bishshouk region (Beja, Northwest Tunisia). 1 — Bridge of Beja Wadi, 2 — Artificial basin, 3 — Crop fields, 4 — Tunnel of water channel, 5 — Train abandoned tunnel.

In order to define appropriate conservation measures for bats in northern Tunisia, we surveyed the area along the Majerda Wadi to locate roosts, and investigated for the first time three sites corresponding to three foraging habitat types.

Study area

The study was conducted in Mastouta-Bishshouk region (Beja governorate, Tunisia) (fig. 1) on the western part of the freshwater lake of Sidi Salem Dam that was built in 1981 across the Majerda Wadi. The main habitat types are wetlands crossed from east to west by Majerda Wadi surrounded by a mosaic of crop fields and human settlements in the plain, Mediterranean shrublands and woodlands on top of hills up to 300–350 m high; the area also includes cliffs, rocky habitats, water springs and wadis. The natural vegetation is restricted to wetlands with *Phragmites communis*, *Tamarix africana*, *Typha latifolia*, *Scirpus maritimus* and *Joncus maritimus*, river banks with *Acacia cyclops*, and top of the hills with *Rosmarinus officinalis*, *Calycotoma vilosa*, *Thymus capitatus*, *Pinus* spp. and *Cupressus sempervirens*. The plains and low hills are occupied by cereal fields. The climate is semi-arid with monthly mean temperature ranging from 10 to 30 °C, and an average annual rainfall of 500 mm.

Material and methods

Bats were surveyed in March 2016, August 2016 and February 2017 in order to sample both winter and summer assemblages by roost search and foraging habitat investigation.

Roost survey

We visited two tunnels and various caves in the study area. The tunnel of water channels (about 1 km long) was inspected only in late February 2017 when its northwestern entrance was closed by straw bales. Some specimens were captured and identified using Dietz et al. (2007) and Aulagnier et al. (2009) and immediately released. The train abandoned tunnel (about 300 m in length) was inspected only in late August 2016 when the soil was dry following the unusual low level of Majerda Wadi during this summer. Echolocation calls of roosting bats were recorded during a night and a diurnal visits in August 2016, at their emergence from the northern entrance. In February 2017, they were recorded using a SM2+ bat detector (Wildlife Acoustics, Inc. Concord, Massachusetts, U.S.A.) and identified as previously described.

Foraging habitat investigation

At each period, we recorded bat activity at one fixed point near the bridge of Baja Wadi, at the artificial basin near the strait of El Hajama, and along one transect of 300–400 m in crop fields near Dahmania (fig 1). Each of the nine sessions, one per period and site, started 15 min after sunset and lasted for 2 hours. Bat calls were detected and recorded with a D240x ultrasound detector (Pettersson Elektronik AB, Uppsala, Sweden) connected to a portable digital tape (Edirol R-09HR; Roland Corporation, Shanghai, China). Calls were subsequently analyzed using the software BatSound, v.3.10 (Petterson Electronik AB). We used a simple frequency of 44.100 samples/s with 16 bits/sample and selected a 512-pt FFT with a Hamming window for analysis (Russ, 1999). We counted one pass every 37.4 s (3.4 s: recording time of the bat detector; 34 s: recording time of the portable digital tape) for each individual. In February 2017 the SM2+ bat detector was also used at the artificial basin together with the active survey with the D240x.

Recorded calls were identified to species level using shape and several call parameters (Barataud, 2012). Echolocation calls of *Tadarida teniotis*, *Miniopterus schreibersii*, *Eptesicus isabellinus*, *Plecotus gaisleri*, *Pipistrellus kuhlii*, *Myotis punicus* and *Myotis capaccinii* were identified using reference calls collected in different places of Tunisia (mainly near Mastouta, and in Jbel Erwa, Bou Hedma, Jbel Mghilla and Dghoumous National Parks). According to Russo and Jones (2002), *Pipistrellus pipistrellus* was identified by their shallow FM/QCF calls at frequency of maximum energy of 46.9 ± 1.8 kHz. *Rhinolophus ferrumequinum* and *Rhinolophus hipposideros* were easily identified as they produced calls with a long constant frequency part differing by peak frequency, between 85 and 88 kHz for *R. ferrumequinum*, over 112 kHz for *R. hipposideros* (Puechmaille et al., 2012).

Activity (number of passes) among the three sites was compared within each session by a chi-square test.

Results

A total of 11 species was recorded in the study area, 3 in the tunnel of water channel, 5 in the train abandoned tunnel, whereas 4 were recorded at the bridge of Beja Wadi, 6 at the artificial basin, and 2 over the crop fields (table 1). Specific richness and bat activity varied according to site and season.

Roosting bats

Among the five subterranean sites reported in the study area, we found guano in the train abandoned tunnel (fig. 1), in the tunnel of water channel and in a crack on Yagouma's Island where no bat was observed in February 2017. A total of nine species were recorded. In the train abandoned tunnel, we detected echolocation calls of *Tadarida teniotis, Miniopterus schreibersii, E. isabellinus, P. kuhlii*, and *M. capaccinii* during a night pass and calls of *Rhinolophus ferrumequinum, M. schreibersii* and *M. capaccinii* during a diurnal pass in August 2016. We then found a maternity colony of *R. ferrumequinum, M. schreibersii* and *M. capaccinii* in several small cracks of this tunnel's ceiling. In February 2017 we captured *Rhinolophus mehelyi*, *M. schreibersii* and *M. punicus* in the tunnel of water channel, and the SM2+ bat detector recorded calls of *M. capaccinii, T. teniotis*, *M. schreibersii*, *E. isabellinus, P. kuhlii* and *R. hipposideros* at the northwestern entrance of the train abandoned tunnel.

Foraging bats

A total of 1073 echolocation calls were recorded during the whole sessions (table 1), and seven bat species were recorded. *P. kuhlii* was the most frequent and active species. It wasn't detected only in harvested fields of Hanshir Bishshouk (August 2016). *P. pipistrellus* was the second most active species and was reported particularly at the bridge of Baja Wadi together with *E. isabellinus*. Other species were rarely detected. Signals of *R. hipposideros*, *M. capaccinii* and *M. punicus* were recorded only near the artificial basin, and those of *P. gaisleri* only at the bridge (table 1).

Table 1. Acoustic activity of bats recorded at three sites of the Mastouta-Bishshouk region (Beja, Northwest Tunisia)

Date	March 2016			August 2016			February 2017			Total
Locality	Bridge	Basin	Fields	Bridge	Basin	Fields	Bridge	Basin	Fields	
R. ferrumequinum	–	–	–	–	–	–	–	–	–	0
R. hipposideros	–	2	–	-	–	–	–	–	–	2
R. mehelyi	–	–	–	–	–	–	–	–	–	0
T. teniotis	–	–	–	–	–	–	–	–	–	0
M. schreibersii	–	–	–	–	–	–	–	–	–	0
E. isabellinus	42	1	3	64	–	–	2	–	1	113
P. kuhlii	298	47	5	212	67	–	32	2	2	665
P. pipistrellus	128	2	–	143	–	-	10	–	–	283
P. gaisleri	2	–	–	–	–	–	–	–	–	2
M. capaccinii	–	1	–	–	–	–	–	–	–	1
M. punicus	–	7	–	–	–	–	–	–	–	7
Total	470	60	8	419	67	0	44	2	3	

Bat activity was higher at the bridge of Baja Wadi than in the other habitat types in March 2016 ($\chi^2 = 714.23$; d.f. = 2; $P < 0.001$), August 2016 ($\chi^2 = 625.42$; d.f. = 2; $P < 0.001$) and February 2017 ($\chi^2 = 70.33$; d.f. = 2; $P < 0.001$). In the three sessions signals of *P. kuhlii*, *P. pipistrellus* and *E. isabellinus* were recorded, supplemented by *P. gaisleri* in March only.

Bat activity was lower at the artificial basin: 30 contacts / h in March when *P. kuhlii* was again the most active bat followed by *M. punicus*. *E. isabellinus*, *R. hipposideros*, *M. capaccinii* and *P. pipistrellus*, 33 contacts / h in August and 1 contact / h in February of *P. kuhlii* only. However, during this last session the SM2+ Bat detector, recording overnight, detected calls of five species: *R. ferrumequinum*, *R. hipposideros*, *P. kuhlii*, *P. pipistrellus* and *M. capaccinii*.

Bat activity was very low in crop fields, 4 contacts / h of *P. kuhlii* and *E. isabellinus* in March, null in summer when they were harvested, 1.5 contacts / h of *P. kuhlii* and *E. isabellinus* in February.

Discussion

We report for the first time the presence of 11 bat species in Mastouta-Bishshouk region. Nine species were reported from roosts and seven from foraging areas. This supports the need to combine different sampling methods for inventory of bat communities (Flaquer et al., 2007). This bat richness is similar to the previous survey in Jebel Mghilla National Park (Dalhoumi et al., 2014), slightly lower than the more extensive monthly monitoring in Bou Hedma National Park (Dalhoumi et al., 2016), and clearly lower than the 19 bat species reported in Tunisia (Dalhoumi et al., 2011). Except *Plecotus gaisleri*, all the recorded species were reported in this northern part of Tunisia during the last decade (Puechmaille et al., 2012; Zava & Masseti 2007). As all the species of the genus *Plecotus* emit echolocation calls with low intensity they are hardly recorded by bat detectors (e.g. Barataud, 2012),

In roost surveys acoustic recording performed better than captures (7 species vs 5 species). These results confirm that combined methods are also required for bat inventories in roosts (Rnjak et al., 2017). However capture is necessary for a morphological identification when *Rhinolophus euryale* and/or *R. mehelyi* are present (Puechmaille et al., 2012) as the call frequencies of these two species overlap (Weid & von Helversen, 1987; Heller & von Helversen, 1989; Papadatou et al., 2008).

The train abandoned tunnel was the most important roost site found in the study area that lacks natural underground sites. The ceiling of this tunnel hosted a mixed maternity colony of *R. ferrumequinum*, *M. schreibersii* and *M. capaccinii*, confirming the breeding status of the later species in northern Tunisia (Dalhoumi et al., 2011). This tunnel is a roost preserved from human disturbance when the tunnel is flooded. On the contrary, the tunnel of water channel, which is frequently visited by local people and where we only found a little amount of faecal pellets, seems to be a temporary roost.

When foraging, bats were mainly recorded near water, crop fields being deserted after harvesting. High levels of bat activity at the bridge and the basin support previous studies that found higher foraging activity of bats over water than in adjacent habitats (Dalhoumi et al., 2014, 2016; Fukui et al., 2006; Hagen & Sabo, 2011; Grindal et al., 1999; Russo & Jones, 2003; Seibold et al., 2013). Water bodies are known to usually provide a higher density of insect prey than other habitat types (Fukui et al., 2006; Hagen & Sabo, 2011).

Pipistrellus kuhlii, *P. pipistrellus* and *Eptesicus isabellinus* were the most recorded species both in the three sampled sites and in the three surveys. *E. isabellinus* and *P. kuhlii* are the most widespread and the more common bat species in Tunisia (Dalhoumi et al., 2011; Puechmaille et al., 2012) and in the whole Northwest Africa (Aulagnier, 2013; Van

Cakenberghe & Benda, 2013). They were recorded in all sites in Jebel Mghilla National Park (Dalhoumi et al., 2014) and all sampled habitats in Bou Hedma National Park (Dalhoumi et al., 2017 a, b).

We recorded the highest level of activity in late March. The activity was still high in late August, a result contrasting with data from arid central Tunisia (Bou Hedma National Park) where bat activity declined during late summer (Dalhoumi et al., 2016). In late February, bat activity was very low, suggesting that most bats still hibernate according to previous records in caves of Djebel Zaghouan (Deleuil & Labbe, 1955). Such low winter activity was previously reported from northern Algeria (Gaisler, 1984) and Morocco (Aulagnier et al., 2017).

Our survey was conducted only at two seasons and during a few days, so this bat assemblage could be larger if we consider the more recent checklists for northern Tunisia (Dalhoumi et al., 2011; Puechmaille et al., 2012). Three species could also be present in Mastouta-Bishshouk region: *Rhinolophus blasii*, *R. euryale* and *Myotis emarginatus* but these species were quite rarely reported in the country. Restricted so far to northern Tunisia and only reported in four localities (Puechmaille et al., 2012) due to the difficulty to locate roosts, *Hypsugo savii* has been detected at the dam and the mine of Beni Metir (Puechmaille et al., 2012), 40 km far from the study area. Its presence should be further investigated using passive ultrasound detectors near cliffs which offer potential roost to this species.

Apart from the habitat-related activity of bats in this part of Tunisia the main result of this survey is the discovery of a mixed maternity colony, including *M. capaccinii*, in the train abandoned tunnel. This site should require conservation attention as underground roosts of this size are rare in the region and most often suffer human disturbance. Obviously the flooding of the tunnel, except during exceptional drought, offers a natural protection to this roost, The water quality of Majerda Wadi should be improved as this river collect pesticides used in crop fields, factory and domestic sewerages.

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