Notes and records

Bat guild structure and habitat use in the Sahara desert

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Introduction

The Sahara is the largest desert in the world and comprises one of the most isolated areas. As such, few ecology works have been performed in this region, especially on bats (e.g. Benda, Hulva & Gaisler, 2004). Around 25 species of bats are known to occur in the Sahara, of which all, except one, are insectivorous and have the ability to echolocate (Le Berre, 1990). In this note, the results of a bat acoustic survey are presented, probably the first one in this region.

As water features are hotspots for insects, it is also likely that they are a limiting factor for the presence of bats. However, guild composition and bat presence in the different habitat types are still unclear.

Echolocating bats can be divided into guilds according to their preferred habitat and foraging behaviour, which are linked to the characteristics of echolocation calls (Siemers & Schnitzler, 2004). Moreover, echolocation guilds also give information about bats' ecological needs regarding, for example, size of insect prey and habitat complexity (Arita & Fenton, 1997; Aguirre *et al.*, 2002). Increasing the knowledge about bat guild composition in the Sahara could enhance understanding of how bats explore this low-resource area and how bat colonization occurred from the two surrounding biogeographic regions, the Mediterranean basin and the sub-Saharan Africa.

Materials and methods

This study was conducted in three countries (Tunisia, Libya and Niger) between September and October 2004. Three habitat types were sampled: oasis, *oued* (dry river beds) and desert (Fig. 1). Oases were characterized by the presence of ponds, canals and other water features (wells, lakes, etc.) surrounded by dense vegetation with tall trees (mainly palm trees and tamarisk). *Oueds* were sandy dry river beds usually surrounded by some vegetation, mainly acacia trees. Most of these rivers are now fossilized and surface water is only present after occasional rain. Desert comprised all desertic landscapes, namely, sand dunes (*Erg*), stony dry plains (*Hamada*) and arid steppes (*Reg*), where vegetation was scarce and water availability was very rare. Bat activity was surveyed with point transects in each habitat type with an ultrasound detector (D-240 Pettersson Elektronic, Uppsala, Sweden). Each transect consisted of three 5-min listening points. Each point was at least 100 m from the nearest listening point. Echolocation calls were recorded with a Sony WM-D6C tape recorder (Sony, Tokyo, Japan) and digitized afterwards using the sound analysis software BatSound v.3.1 (Pettersson Elektronic). From the sonograms, calls were classified into four guilds: FM (steep frequency modulated: includes species from the families Vespertilionidae and Nycteridae present in the region), CF (constant frequency: includes Rhinolophidae and Hipposideridae), QCF (quasi-constant frequency: includes Rhinopomatidae, Molossidae and Emballonuridae) and FM–QCF (only Vespertilionidae) based on Schnitzler, Moss & Denzinger (2003). Each bat pass consisted of a series of individual echolocation calls and the number of bat passes per transect was taken as a measure of bat activity (Vaughan, Jones & Harris, 1997). The phase of the moon was recorded. Statistical tests were performed with SPSS 14.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

A total of 188 bat passes were recorded in 21 transects: five in oases, eight in *oueds* and eight in desert. Moon phase did not affect bat activity (Spearman rank correlation coefficient $= -0.124$, $P = 0.297$). Differences between habitat types concerning bat activity were significant (Dunn's *post hoc* test, $P < 0.05$): oases were much more used as a foraging ground than any other habitat type, accounting for 75% of the registered bat passes. Nevertheless, bat activity in *oueds* was also considerably

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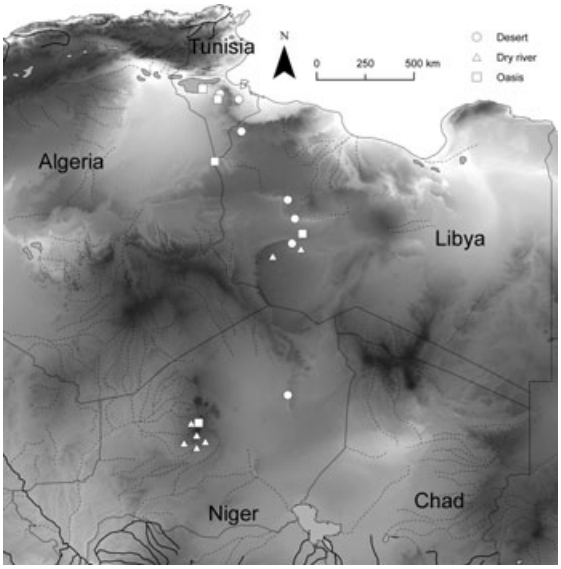

Fig 1 Location of sampling sites and habitat types

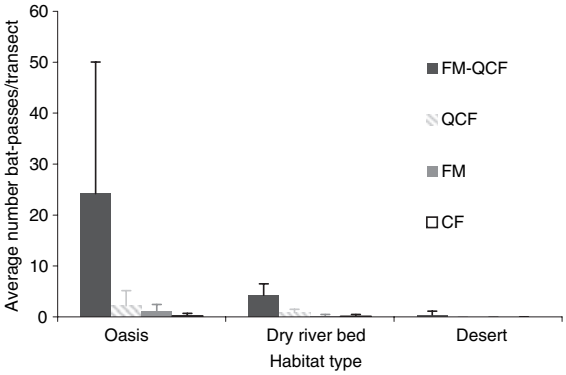

Fig 2 Guild average number of bat passes per transect in each habitat type. The vertical lines show the standard deviation. FM, steep frequency modulated; CF, constant frequency; QCF, quasi-constant frequency; FM–QCF, steep frequency modulated with a quasi-constant frequency end

registered (Kruskal-Wallis-ANOVA, $H = 14.34$, d.f. $= 2$, $P < 0.001$). Surprisingly, bat activity was also detected in desertic areas although at very low levels.

Vespertilionids were clearly the most abundant bats in surveyed habitats (KW-ANOVA, $H = 46.99$, d.f. $= 5$, $P < 0.0001$; Fig. 2) accounting for 84% of total bat passes, followed by rhinopomatids and molossids with 9.5% of all recordings. The other guilds together accounted for <5%. Only 2% of the echolocation calls were classified as not identified.

Discussion

The importance of water, as demonstrated by these results, is unsurprising. Water features are clearly a limiting factor for survival, thus affecting biodiversity distribution and abundance in the Sahara (Le Houérou, 1997). The development of diverse vegetation is also linked with insect diversity (Vaughan *et al.*, 1997) which constitutes the main prey for these bats. As such, bat abundance and diversity were also clearly associated with ecosystem complexity supported by the existence of water. These vegetated habitats seem to be key areas for bat conservation in the region.

Although the echolocation characteristics of each guild are different, there was no apparent selection for different habitat types, all guilds being more frequent in oases. However, different echolocation types will allow these guilds to explore different areas within the oases, as echolocations with stronger CF components (rhinopomatids, rhinolophids, hipposiderids, emballanorids and molossids) are more adapted to forage in open areas, whereas species with FM echolocations (nycterids and some vespertilionids) are more adapted to cluttered environments. Through different micro-habitat usage, these guilds may be avoiding competition (Siemers & Schnitzler, 2004). FM–QCF echolocations are highly plastic and associated with edge habitats; nevertheless, these species may adapt their calls to habitat spatial complexity. This could explain the presence of these bats in all habitat types, including remote desertic areas, demonstrating an ability to fly considerable distances into the desert. This implies these bats have high colonization potential.

The dominance of Vespertiolionidae contrasts with what was found in sub-Saharan landscapes, where molossids were clearly the dominant family with vesper bats accounting for no more than 10% of the recorded echolocations (Meyer, Schwarz & Fahr, 2004). On the other hand, Mediterranean countries are known to have vesper bats as the dominant family, especially from the *Pipistrellus* genus (Hulva *et al.*, 2004). In Europe, vesper bats seem to be highly adaptable being the most abundant and widespread bat group (Mitchell-Jones *et al.*, 1999). Moreover, their presence in dry and semi-dry environments (e.g. south Iberia and Mahgreb) shows that they are also well adapted to these type of conditions, giving them an advantage when competing with sub-Saharan bats for the Sahara colonization.

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References

AGUIRRE, L.F., HERREL, A., van DAMME, R. & MATTHYSEN, E. (2002) Ecomorphological analysis of trophic niche partitioning in a tropical savannah bat community. *Proc. R. Soc. B* **269,** 1271–1278.

ARITA, H.T. & FENTON, M.B. (1997) Flight and echolocation in the ecology and evolution of bats. *Trends Ecol. Evol.* **12,** 23–58.

BENDA, P., HULVA, P. & GAISLER, J. (2004) Systematic status of African populations of *Pipistrellus pipistrellus* complex (Chiroptera: Vespertilionidae), with a description of a new species from Cyrenaica, Libya. *Acta Chiropt.* **6,** 193–217.

HULVA, P., HORACEK, I., STRELKOV, P.P. & BENDA, P. (2004) Molecular architecture of *Pipistrellus pipistrellus/Pipistrellus pygmaeus* complex (Chiroptera: Vespertilionidae): further cryptic species and Mediterranean origin of the divergence. *Mol. Phylogenet. Evol.* **31,** 1023–1035.

LE BERRE, M. (1990) Faune du Sahara – Tome 2, Mammifères. R. Chabaud-Lechevallier, Paris.

LE HOUÉROU, H.N. (1997) Climate, flora and fauna changes in the Sahara over the past 500 million years. *J. Arid Environ.* **37,** 619–647.

MEYER, C.F.J., SCHWARZ, C.J. & FAHR, J. (2004) Activity patterns and habitat preferences of insectivorous bats in a West African forest–savanna mosaic. *J. Trop. Ecol.* **20,** 397–407.

MITCHELL-JONES, A.J., AMORI, G., BOGDANOWICZ, W., KRYSTUFEK, B., REIJNDERS, P.J.H., SPITZENBERGER, F., STUBBE, M., THIESSEN, J.B.M., VOHRALIK, V. & ZIMA, J. (Eds) (1999) The Atlas of European Mammals. Poyser-Academic Press, London.

SCHNITZLER, H., MOSS, C.F. & DENZINGER, A. (2003) From spatial orientation to food acquisition in echolocating bats. *Trends Ecol. Evol.* **18,** 386–394.

SIEMERS, B.M. & SCHNITZLER, H.-U. (2004) Echolocation signals reflect niche differentiation in five sympatric congeneric bat species. *Nature* **429,** 657–661.

VAUGHAN, N., JONES, G. & HARRIS, S. (1997) Habitat use by bats (Chiroptera) assessed by means of a broad-band acoustic method. *J. Exp. Biol.* **34,** 716–730.

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