Seasonal diet of *Asellia tridens* (Chiroptera: Hipposideridae) in North-Western Africa

H. E. LOUMASSINE¹,²*, F. MARNICHE³, F. BOUNACEUR¹, & S. AULAGNIER⁴

¹Equipe de recherche Biologie de la Conservation en Zones arides et Semi Arides, Faculté des Sciences de la Nature et de la Vie, Université Ibn Khaldoun, Tiaret, Algeria, ²Naturalia Environnement, Site AGROPARC, AVIGNON Cedex 9, France, ³Laboratoire de Zoologie, Ecole Nationale d’Études Supérieures Vétérinaires, Alger, Algeria, and ⁴Comportement et Ecologie de la Faune Sauvage, Institut National de la Recherche Agronomique, Université de Toulouse, Castanet-Tolosan cedex, France

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Abstract
The seasonal variations of the diet of the desert Trident leaf-nosed bat, *Asellia tridens*, were investigated using dropping analyses during the whole year 2015 in the Timimoun region, south-western Algerian Sahara. We identified one order of arachnids (Araneae) and ten orders of insects: Coleoptera, Hymenoptera, Diptera, Orthoptera, Mantodea, Hemiptera, Isoptera, Ephemeroptera, Blattodea and Odonata in a decreasing rank. Coleoptera (31.07%) were Carabidae, Curculionidae, Chrysomelidae, Tenebrionidae, Aphodidae, Scarabaeidae, and Histeridae. Hymenoptera (21.31%) were Formicidae, Myrmicidae and Vespidae, Diptera (13.78%) were Culicidae and Tabanidae, and Orthoptera (11.40%) were Acrididae and Gryllidae. The autumn-winter diet (October to December) included a large amount of Odonata, Scarabaeidae, Blattodea, Acrididae and Myrmicidae. The spring-summer diet (February to August) was characterized mainly by Chrysomelidae, Vespidae, Tenebrionidae, Aphodidae and Araneae. As other desert bat species *A. tridens* displays a combination of opportunism and selective predation depending on the abundance of insect groups.

Keywords: Desert, feeding ecology, season, Sahara, trident leaf-nosed bat

Background
Understanding foraging habitats and feeding behaviour of bats has become increasingly recognized as crucial for the conservation of many species (Dietz et al. 2007). Foraging behaviour and diet vary among bat species, even among insectivorous bats (e.g. Beck 1995; Vaughan 1997; Smirnov & Vekhnik 2014) depending on dental and cranial morphology, wing shape, echolocation call frequency and habitat (Neuweiler 2000; Altringham 2011; Weterings & Umpstonira 2014). Hill and Smith (1984) identified three general categories of foraging styles used by bats to capture insects: aerial insectivory, foliage gleanin9 and terrestrial acquisition. Alternate classifications were then suggested by, among others, Findley (1993), Patterson et al. (2003) and Denzinger and Schnitzler (2013) who suggested seven bat guilds from open-space aerial foragers to narrow-space passive/active foragers on the basis of foraging behaviour and echolocation signals. Studying the diet of 15 species of European bats, Smirnov and Vekhnik (2014) also identified seven, but different, guilds. Although insectivorous bats mainly feed on insects, some of them feed on spiders, crustaceans and even scorpions (Altringham 2011). Their diet differs both in space and time and changing it could reflect a change in strategy by the bats or different prey abundances (Fenton 1982), insectivorous bats being mainly opportunistic feeders (Fenton & Morris 1976).

The trident leaf-nosed bat, *Asellia tridens* (Geoffroy, 1813), is highly adapted to arid environments and the most common species in the arid and Saharan North Africa (Aulagnier 2013). This bat is widely spread from the Western Sahara and Sahel savannah to Pakistan...
through the Arabian Peninsula (Simmons 2005; Aulagnier 2013). It forages low by slow-hawking with rapid twists and turns and presumably by ground gleaning, but it was observed foraging around palm trees, buildings and over water (Jones et al. 1993; Whitaker et al. 1994; Dietz et al. 2007). A. tridens was recorded to feed mainly on medium-sized Coleoptera, Hymenoptera, Orthoptera, Diptera and Lepidoptera (Jones et al. 1993; Whitaker et al. 1994; Feldman et al. 2000; Benda et al. 2001, 2006, 2012, 2014; Whitaker & Yom-Tov 2002; Amichai et al. 2013; Žďárská 2013). Even if each of these authors did not survey for a long period and sometimes analysed a small number of samples (faeces or stomach), they reported important variations in diet, both locally from Gambia (Jones et al. 1993) to Iran (Benda et al. 2012), and seasonally from spring to autumn (Žďárská 2013). Identifying the main factor for these variations remains difficult, and no study was extended over a whole year, including winter when bats are still active [e.g. Koch-Weser (1984) in Burkina Faso, Aulagnier and Destre (1985) in Morocco).

In Algeria, A. tridens is quite common in caves, other underground shelters (e.g. subterranean irrigation channels), and buildings from the whole desert zone to the Saharan Atlas in the north (Kowalski & Rzebik-Kowalska 1991). So it was reported as one of the 16 mammal species in the Timimoun region (Boukhemza et al. 1994) where we found a colony of 300 bats which occupies the same underground cavity all year round. This finding allowed the opportunity to regularly collect droppings and study the seasonal variations of the diet of A. tridens in one locality. This is the first time that the feeding ecology of this bat species was monitored in North Africa. We hypothesized that, as most insectivorous desert species, A. tridens may have a broad diet and hunt prey depending on the seasonal cycle of insect species abundance.

Materials and methods

Study area

The study took place in El Hadj Guelmame oasis (N 29° 25’31.188”, E 0°16’35.976”), 18 km north of Timimoun (Adrar governorate, central Sahara). Annual rainfall in the study area is low (22.5 mm) and mainly occurs during winter and spring. The summer is dry and hot (mean temperature of the hottest month: 24.5°C, maximum: 46.0°C) (Allal-Benfekih 2006).

The area is a sandy landscape consisting of dunes of the Western Erg and palm groves. The dominant plant species is the date palm Phoenix dactylifera. In the oasis, the understory includes some fig trees Ficus sp., pomegranate trees Punica granatum, vineyards Vitis vinifera and Rosaceae (Karimi 2016). The ground is more or less covered by Aristida pungens, Danthonia forsklii, Phragmites communis, Arundo plinii, Panicum turgidium (Souttou 2010), vegetable crops and fodder plants. Outside the cultivated area, sandy banks are sprinkled with Euphorbia guyoniana; some acacia trees (Acacia arabica and A. raddiana) surviving in dry wadis and dayas. There, a monospecific colony of ca. 300 Asellia tridens was discovered in an underground cavity of an old castle, in the resort of Ksar Abdennour. The colony, females and males, roosted in the cavity all around the year.

Methods

The diet of Asellia tridens was investigated from 10 g of droppings (ca. 60) collected twice per month from January to December 2015 under both female and male colonies when they segregate inside the roost from March to July. A sheet of paper was placed underneath and removed each fifteen days to collect all droppings and store them dry in a tube. In the laboratory, they were soaked a few minutes in 70% ethanol to sterilize them and, after softening, spread individually, using two dissecting needles under a 40 × 10 binocular microscope. The content of each dropping was spread in a Petri dish and dried. The chitinous remains of arthropods were separated according to their form and colour in order to identify and count prey items under a microscope. We identified remains to the lowest taxonomical level possible with the aid of identification keys (McAney et al. 1991; Shiel et al. 1997) and the reference collection of the Superior National Veterinary School in Algiers (Zoology laboratory). Asellia tridens has strong jaws and powerful upper canines (Aulagnier 2013); arthropod remains in droppings are tiny and particularly difficult to identify at a taxonomic level under the family or even the order. Taxonomy follows Misof et al. (2014). For quantitative analyses, identifications were restricted to family (or order) level. Results were expressed in terms of relative frequency (% F), calculated as the ratio of the number of items for a taxon to the total number of items identified. We performed a Factorial Correspondence Analysis (FCA) on the two-week numbers of items for each taxon followed by a hierarchical classification on factorial co-ordinates of time variable using PAST 1.37 (Hammer et al. 2001) in order to identify
unsupervised seasonal patterns. This analysis identified subsequently two and four seasons that were compared using chi-square tests; the significance level was 0.05.

**Results**

**Annual diet**

We identified a total of 2806 items belonging to 10 insect and one arachnid orders (Table I), however insects dominated the faecal fragments as the 36 Araneae items accounted for only 1.28% of items. The most abundant order was Coleoptera (31.08%) which were mainly Carabidae (9.23%), Curculionidae (4.89%), Tenebrionidae (4.81%), Scarabaeidae (4.70%) and Aphodidae (4.13%). The main additional prey were Hymenoptera (21.31%) including Formicidae (13.22%), Myrmicidae (2.99%) and Vespidae (2.42%), Diptera (13.79%) with Culicidae (7.84%) and Tabanidae (5.97%), and Orthoptera (11.40%) with Acrididae (4.49%) and Gryllidae (2.39%). Mantodea, Hemiptera, Isoptera, Ephemeroptera, Blattodea and Odonata accounted for 21.13% of prey.

**Table I. Annual diet of *Asellia tridens* at El Hadj Guelmane, Timimoun (Algerian Sahara) from January 2015 to December 2015: orders/families identified in droppings, relative frequency (F%) calculated as the ratio number of items from a taxon (Nb Items)/total number of identified items.**

| Order         | Family            | Nb Items | F%  |
|---------------|-------------------|----------|-----|
| Araneae       |                   | 36       | 1.28|
| Odonata       |                   | 58       | 2.07|
| Ephemeroptera | Ephemeridae       | 92       | 3.28|
| Orthoptera    | Family unidentified. | 76       | 4.52|
|               | Acridida          | 141      | 4.49|
|               | Gryllidae         | 103      | 3.39|
| Mantodea      | Mantidae          | 127      | 5.03|
| Blattodea     | Blattidae         | 126      | 2.70|
| Isoptera      | Termitidae        | 67       | 3.67|
| Hemiptera     |                   | 123      | 4.38|
| Hymenoptera   | Family unidentified. | 259      | 2.67|
|               | Formicidae        | 137      | 13.22|
|               | Myrmicidae        | 32       | 2.99|
|               | Vespidae          | 135      | 2.42|
| Coleoptera    | Carabidae         | 116      | 9.23|
|               | Curculionidae     | 132      | 4.89|
|               | Chrysomelidae     | 61       | 1.14|
|               | Tenebrionidae     | 75       | 4.81|
|               | Aphodidae         | 371      | 4.13|
|               | Scarabaeida       | 68       | 4.70|
|               | Histeridae        | 84       | 2.17|
| Diptera       | Culicidae         | 220      | 7.84|
|               | Tabanidae         | 167      | 5.97|
| **Total**     |                   | 2806     | 100 |

**Discussion**

As previously reported (Jones et al. 1993; Whitaker et al. 1994; Feldman et al. 2000; Benda et al. 2001, 2006, 2012, 2014; Whitaker & Yom-Tov 2002;
Amichai et al. 2013; Žďárská 2013), *Aselia tridens* mainly feeds on insects even if we found some spider remains as Whitaker and Yom-Tov (2002) did in the Jordan valley (Israel). As in these studies, except for a very small sample from the Dead Sea (Whitaker et al. 1994), Coleoptera were the most abundant. As in several species of insectivorous bats (e.g. Graclik & Wasielewski 2012; Smirnov & Vekhnik 2014),
Coleoptera were the main prey in spite of seasonal variations of food availability. Scarabaeidae and Carabidae were also reported by Whitaker and Yom-Tov (2002), but not Curculionidae, Tenebrionidae and Aphodidae, which were possibly gathered in the group “other”, and Chrysomelidae were less abundant in the Timimoun samples.

The main additional prey differed among the studies. In our study Formicidae were the main prey even if they accounted for a small volume. Hymenoptera were also abundant in two Israeli studies (Whitaker et al. 1994; Whitaker & Yom-Tov 2002) and two Syrian samples (Benda et al. 2006). Contrary to our study, the main additional prey were Heteroptera (Hemiptera) in one Israeli sample (Amichai et al. 2013) and one Omani sample (Žďárská 2013), together with Auchenorrhyncha (Hemiptera) in one Syrian sample (Benda et al. 2006) and two Iranian samples (Benda et al. 2012). However the main difference is the absence of Lepidoptera at Timimoun while this group was the second one in the Jordan valley (Whitaker & Yom-Tov 2002), in Gambia (Jones et al. 1993) and two Syrian samples (Benda et al. 2006), and even the first group in a small sample from the Dead Sea (Whitaker et al. 1994). This difference can be explained by the semi-desert environment of the later sites whereas Timimoun is

Table III. Seasonal diet of *Asellia tridens* at El Hadj Guelmane, Timimoun (Algerian Sahara) from January 2015 to December 2015 according to seasons identified by the third level of a hierarchical classification performed on the co-ordinates of a factorial correspondence analysis: relative frequency of orders/families identified in droppings. Jan: January. Mar: March. Sep: September. Oct: October. Nov: November. Dec: December; 1: first half of the month. 2: second half of the month. * includes also Jan1. The main items contributing to chi-square tests within the seasons are in bold.

| Order | Family | Autumn | Winter | Early spring | Late spring-Summer |
|-------|--------|--------|--------|--------------|--------------------|
|       |        | Sep 2–Oct 2* | Nov 1–Dec 2 | Jan 2–Mar 1 | Mar 2–Sep 1 |
| Araneae | 1.76 | 0.39 | 0.47 | 1.51 |
| Odonata | 1.51 | 5.84 | 1.40 | 1.80 |
| Ephemeroptera | Ephemeresidae | 3.27 | 2.33 | 3.49 | 3.37 |
| Orthoptera | Family unidentified. | 3.27 | 1.56 | 6.05 | 4.88 |
| | Acrididae | 4.77 | 8.17 | 5.58 | 3.60 |
| | Gryllidae | 2.01 | 3.50 | 0.70 | 2.73 |
| Mantodea | Mantidae | 3.77 | 2.72 | 4.65 | 5.75 |
| Blattodea | Blattidae | 3.52 | 5.45 | 2.09 | 2.27 |
| Isoptera | Termitidae | 4.77 | 5.45 | 3.49 | 3.20 |
| Hemiptera | 5.53 | 2.72 | 5.35 | 4.13 |
| Hymenoptera | Family unidentified | 2.26 | 3.50 | 2.09 | 2.79 |
| | Formicidae | 16.08 | 16.73 | 16.05 | 11.33 |
| | Myrmicidae | 4.27 | 5.06 | 3.02 | 2.38 |
| | Vespidae | 0.25 | 0.00 | 0.93 | 3.66 |
| Coleoptera | Carabidae | 9.05 | 5.06 | 11.86 | 9.24 |
| | Curculionidae | 6.03 | 4.28 | 3.02 | 5.17 |
| | Chrysomelidae | 0.25 | 0.00 | 1.16 | 1.51 |
| | Tenebrionidae | 3.02 | 0.39 | 5.58 | 5.69 |
| | Aphodidae | 2.76 | 1.95 | 3.26 | 5.00 |
| | Scarabaeidae | 6.53 | 8.56 | 3.72 | 3.95 |
| | Histeridae | 1.26 | 1.95 | 3.26 | 2.15 |
| Diptera | Culicidae | 9.30 | 10.51 | 6.74 | 7.38 |
| | Tabanidae | 4.77 | 3.89 | 6.05 | 6.51 |
located in a harsh desert. If we add Trichoptera, Neuroptera and Dermaptera (Feldman et al. 2000; Whitaker & Yom-Tov 2002; Benda et al. 2006) to Blattodea, Mantodea, Odonata and Ephemeroptera to the list of incidental prey of *A. tridens*, we confirm that this bat has a broad diet and could be considered as a “generalist” species following Smirnov and Vekhnik (2014). Despite a specialized foraging strategy reported by Jones et al. (1993), Whitaker et al. (1994) and Amichai et al. (2013), *A. tridens* hunts whatever prey is available at its foraging site as most insectivorous bat species do (Fenton 1982). This combination of behaviour and diet has been recorded in most desert bat species studied so far: *Antrozous pallidus* in Arizona (Fenton & Morris 1976) and Sonora in New Mexico (Bell 1982), *Rhinopoma microphyllum*, *R. hardwickii* and *Nyctinomus aegyptiacus* in Rajasthan, India (Advani 1981, 1982a, 1982b), *R. microphyllum* and *R. cystops* in Israel (Whitaker & Yom-Tov 2002), *Otonycteris leucophaea* in Kirghistan (Arlettaz et al. 1995) and *Otonycteris hemprichii* Israel (Fenton et al. 1999).

Feeding opportunism constitutes an adaptation to changing environmental conditions, and *Asella tridens* seemed to adapt its feeding ecology to local, and probably seasonal, prey availability and abundance (Amichai et al. 2013). Seasonal variations of prey in the Timimoun Region were prominent during our study. They were probably a response to seasonal changes in abundance of each category of prey, which is related to water and vegetation availability in the Sahara (Rebelo & Brito 2006).

Seasonal variations of the diet of *A. tridens* were investigated for the first time, but for comparisons we can refer to similar studies of desert bat species, unfortunately not in the Sahara and not in the same harsh conditions. For instance in Rajasthan the diets of *Rhinopoma microphyllum*, *R. hardwickii* and *Nyctinomus aegyptiacus* changed along the four identified seasons (Advani 1981, 1982a, 1982b) with huge species differences. So Coleoptera were the main prey (ca. 40%) for *R. microphyllum* in the winter and post-monsoon season, for *R. hardwickii* only in the post-monsoon season and for *N. aegyptiacus* in the summer and winter. Isoptera were the main prey (24–48%) for the three species in the monsoon season. Finally, Orthoptera were the main prey (23–26%) for *R. hardwickii* in the summer and winter. We did not record such differences in the seasonal diet of *A. tridens* at Timimoun. When pooling families, Coleoptera were less abundant prey than for those sympatric species, particularly in winter (22.19% vs 28.90–32.71% in the three other seasons) and Hymenoptera were always the secondary prey with a slight difference between the summer (20.16%) and the winter (25.29%). Diptera and Orthoptera also displayed slight differences, 12.09–14.40% and 10.05–13.23% respectively. The main differences were observed for the large amount of Odonata and Blattodea in the winter. This abundance of Odonata may be related to the migration of some species such as *Hemianax ephippiger* which concentrates in the Sahara during the cold season before moving to more northern regions in the spring (Dumont 1977, 1988; Dumont & Desmet 1990). Blattodea are also an available group of insects in the winter in the area, so they were also among the main prey of the desert hedgehog *Paracrinus aethiopicus* (Loumassine 2014) and the second insect prey of the barn owl *Tyto alba* (Belkacem 2017).

Most Coleoptera families (Chrysomelidae, Tenebrionidae, Aphodidae and Carabidae) were less abundant in the winter, except Scarabaenidae whose reproduction is favoured by mild and cool weather (Haloti et al. 2006). Formicidae and Myrmicidae were main prey too. With the high number of Termitidae, this result shows that this season is poor in large insects which are the main prey of *A. tridens* according to Whitaker et al. (1994). The consumption of Acrididae can be related to the migration of the desert locust to oases (Ould Elhadj 2002; Allal–Benfekih 2006; Kara-Toumi et al. 2010).

During spring, Formicidae were still a major component of the diet together with Acrididae which are more common during this season (Souttou 2010). However, Araneae and Vespidae, which are not active during the cold season, were less hunted than in the summer, as well as Curculionidae and Gryllidae, the latter reaching the last larvae stages (Lakhdari et al. 2015). These seasonal variations support the model in which certain predators tend to specialize when resources become abundant in environment by searching profitable and common prey (Boukhemza et al. 1994).

**Conclusions**

Apparently, *Asella tridens* has a large geographic range both in latitude and longitude, overlaying different temperature and precipitation conditions which presumably impact the number and diversity of arthropods at each location (Kunz 1974; Jones & Rydell 1994; Moosman et al. 2012). These variations are overcome by a broad diet even if this bat mainly hunt terrestrial prey, Coleoptera and
Orthoptera, as most Saharan bat species do (Benda et al. 2012). Emergence and abundance figures for each prey item should be further investigated. Besides, soft-bodied prey items could be identified by DNA barcoding.

We consider that, according to the presence of the colony throughout the year, this site does not present food restrictions that the species cannot deal with. Yet, as the Sahara could experience the fastest climate change among world deserts (Loarie et al. 2009), global warming and increasing aridity will affect arthropod resources for bats. Whereas A. tridens still form large colonies in the North-African desert, conservation measures should be undertaken, at least for protecting their roosts, as part of optimised conservation suggested by Brito et al. (2014).

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Authors’ contributions
Hibat-ellah Loumassine collected and analyzed the faeces, performed statistic analyses and wrote a draft of the paper. Faiza Marniche participated to identify prey remains and contributed to the discussion. Farid Bounaceur supervised the work and corrected the manuscript. Stéphane Aulagnier suggested statistical analyses and wrote the final version of the paper.

Availability of data and materials
All material is stored in the University of Tiaret. Raw data are provided in the tables.

Disclosure statement
No potential conflict of interest was reported by the authors.

References
Advani R. 1981. Food and feeding ecology of the rat tailed bat in the Rajasthan desert. Acta Theriologica 26:269–272. DOI: 10.4098/0001-7051.
Advani R. 1982a. Seasonal fluctuations in the diet composition of Rhinopoma hardwickei in the Rajasthan desert. Proceedings: Animal Sciences 91:563–568. DOI: 10.1007/BF03186156.
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Unravelling biodiversity, evolution, threats and conservation in the Sahara-Sahel. Biological Reviews 89:215–231. DOI: 10.1111/j.1365-2028.2006.00721.x

Denzinger A, Schnitzler HU. 2013. Bat guilds, a concept to classify the highly diverse foraging and echolocation behaviors of microchiropteran bats. Frontiers in Physiology 4:164. DOI: 10.3389/fphys.2013.00164.

Dietz C, Von Helversen O, Nill D. 2007. Handbuch der Fledermäuse Europas und Nordwestafrikas. Biologie, Kennzeichen, Gefährdung. Stuttgart: Franckh-Kosmos.

Dumont HJ. 1977. On migrations of Hemianax ephippiger (Burmeister) and Traemea basiliris (P. de Beauvois) in West and North-West Africa in the winter 1975/1976 (Anisoptera: Aeshnidae, Libellulidae). Odonatologica 6:13–17. Available: http://natuurtijdschriften.nl/record/393418.

Dumont HJ. 1978. Hemianax ephippiger (Burmeister) in the northern Algerian Sahara in winter (Anisoptera: Aeshnidae). Notulæ Odonatologica 3:20–22. Available: http://natuurtijdschriften.nl/record/393418.

Dumont HJ, Desmet K. 1990. Transsahara and transmediterranean migratory activity of Hemianax ephippiger (Burmeister) in 1988 and 1989 (Anisoptera: Aeshnidae). Odonatologica 19:181–185. Available: http://natuurtijdschriften.nl/record/591906.

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

Fenton MB. 1982. Echolocation, insect hearing, and feeding ecology of insectivorous bats. In: Kunz TH, editor. Ecology of bats. New York & London: Plenum Press; p. 261–285. DOI: 10.1007/978-1-4613-3421-7_7.

Fenton MB, Morris GK. 1976. Opportunistic feeding by desert bats (Myotis spp.). Canadian Journal of Zoology 54:526–530. DOI: 10.1139/z76-059.

Fenton MB, Shalmun B, Makin D. 1999. Roost switching, foraging behavior, and diet of the vespertilionid bat, Otonyctes hemprichii. Israel Journal of Zoology 45:501–506. DOI: 10.1080/00212210.1999.10689015.

Findley JS. 1993. Bats: A community perspective. Cambridge: Cambridge University Press.

Gracik A, Wasielewski O. 2012. Diet composition of Myotis myotis (Chiroptera, Vespertilionidae) in western Poland: Results of fecal analyses. Turkish Journal of Zoology 36:209–213.

Gustafson Y, Schnitzler HU. 1979. Echolocation and obstacle avoidance in the hipoisiderid bat Asellia tridens. Journal of Comparative Physiology 131:161–167. DOI: 10.1007/BF00619076.

Halogt S, Janati-Idrissi A, Cherqui H, Lumaret JP. 2006. Structure des communautés de Scarabéides coprophages du Maroc nord-occidental (Coleoptera, Scarabaeoidea). Bulletin De L’Institut Scientifique, Rabat, Section Sciences De La Vie 28:25–34.

Hammer Ø, Harper DAT, Ryan PD. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeoecologia Electronica 4:9. Available: http://palaeo-electronica.org.

Hill JE, Smith JD. 1984. Bats: A natural history. London: British Museum (Natural History).

Jones G, Morton M, Hughes PM, Budden RM. 1993. Echolocation, flight morphology and foraging strategies of some West African hipposiderid bats. Journal of Zoology 230:385–400. DOI: 10.1111/j.1469-7998.1993.tb02691.x.

Jones G, Rydell J. 1994. Foraging strategy and predation risk as factors influencing emergence time in echolocating bats.

Philosophical Transactions of the Royal Society of London 346:445–455. DOI: 10.1098/rstb.1994.0161.

Kara-Toumi FZ, Doummandji-Mitiche B, Guendouz-Benzima A, Merah O. 2010. Seasonal dimorphism of the desert locust in agricultural areas in the Sahara. African Entomology 18:313–321. DOI: 10.4001/003.018.0208.

Karimi MH. 2016. Caractérisation phytoclimatologique des parcs de Belghazi dans la région de Timimoun - Wilaya d’Adrar. Dissertation, Université de Tlemcen.

Koch-Weser S. 1984. Fledermäuse aus Obervolta, W-Afrika (Mammalia: Chiroptera). Senckenbergiana Biologica 64:255–311.

Kowalski K, Rzebik-Kowalska B. 1991. Mammals of Algeria. Wrocław: Ossolineum.

Kunz TH. 1974. Feeding ecology of a temperate insectivorous bat (Myotis veliler). Ecology 55:693–711. DOI: 10.2307/1934408.

Lakhdir W, Doummandji-Mitiche B, Acheuk F, Dehlie A, Milik R, Soud A, Hammami H. 2015. Morphological study of different developmental stages of Brachytrupes megacephalus Lefebvre, 1827 (Orthoptera, Gryllidae) and their development in Oued Righ region (Algerian Sahara). Academy Journal of Entomology 8:117–126.

Loarie SR, Duffy PB, Hamilton H, Asner GP, Field CB, Ackerly DD. 2009. The velocity of climate change. Nature 462:1052–1055. DOI: 10.1038/nature08649.

Loumassine H. 2014. Ecologie trophique de Fennec Vulpes zerda (Zimmerman, 1780) et l’herisson du désert Parmachinus aethiopicus (Ehlenberg, 1833) dans la région du grand Erg Occidental “Timimoum”. Dissertation, Université de Tiaret.

McAney C, Shiel C, Sullivan C, Fairley J. 2014. Echolocation and obstacle avoidance in a desert chiropteran: A taxonomic and geographic reference. 3rd ed. Baltimore: The Johns Hopkins University Press; p. 312–529.

Smirnov DG, Vekhnin VP. 2014. Ecology of nutrition and differentiation of the trophic niches of bats (Chiroptera: Vespertilionidae) in floodplain ecosystems of the Samara Bend. Biol Monogr 41:60–70. DOI: 10.1134/S1062359014101050.

Moosman PR, Thomas HH, Veilleux JP. 2012. Diet of the widespread insectivorous bats Eptesicus fuscus and Myotis lucifugus relative to climate and richness of bat communities. Journal of Mammalogy 93:491–496. DOI: 10.1644/11-MAMM-A-274.1.

Neuweiler R. 2000. The biology of bats. Oxford: Oxford University Press on Demand.

Ould Elhadj MD. 2002. Les nouvelles formes de mise en valeur dans le Sahara algérien et le problème acridien. Science et Changements Planétaires/Sécheresse 13:37–42.

Patterson BD, Willig MR, Stevens RD. 2003. Trophic strategies, niche partitioning, and patterns of ecological organization. Bat Ecology 9:536–557.

Rebelo H, Brito JC. 2006. Bat guild structure and habitat use in the Sahara desert. African Journal of Ecology 45:228–230. DOI: 10.1111/j.1365-2028.2006.00721.x.

Shiel C, McAney C, Sullivan C, Fairley J. 1997. Identification of arthropod fragments in bat droppings. London: The Mammal Society. Occ Publ 17.

Simmons NB. 2005. Order Chiroptera. In: Wilson DE, Reeder DM, editors. Mammal species of the World. A taxonomic and geographic reference. 3rd ed. Baltimore: The Johns Hopkins University Press; p. 312–529.

Smirnov DG, Vekhnin VP. 2014. Ecology of nutrition and differentiation of the trophic niches of bats (Chiroptera: Vespertilionidae) in floodplain ecosystems of the Samara Bend. Biology Bulletin 41:60–70. DOI: 10.1134/S1062359014101050.
Souttou K. 2010. Bioécologie de quelques rapaces diurnes en Algérie. Doctorat, Ecole Nationale Supérieure d’Agronomie, Alger.

Vaughan N. 1997. The diets of British bats (Chiroptera). Mammal Review 27:77–94. DOI: 10.1111/j.1365-2907.1997.tb00373.x.

Weterings R, Umponstira C. 2014. Bodyweight-forearm ratio, cranial morphology, and call frequency relate to prey selection in insectivorous bats. Electronic Journal of Biology 10:21–27.

Whitaker JO, Shalmon B, Kunz TH. 1994. Food and feeding habits of insectivorous bats from Israel. Zeitschrift für Säugetierkunde 59:74–81.

Whitaker JO, Yom-Tov Y. 2002. The diet of some insectivorous bats from northern Israel. Mammalian Biology- Zeitschrift für Säugetierkunde 67:378–380. DOI:10.1078/1616-5047-00053.

Žďárská L. 2013. Potravní ekologie netopýrů východního Středomoří [Feeding ecology of bats in the Eastern Mediterranean]. Dissertation, Charles University, Praha.

Znari M, El Mouden EH. 1997. Seasonal changes in the diet of adult and juvenile Agama impalearis (Lacertilia: Agamidae) in the Central Jbilet mountains, Morocco. Journal of Arid Environments 37:403–412. DOI: 10.1006/jare.1997.0271.

Znari M, El Mouden EH, Benfaida H, Boumezzough A. 2000. Partage des ressources spatiales et trophiques au sein d’un peuplement de lézards insectivores des Jbilets centrales (Maroc occidental). Revue d’écologie 55:141–160. Available: http://hdl.handle.net/2042/55405.