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Evidences of piscivory by *Myotis capaccinii* (Bonaparte, 1837) in Southern Iberian Peninsula

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Faeces of *Myotis capaccinii* were collected from four individuals netted in a spring colony in Denia, Alicante (south-eastern Iberian Peninsula). Faecal analysis revealed the presence of fish scales and bones in all droppings examined (two pellets for each individual, i.e., *n* = 8), with volumes ranging 6–82.5 % of prey remains. Remains of Diptera and Trichoptera were also found. These data provide the first evidence of piscivory in *M. capaccinii*, and reveal that this may be an important feeding behaviour in this species, at least locally and/or seasonally.

Key words: *Myotis capaccinii*, diet, piscivory, Iberia

Introduction

Carnivory in bats almost certainly evolved from insectivory, and most carnivorous bats still feed largely on arthropods (Nowak, 1994; Altringham, 1996). As a specialised form of carnivory, piscivory is known to be the primary feeding strategy of two species of bats: *Noctilio leporinus* and *Myotis vivesi* (e.g., Bloedel, 1955; Reeder and Norris, 1954). Other species such as *Myotis adversus*, *M. hasseltii*, *M. macrotarsus* and *M. ricketti*, although predominantly insectivorous, also prey on fish (Robson, 1984; Jones and Rayner, 1991; Nowak, 1994; Ma *et al*., 2003). Fish-eating species share a set of morphological, functional and behavioural features with trawling insectivorous bats: both groups have large feet and long fingers armed with well developed claws, suited for capturing prey from the water surface (Brosset and Delamare Deboutteville, 1966; Brosset, 1975; Jones and Rayner, 1988), and both share relatively large and pointed wings, with high aspect ratio, fitted to allow relatively slow flight in open environments (Norberg and Rayner, 1987). Consequently, several authors have suggested a close link between trawling insectivory and piscivory, considering the former as a possible preadaptation for the latter (e.g., Novick and Dale, 1971; Jones and Rayner, 1988; Kalko *et al*., 1998). A recently published research on the molecular taxonomy of genus *Myotis* revealed that the subgenus *Leuconoe* (Findley, 1972), which includes all trawling myotid species, is paraphyletic, and consequently constitutes an ecomorph that has evolved independently several times (Ruedi and Mayer, 2001).

This hypothesis is also supported by a morphometric study of 41 species of *Myotis* carried out by Fenton and Bogdanowicz (2002).

Myotis capaccinii is a medium sized Mediterranean *Myotis* distributed in north-western Africa, southern Europe and south-western Asia. Although *M. capaccinii* is considered an endangered species in Europe, knowledge of its habitat and trophic requirements is lacking (Guillén, 1999; Spitzenberger and von Helversen, 2001). *Myotis capaccinii* hunts mainly over streams, ponds and lakes (Courtois, 1998; Roué and Barataud, 1999; Russo and Jones, 2003), where it is specialised to forage by gaffing insects from the water surface in shallow and slow waters (Kalko, 1990), as do other European trawling bats such as *M. daubentonii* and *M. dasycneme* (Brosset and Delamare Deboutteville, 1966; Terrasse, 1975; Jones and Rayner, 1988; Ahlén, 1990; Britton *et al*., 1997). There is also limited knowledge regarding the diet of *M. capaccinii*. Analysis of faecal pellets collected in Hérault (southern France) and the Pyrenees revealed Diptera (Culicidae and Chironomidae), Trichoptera and Lepidoptera as their main prey (Médard and Guibert, 1992). Whereas the high consumption of Culicidae, Chironomidae, and Trichoptera is related to hunting over streams and other wetlands, the occurrence of moths in the diet suggests a broader spectrum of foraging habitats.

In order to better define the design of a large-scale research project on the spatial and trophic ecology of *M. capaccinii* in the south-east Iberian Peninsula, we carried out a preliminary study on the diet of this bat during 2003.

Materials and Methods

We netted four adult females in the entrance of a limestone cave situated in Denia, Alicante, at 60 m a.s.l. (UTM: 31S BD453013). Bats were kept in individual cages until they defecated, and subsequently released. Droppings were collected and air-dried for storage. Two faecal pellets from each of the trapped bats were analysed. Before analysis, pellets were softened by soaking in 50% ethanol for 30 minutes and then teased apart under magnifying lens using two dissecting needles. The contents of each dissected pellet was spread on a microscope slide and fixed with glycerine. Identification of arthropod remains was carried out with the aid of Chinery (1977), Barrientos (1988), and McAney *et al*. (1991) and by comparison with a reference collection. Fish scales were identified following Elvira (1988) and by comparison with collection specimens. Results are expressed as both occurrence and volume percentage for each individual (McAney *et al*., 1991; Whitaker, 1988).

Results

The bats fed mainly on fish, Diptera and Trichoptera (Table 1). Fish were the main prey both following occurrence frequency and by volume. In fact, fish scales were found in every analysed dropping (Fig. 1), with individual volumetric estimates ranging 6–82.5% (48.4% average). We also found fish bones – vertebrae – in three pellets. Diptera were found in 6 droppings belonging to 3 bats, and Trichoptera in two droppings of a single bat. All the fish scales belonged to order Ciprinodontiformes.

Table 1. Individual and total volume (in %) and total occurrence (in %) for each prey category of *M. capaccinii*. Individual bats – females – are named F1–F4; F3 and F4 were pregnant

Prey	Volume					Occurrence
	F1	F2	F3	F4	Total	
Fish	6	82.5	65	40	48.4	100
Diptera	94	17.5	35	0	36.6	75
Trichoptera	0	0	0	60	15	25

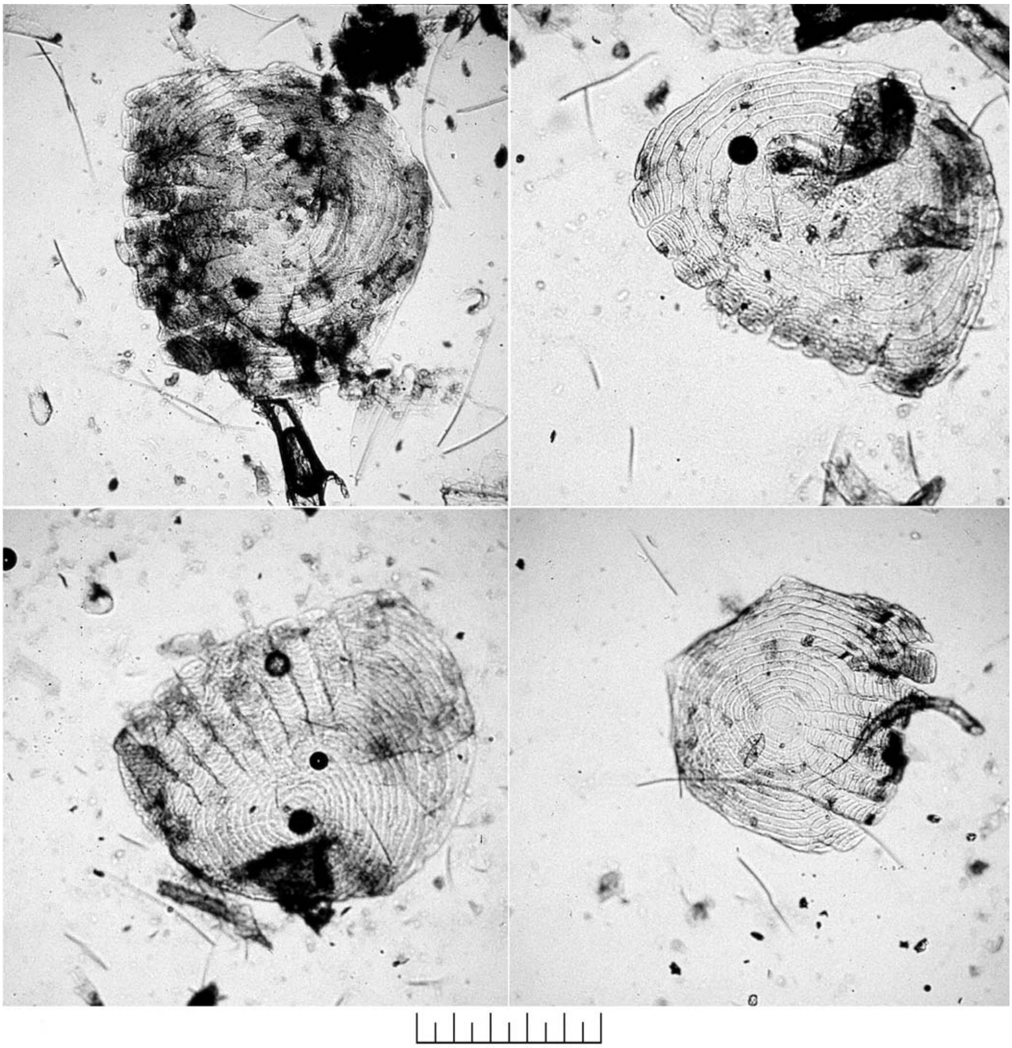

FIG. 1. Fish scales found in faecal pellets of *Myotis capaccinii*. Scale = 0.5 mm

Growth rings on scales allowed to age consumed fish as individuals of first and second year.

DISCUSSION

Our findings provide the first conclusive evidence that free-living *M. capaccinii* feeds on fish and, in view of the volume percentage and the frequency of occurrence observed in our sample, we believe that this behaviour can be important (at least locally and/or seasonally) moreover bearing in mind that remains of small fish might be underrepresented in faeces due to digestion (Siemers *et al*., 2001*a*).

Piscivory has been proposed as a possible feeding behaviour for this species by Brosset and Delamare Deboutteville (1966), and more elaborately by Jones and Rayner (1988). The first evidence of fish eating by bats in Europe was reported by Brosset and Delamare Deboutteville (1966), who found scales, bone and other fish remains in faeces of free living *M. daubentonii*. Later on, Terrasse (1975) reported a new case of possible fishing by *M. daubentonii* trawling over a fish hatchery. Nevertheless, piscivory has been considered exceptional or unlikely in *M. daubentonii* (Brosset and Delamare Deboutteville, 1966; Jones and Rayner, 1988; Kalko and Schnitzler, 1989). The lack of new findings of fish remains in faeces of free-living *M. daubentonii* (see review in Vaughan, 1997) supports this point of view (but c.f. Siemers *et al*., 2001*a*).

Field studies as well as behavioural experiments have shown that isolated objects floating on smooth water, including debris and prey dummies, can be confused with prey and may be captured by *M. daubentonii*, *M. capaccinii* and *M. dasycneme* (Kalko and Schnitzler, 1989; Britton *et al*., 1997; Boonman *et al*., 1998; Britton and Jones, 1999; Siemers *et al*., 2001*b*). Therefore it would not be too surprising that all these species catch dead fish from the water surface. In fact, recent experimental work confirmed that in controlled conditions *M. daubentonii* actually catch dead fish if it is situated protruding above the water surface, although not a single case of predation upon living fish was recorded (Siemers *et al*., 2003*a*). Most of the bodies of water in the study area were highly eutrophicated (Alvarez-Cobelas *et al*., 1992; Vicente and Miracle, 1992; Sostoa, 2001), and both hypoxic and anoxic conditions are frequent during the Mediterranean dry season. Under those circumstances dead fish may be abundant enough to be exploited as a locally profitable resource by *M. capaccinii*. Nevertheless this explanation does not fit with the present data, since in May – when faeces were collected – river flow is important in the study area.

Therefore, an ecological scenario enabling predation upon living fish can be outlined. There are three species of ciprinodontiform fish in the Mediterranean area of the Iberian Peninsula: both the Iberian toothcarp *Aphanius iberus* and the Valencia toothcarp *Valencia hispanica* are endemic, and the eastern mosquitofish *Gambusia holbrooki* is an exotic species introduced in Spain in 1921 (Doadrio, 2001). All of them are small fish, with maximum sizes of 5 cm in *A. iberus*, 8 cm in *V. hispanica*, and 8 cm in *G. holbrooki* – 5 cm in males –, and all of them have been cited in the vicinity of the study site (Doadrio, 2001). Toothcarps and mosquitofish inhabit slow waters in lower stretches of rivers, ponds, marshes, and estuarine or littoral lagoons. They are eurythermal species, resistant to lack of oxygen, and capable of surviving in small ponds, where they swim very close to water surface using their up-turned mouth to capture Copepoda, Culicidae, Chironomidae, and other insects floating (Muus and Dahlström, 1981; Terofal, 1991; Doadrio, 2001). Thus, size, habitat and behaviour of ciprinodontiforms seem to fit in with habitat and hunting behaviour of *M. capaccinii* (Kalko, 1990; Courtois, 1998; Roué and Barataud, 1999). Moreover, the expected fall of oxygen availability during the night (Harper, 1992; Elosegi *et al*., 1997) might force these fish even more to the water surface to breath, exposing themselves above it, and becoming a good target for a trawling bat.

Unfortunately, limitations of the present study do not allow us to draw further conclusions. Additional investigations are required to determine the feeding and spatial ecology of *M. capaccinii*, and particularly the importance of piscivory, regarding its implications in the energy budget of this species, as well as possible inter-population and seasonal variations of this feeding behaviour. Likewise, it is necessary to compare the importance of piscivory in *M. capaccinii* and *M. daubentonii*, to assess possible interaction between these two species relative to a differential response capability to changes in habitat quality. Increasing the knowledge on these issues could be particularly important to design effective management policies for the conservation of this endangered species in Europe.

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