

Diet and prey selection in the Mediterranean horseshoe bat *Rhinolophus euryale* (Chiroptera, Rhinolophidae) during the pre-breeding season

Urtzi GOITI
Jose Ramon AIHARTZA
Inazio GARIN

Department of Zoology and Animal Cell Dynamics, University of the Basque Country,
Box. 644, E-48080, Bilbao (Spain)

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ABSTRACT

In May 2001 we collected droppings of *Rhinolophus euryale* from a colony located in the Basque Country (southwestern Europe). Simultaneously, we used Malaise traps to determine prey availability in different habitats, weighting it according to the habitat use of bats. Prey categories found in droppings were then compared to availability to perform the selection analysis. The main consumed prey were by far small lepidopterans (5-11 mm long), followed by tipulids, and scarabaeid beetles (entirely *Rhizotrogus* sp.). Moths and beetles were selected positively, whereas the other categories were under-represented in the diet. These results suggest the importance of small moths in the pre-breeding diet of this species, although other items might seasonally play an important role.

KEY WORDS

Rhinolophus euryale,
diet,
prey selection,
Basque Country,
southwestern Europe.

RÉSUMÉ

Régime alimentaire et sélection des proies par le Rhinolophe euryale (*Rhinolophus euryale*) (Chiroptera, Rhinolophidae) au printemps.

En mai 2001 le guano a été collecté sous une colonie de *Rhinolophus euryale* du Pays Basque (sud-ouest de l'Europe). Simultanément, des pièges Malaise ont été posés dans les différents habitats pour y mesurer la disponibilité en insectes, pondérée par l'utilisation des habitats par les chauves-souris. Les fréquences des groupes de proies identifiés dans les fèces et disponibles ont été comparées statistiquement. Les insectes les plus consommés ont été, de loin, les petits Lépidoptères (5-11 mm long), suivis par les Tipulidés et les Scarabéidés (*Rhizotrogus* sp.). Une sélection des Lépidoptères et Scarabéidés a été mise en évidence, alors que les autres proies disponibles apparaissent sous-représentées dans le régime. Ces résultats confirment l'importance des petits Lépidoptères pour les rhinolophes euryales en période de pré-mise bas, les autres proies pouvant constituer une ressource saisonnière importante.

MOTS-CLÉS

Rhinolophus euryale,
proies,
sélection,
Pays Basque,
Europe sud-occidentale.

INTRODUCTION

At a global scale the Mediterranean horseshoe bat, *Rhinolophus euryale* Blasius, 1853, has been classified as Vulnerable (Hutson *et al.* 2001) and following alarming population declines (Brosset *et al.* 1988; Palmeirim & Rodrigues 1992; Paz & Alcalde 2000) it is nowadays considered to be amidst the most endangered bat species in Europe. It inhabits Mediterranean areas as well as other European regions with mild climate (Ibañez 1999). *R. euryale*'s wing morphology is characterised by medium to low wing loading and aspect ratio (Norberg & Rayner 1987), which allows foraging close to and within vegetation, and besides aerial feeding also foraging in a fly-catching style (Russo *et al.* 2002; Goiti *et al.* 2003).

Only recently have we started to get an insight into the ecology of *R. euryale* (Paz 1985; Brosset *et al.* 1988; Masson 1990, 1999; Russo *et al.* 2001; Russo *et al.* 2002; Aihartza *et al.* 2003). Two studies have analysed diet (Koselj & Krystufek 1999; Grabovac *et al.* 1999), but none has actually dealt with prey selection. Therefore, our aims were to describe *R. euryale*'s spring diet and determine whether the species forages selectively or opportunistically.

MATERIALS AND METHODS

The study was conducted in May 2001 in the Karrantza Valley, Basque Country (Southwestern Europe). The area is characterised by Atlantic warm oceanic climate, mean temperature in January is 7°C and in August 19°C, and rainfall occurs throughout the year (annual mean 1400 mm). Cattlebreeding is the main human activity and so the main force shaping the landscape. Therefore the vegetation is highly patchy and consists of a mosaic of pastures, surrounded by an important hedgerow network mainly consisted of *Salix atrocinerea*, *Corylus avellana*, *Rubus ulmifolius*, *Acer campestre* and *Crataegus monogyna*, and interspersed with deciduous woodland copses including *Quercus robur*,

Fraxinus excelsior, *Castanea sativa* and *Corylus avellana*, and a few plantations of exotic species, mainly *Pinus radiata* and *Eucalyptus globulus*. Elevation ranges between 200–855 m a.s.l. and the ground is hilly and steep.

A harp-trap (2 × 2 m, adapted from Tuttle, 1974) was used to capture bats in the entrance of a limestone cave (situated at 334 m a.s.l.) as they returned to roost. The bats (17 males/19 females) were maintained in individual cages for some hours until they defecated, after which they were released into the cave.

Droppings were collected and air-dried for storage. Three to four faecal pellets from each bat were analysed (n = 120). The pellets were soaked for half an hour in ethanol (50%) and after softening they were teased apart under magnifying lens using two dissecting needles. Each pellet was laid and its contents scattered on a microscope slide and fixed with glycerine. Arthropod remains were identified with the aid of Chinery (1977), Barrientos (1988), and McAney *et al.* (1991) and by comparison with a reference collection. The results were expressed as percentage frequencies, i.e. the number of identifiable fragments of a particular prey category as a percentage of the total number of identified fragments of all categories (McAney *et al.* 1991).

Moreover, we captured insects using two-sided Malaise traps on 5 nights. Sampling sites were chosen within 5 km from the roost and each night they were located in different habitat types, i.e., meadow, broadleaved woodland, hedgerow, pine plantation and eucalypt plantation. Prey frequencies found in each habitat type were weighted according to the bat habitat use determined in a simultaneous study on the spatial behaviour of *R. euryale* in the same area (Goiti *et al.* 2003). Absolute numbers of insects of a given habitat type were multiplied by the respective bat use proportion to achieve the weighted frequencies, hereafter referred to as prey availability.

We analysed diet selection comparing insect frequencies in droppings and prey availability by a Chi square goodness-of-fit test ($p < 0.05$), applying the Yates correction where the degree of freedom was one. When statistically significant

TABLE 1. — Percent frequency of insects in the diet of *R. euryale* and percent composition of insects trapped at foraging sites (available sample). Selection analysis was performed by calculating Bonferroni confidence intervals (C.I.) in two steps. In the first step (A) flies other than tipulids were compared to a lumped group of categories, which were afterwards analysed in a second step (B).

	Diet	Available	Bonferroni C.I.	Selection ($p < 0.05$)
A				
Order Diptera (but Tipulidae)	7.0	93.4	2.7-11.3	Negative
Others	93.0	6.6	88.7-97.3	Positive
Frequency totals	171	2854		
B				
Order Lepidoptera	69.2	20.3	61.1-77.3	Positive
Family Tipulidae	18.9	68.5	12.0-25.8	Negative
Order Coleoptera	8.8	2.7	3.8-13.8	Positive
Order Hymenoptera	3.1	8.6	0.0-6.1	Negative
Frequency totals	159	187		

TABLE 2. — Number of insects trapped with Malaise nets weighted according to the habitat use observed by Goiti *et al.* (2003). Only insects preyed by *R. euryale* are considered.

	Broadleaved	Hedgerow	Pinewood
Diptera*	580	2068	19
Tipulidae	23	104	1
Lepidoptera	10	27	1
Coleoptera	4	1	0
Hymenoptera	5	11	0
Habitat use (% fixes)	30	68	2

*but Tipulidae

differences between diet and prey availability occurred (selective feeding) we applied Bonferroni confidence intervals for each prey category to determine which category was selected (Manly *et al.* 1993).

RESULTS

In May, *Rhinolophus euryale*'s diet consisted mainly of moths, followed by tipulids and scarabaeid beetles (entirely *Rhizotrogus* sp.) (Table 1). Droppings containing Lepidoptera usually comprised scales and wing fragments, as well as leg and antenna fragments, occasionally proboscis fragments and exceptionally head capsules; those containing beetles consisted of abdominal cuticle, tarsi, and wing fragments.

Preyed moths were small (5-11 mm long), whereas the range size of available lepidoptera was between 1-70 mm long.

Dipterans were by far the most frequent prey category caught in Malaise traps (Table 2).

The selection analysis was performed in two steps owing to the high number of available dipterans in comparison with the other taxa. In the first step, Diptera other than Tipulidae was selected negatively when compared to a category lumping together Tipulidae, Lepidoptera, Coleoptera and Hymenoptera ($X^2 = 2085$, $df = 1$, $p < 0.001$) (Table 1). In the second analysis, the diet frequencies of the categories grouped in step A also differed significantly from availability ($X^2 = 267$, $df = 3$, $p < 0.001$). Lepidoptera and Coleoptera were selected positively, whereas Hymenoptera and Tipulidae were selected negatively (Table 1).

DISCUSSION

Our study showed that *R. euryale*'s spring diet in the study area consisted predominantly of small moths (Lepidoptera), stressing the importance of this prey previously reported for Slovenia (Koselj & Krystufek 1999). This item has also been found to be the main prey for the closely related *R. mehelyi* in Iran (Sharifi & Hemmati 2001), and *R. blasii* in Zambia (Findley & Black 1983). The diet of *R. euryale* presented by Grabovac *et al.* (1999) showed different percentages (e.g. Coleoptera 84.7 %) of a wider variety of prey, some of which have not been recorded, or at least not in such percentages (e.g. Blattodea 22.8%, Opiliones 20.4 %, Saltatoria), neither in *R. euryale* nor in other European Rhinolophidae (e.g. McAney & Fairley 1989; Duvergé & Jones 1994; Beck 1995; Ransome 1996; Arlettaz *et al.* 2000). It should be then considered that the samples of this study were collected inside a cave also used by *Myotis emarginatus*, *M. nattereri*, *M. myotis*, *M. blythii*, *M. daubentonii*, *M. bechsteinii*, *Barbastella barbastellus*, *Rhinolophus ferrumequinum*, *R. hipposideros*, *Plecotus auritus* and *Miniopterus schreibersii* (I. Grabovac, *pers. comm.*). Thus, considering the tendency of *R. euryale* to form multispecific colonies (e.g. Brosset & Caubère 1959; Paz 1985; Russo *et al.* 2002) it is likely that droppings from those species were unintentionally gathered biasing the results.

R. euryale during the pre-breeding season selected for the most consumed prey, i.e. small moths, which suggests this rhinolophid may be regarded as a moth specialist. Consumed beetles, which all corresponded to the scarabaeid *Rhizotrogus* sp., were also selected for. Thus, this bat seems not to be totally restricted to a particular prey type, i.e. small, long-winged, relatively slow flying insects. The differences in size, texture and hardness of prey may then imply contrasting foraging techniques and thus different energy efficiencies. The total lack of elitra fragments of *Rhizotrogus* sp. among the remains recovered from droppings suggests that the partial consumption of a relatively hard but large prey may compensate for

ingestion constraints. In aerial feeding, however, handling time of this prey type would increase considerably overall flying time, whereas hunting in a flycatching style would avoid unnecessary flights. Therefore, we think that the use of perch hunting, actually observed for *R. euryale* (Goiti *et al.* 2003), may be focused on the capture of larger and harder prey as Jones & Rayner (1989) proposed.

Tipulids, although accounting almost for a fifth of the diet, were consumed less than expected. These insects were an important item in Slovenia too (Koselj & Krystufek 1999). It is noteworthy that in both studies all other flies but tipulids were seldom consumed. The higher profitability of tipulids among flies may be a consequence of their higher wingspan and slower flight. Although tipulids may be somehow preferred among Diptera, apparently this is not the case when moths or scarabaeid beetles are available.

Prey selection studies carried out on rhinolophids have reported selective feeding (Jones 1990; present study; but see Lugon 1996 in Roué & Barataud 1999). This would be actually consistent with the ability of horseshoe bats to discriminate between different kinds of prey in cluttered environments (Emde & Menne 1989; Jones & Rayner 1989; Emde & Schnitzler 1990). Jones (1990) complemented faecal analysis with identification of culled parts, concluding that *R. ferrumequinum* selected prey according to size: identified lepidopteran remains all corresponded to large species. In our case we could not collect any dismembered item. Anyhow, although faecal analysis prevented accurate identification of the moth species consumed, the comparison of the leg fragments recovered from droppings with those of netted moths, revealed that the size of the moths consumed by *R. euryale* was within the lower range of the available sample. The difference in size between the preferred prey of *R. euryale* and *R. ferrumequinum*, is likely to depend on the differences in echolocation call frequency (e.g. Russo & Jones 2002) and body size occurring between both bat species.

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