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THE WINTER DIET OF THE LESSER HORSESHOE BAT (*RHINOLOPHUS HIPPOSIDEROS)* IN BRITAIN AND IRELAND

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ABSTRACT - The lesser horseshoe bat *Rhinolophus hipposideros* feeds regularly throughout the winter across its British and Irish range. During winter 1995/96 and 1998/99, in Cornwall *R. hipposideros* fed mainly on dipteran flies in the families Tipulidae/Trichoceridae, Sphaeroceridae and Mycetophilidae. Differences in dietary composition were found across the British and Irish range of *R.hipposideros* in winter, and these probably relate to local habitat differences. Nevertheless, across sites Tipulidae/Trichoceridae were always the most frequently eaten prey in winter, with Mycetophilidae and Anisopodidae also eaten frequently. The ecology of the important prey families indicated the value of damp woodland with decaying wood and grazing animals, particularly cattle, for the winter foraging of *R. hipposideros*.

Key words: foraging, faecal analysis, dipterans, conservation

RIASSUNTO - ***Dieta invernale del rinolofo minore* (Rhinolophus hipposideros) *in Bretagna e Irlanda***. Il rinolofo minore *Rhinolophus hipposideros* si alimenta regolarmente in inverno nel suo areale britannico e irlandese. Durante gli inverni 1995/96 e 1998/99, in Cornovaglia questa specie aveva una dieta costituita principalmente da ditteri appartenenti alla famiglie Tipulidae/Trichoceridae, Sphaeroceridae e Micetofilidi. Differenze nella composizione della dieta invernale sono state trovate attraverso il suo areale, probabilmente imputabili alla diversità degli habitat locali. Tuttavia, nelle zone esaminate i Tipulidae/Trichoceridae erano sempre le prede più frequentemente consumate in inverno, seguite da Micetofilidi e Anisopodidae. Tenendo conto dell'ecologia dei ditteri maggiormente consumati, le aree invernali di foraggiamento del rinolofo minore erano indicativamente i boschi umidi con legno in decomposizione e animali al pascolo, in particolare bovini.

Parole chiave: foraggiamento, analisi delle feci, ditteri, conservazione

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INTRODUCTION

For an animal to feed successfully, the amount of energy acquired from feeding needs to be greater than that expended in foraging. For small insectivorous bats the energetic costs of flying can be as high as 21 x their basal metabolic rate (Racey and Speakman 1987) and 600 x higher than the energy con-

sumption in torpor (Avery 1985). During the winter period (from October to April) when insect abundance in temperate regions is reduced, bats enter hibernation (prolonged torpor). Hibernation is punctuated by arousals from torpor, although the frequency of arousal varies among species and individuals (Menaker 1964; Daan 1973; Funakoshi and Uchida 1978a; 1978b; Ransome 1990). The exact cause of arousal is uncertain (Park et al. 2000) but temperature in the roost plays a part. Arousal can lead to foraging if temperatures are sufficiently high and if other climatic conditions are suitable (Ransome 1971, 1990; Avery 1985; Duvergé and Jones 1994).

Because insect activity, temperature and bat arousal are correlated (e.g. Jones et al. 1995), bats may feed more often in parts of Britain that are mild during the winter (see Ransome 2002). Cornwall is in the extreme south west of Britain, and experiences a maritime climate and *Rhinolophus hipposideros* (IUCN Near Threatened status) feeds regularly throughout the winter. In coastal regions of Cornwall, winters are very mild with temperatures falling below freezing only infrequently (2-23 days/winter with air frost, 1971-2000: Meteorological Office, Exeter, U.K.), and winter foraging by *R. hipposideros* is expected to be common.

At present knowledge of the diet of *R. hipposideros* is restricted to summer feeding (Beck et al. 1989; McAney and Fairley 1989; Hollyfield 1993; Beck 1994/5; Arlettaz et al. 2000). None of these studies have examined prey taken during winter foraging. The work reported here addresses this situation by the analysis of species diet in Cornwall and across the range in Britain and Ireland.

MATERIALS AND METHODS

1. Faecal analysis

Faecal pellets were collected at fortnightly intervals from a *R. hipposideros* night roost in a cellar/boiler room of a small manor house, situated at the head of a valley that leads down to a tributary of the Helford River, Cornwall (50° 7'N; 5° 8'W). The collections were made, from the same site, throughout two winters, 1995/96 and 1998/99. The boiler was in use during the study and resulted in temperatures in the range of 13°C to 18°C. Polythene sheeting was placed on top of the boiler and faecal pellets and any discarded insect fragments (such as wings and legs) fell onto the sheet and were collected. From each fortnightly collection, a random selection of 20 pellets was taken for analysis.

The pellets were left to soak in water saturated tissue paper for at least 4 hours and then added with a few drops of glycerine into a petri dish to aid the separation of the fragments contained in the pellet" (Shiel et al. 1997). Using a headless entomological pin, the pellet was then gently teased apart in the glycerine until the fragments that it contained could be readily seen under a Brunel MX-7T low power stereomicroscope (magnification x 40) once mounted on a microscope slide.. Under the microscope, all fragments were identified to order and most to family (Tab. 1). The identification was carried out with the aid of various handbooks and keys (Skidmore 1991; Unwin 1991; Chinery 1993; Shiel et al. 1997). Tipulidae and Trichoceridae have been grouped together as it is only if antennal sections are present that it is possible to distinguish between them, and their habitat needs are largely the same. Similarly Chironomidae and Ceratopogonidae have been grouped together. A list of all recognizable

families was made for each faecal pellet and from this a percentage frequency of the prey families found could be calculated for each fortnightly period. Percentage frequency is the number of occurrences of a category, divided by the total occurrences of all categories, multiplied by 100%. The presence of moths (Lepidoptera) can be a source of bias because moth scales remain in the digestive tract for long periods (Whitaker 1988; Robinson and Stebbings 1993). This could lead to an overestimation of the importance of moths in the diet if all pellets containing scales are counted. In this work in order to accommodate this problem only a moderate to large amount of scales, or scales along with other remains of moth classified the pellet as positive for Lepidoptera.

A reference collection of insects, caught in a similar habitat to that surrounding the roost some 4.5 km distant from it, was made using a suction trap. Trapping was carried out on an approximately fortnightly basis (avoiding nights with rain) by a Johnson-Taylor 12 inch insect suction trap, which was put into operation half an hour after sundown and left functioning until dawn the following day.

2. Collection of faecal pellets from across the British range of *R. hipposideros*

Faecal pellets of *R. hipposideros* were collected during a nationwide annual survey of hibernacula organised through the Bat Conservation Trust (BCT). The collection of a sample of 'fresh' *R. hipposideros* faecal pellets was made during visits to hibernacula where this was possible without causing disturbance. These samples were analysed by the same procedure used for pellets collected in Cornwall. Similar collections were made in western Ireland. The sample sizes for this part of the study (often 10 pellets analysed per collection) were not as large as those used in Cornwall nor were the samples collected as frequently (between one to five collections per winter) as in Cornwall and therefore the results are not as comprehensive. The results are presented as a total of all sites for Devon, Wales and Ireland for winter 1998/99.

RESULTS

In winter 1995/96, Diptera were by far the most frequently occurring order (86%; Tab. 1). Sphaeroceridae (24%) were the most frequent family, followed closely by Tipulidae/Trichoceridae (23%). Mycetophilidae (12%) and Scathophagidae (11%) also occur in significant numbers. Changes in diet were relatively small (Fig. 1a), though Scatophagidae became scarce after the end of December. Due to the large number (21) of categories involved at a low occurrence, in Fig. 1 those below a percent frequency of 5% are shown in the 'others' category. In winter 1995/96, this includes Araneida (spiders) and Oniscidea (woodlice) which both indicate gleaning as a mode of feeding. Acari (mites) were also noted in the diet but it was found that Sphaeroceridae, when trapped, were host to Acari and this could be the mode by which Acari entered the diet of *R. hipposideros.*

In Cornwall, in winter 1998/99, Diptera were still the predominant order (78%; Tab. 1). Tipulidae/Trichoceridae formed the largest category (24%), followed by Mycetophilidae (13%) and Sphaeroceridae (12%) The percent frequency of the latter, as so as that of Scathophagidae (from 11% to 3%), was evidently lower than in winter 1995/96. In contrast, increases were apparent for Lepidoptera (7% to 12%), which were the predominant category in January (Fig. 1b), Anisopodidae (3% to 11%) and Neuroptera (2% to 5%).

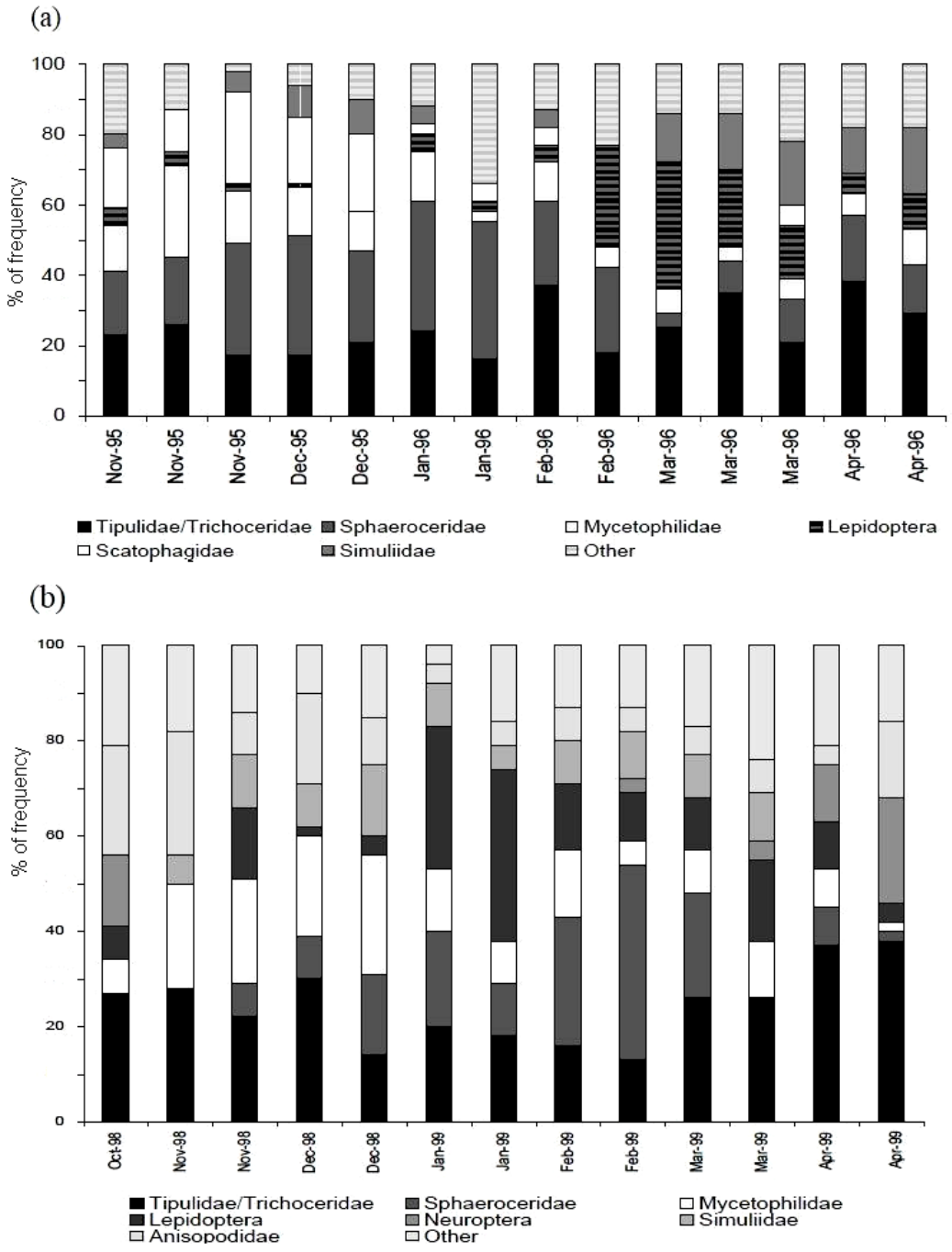

Figure 1 - Seasonal changes in the percentage frequency of prey groups eaten by *R. hippo-sideros* during winter in Cornwall during 1995/6 (a) and 1998/9 (b).

Table 1 - Dietary composition of prey eaten by *Rhinolophus hipposideros* as measured by percentage frequency from samples collected from Cornwall, Devon, Wales and Ireland; Cw = Cornwall winter; Dw = Devon winter; Ww = Wales winter; Iw = Ireland winter.

			Cw 1995/6	Cw 1998/9	Dw 1998/9	Ww 1998/9	Iw 1998/9
Number of sites			1	1	5	2	6
Number of droppings analysed			280	260	45	56	42
Class	Order	Family					
Arachnida	Acari		4	<1			
	Araneae	Araneidae	<1	<1	1		<1
Insecta	Coleoptera		1	<1	1		3
	Dermaptera			<1			
	Diptera	Anisopodidae	3	11	18		
		Chironomidae/Cerato	<1	1	7	8	15
		Culicidae	1			7	1
		Doliocoptidae	1				3
		Ephydridae	<1	<1	1		
		Lonchopteridae	<1	<1			4
		Mycetophilidae	12	13	14	1	
		Muscidae/Calliphorid	<1	2		11	17
		Platypezidae		<1		1	4
		Psychodidae	2	4	7		
		Scathophagidae	11	3	3	4	7
		Sciaridae		<1		5	9
		Simulidae	7	7	6		
		Sphaeroceridae	24	12	4	10	<1
		Tipulidae/Trichocerid	23	24	19	11	2
	Hemiptera	Aphidoidea				15	20
	Hymenoptera		1	<1			
	Lepidoptera		7	12	4	3	5
	Neuroptera		2	5	8	10	3
	Psocoptera					12	1
	Trichoptera		<1	3	7		

Results for Devon, Wales and Ireland (Tab. 1) show in all cases Tipulidae/Trichoceridae as the most frequently occurring category, followed by Mycetophilidae and Anisopodidae in Devon and Ireland, while Neuroptera, Mycetophilidae and Sphaeroceridae were most prevalent in the diet at Welsh sites.

DISCUSSION

Sources of bias can exist in any study which uses faecal analysis to investigate the diet of bat species but ethical considerations mean that faecal analysis is the only viable option.

The main source of bias in faecal analysis is the over representation of hard-bodied prey over soft-bodied insects (Belwood and Fenton 1976; Rabinowitz and Tuttle, 1982; Kunz and Whitaker 1983; Dickman and Huang 1988). However, in this study because the majority of the diet of *R. hipposideros* is small soft-bodied prey, this has not been

as important a source of error as it would be for other bat species.

Faecal analysis could also be non-representative because not all faecal pellets from winter foraging would be deposited at the night roost; rapid digestion makes it likely that some would be deposited whilst still out on the wing (Hoare 1991; Robinson and Stebbings 1993). However, the time spent foraging each evening is greatly reduced in winter (Williams 2001) so any bias due to this effect should be minimised. The value of faecal analysis is supported by blind tests on the reliability which concluded that faecal analysis yields reasonable estimates of food eaten (Kunz and Whitaker 1983). The analysis of bat droppings is now generally considered to yield reliable information on the diet of insectivorous bats, as long as sustained scrutiny for fragments is maintained (Shiel et al. 1997).

Although with some variation due to local differences in climate and insect availability, our results were consistent throughout the British range of *R. hipposideros*, pointing out the importance of some families of Diptera, especially Tipulidae/Trichoceridae Mycetophilidae and Sphaeroceridae, for the winter feeding of this bat species.

Mycetophilidae are often found in woodland habitats - particularly ones which are not managed to remove rotting wood. Damp woodland with decaying vegetation also support larvae of the Tipulidae (crane flies) and Trichoceridae (winter gnats), as those of Anisopodidae (window midges).

The life cycles of Sphaeroceridae and Scathophagidae is associated with dung (Skidmore 1991; Cox 1999). In recent years in the United Kingdom, low prices fetched by beef and the "Foot and Mouth disease crisis" in 2001 have resulted in many cattle farmers (particularly the smaller, less intensive farms) diversifying into other areas of farming and often ceasing to farm cattle. Although sheep dung does also have an associated insect fauna it is not as extensive as that of cattle where each cow pat may contain up to 1,000 developing insect larvae, principally Diptera (Cox 1999). Møller (2001) found that the abundance of barn swallows *Hirundo rustica* decreased by 48% when dairy farming ceased and sweep netting indicated that this was due to insect density being significantly lower in the absence of cattle.

Also endectocides have an adverse effect on the dung fauna. Strong and James (1992) found that 50% of *Scatophaga stercoraria* were killed within 48 hours of exposure to Ivermectin at a concentration found in cattle dung treated with a slow-release bolus, while, at lower levels, abnormal development of insect fauna can occur (Sommer et al. 1992).

Within the winter foraging range of *R. hipposideros*, which is reduced by approximately 50% to their summer range and has a mean radius of 1.2 km around hibernation sites (Williams 2001), conservation measures should include the retention of native broad-leaved woodland and damp areas and the promotion of hedgerows and other linear features and winter grazing, particularly by cattle, where conditions permit.. Where conventional farming is practiced, the use of endectocides, particularly bolus application, should be avoided.

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