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DIET OF *GALEMYS PYRENAICUS* (GEOFFROY, 1811) IN THE NORTH OF THE IBERIAN PENINSULA

by

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ABSTRACT

In this study data about the trophic ecology of *Galemys pyrenaicus* in the north of the Iberian peninsula are reported, based on analysis of the digestive tracts of 46 specimens from the Quinto Real mountain range (Navarra). Diet composition, trophic niche width and seasonal variations are described. The total number of prey identified was 2,629. The diet almost completely consisted of aquatic prey. The greater number of prey corresponded to Ephemeroptera larvae (46.6%), Trichoptera larvae (23.1%), Diptera larvae (13.3%) and Plecoptera larvae (9.0%). Trichoptera larvae provided 56.8% of the biomass, Diptera larvae 17.9% and Ephemeroptera larvae 16.1%. *Galemys pyrenaicus* does not select its prey by size, however a positive selection towards Ephemeroptera and Trichoptera larvae and a negative one towards Amphipoda was found. The results obtained mean that *Galemys pyrenaicus* can be characterised as a stenophagous species in which energy input is obtained from not-very-mobile invertebrates with a large amount of biomass (Trichoptera larvae), and other small but numerous and accessible taxons (Ephemeroptera larvae).

KEY WORDS: diet, trophic ecology, Iberian peninsula, *Galemys pyrenaicus*.

INTRODUCTION

The Pyrenean Desman (*Galemys pyrenaicus*) (GEOFFROY, 1811) (Insectivora, Talpidae) is a species found in mountain fluvial stretches, distributed throughout the Pyrenean environment (RICHARD, 1976, 1984; CASTIÉN & MENDIOLA, 1984) and through the highlands of the W, NW and centre of the Iberian peninsula (NIETHAMMER, 1970; NORES, 1986; SANTAMARINA & GUITIAN, 1988; QUEIROZ *et al.*, 1992).

The trophic ecology of this species is scarcely known. Its diet has been studied in the Pyrenees (PUISSEGUR, 1935; NIETHAMMER, 1970; SAINT-GIRONS, 1973; RICHARD, 1984). SANTAMARINA and GUITIAN (1988) report detailed information on the contents of the digestive tract in eight specimens from the NW of the Iberian peninsula.

This study reports data on the quantitative composition of *G. pyrenaicus* feeding, thus characterising its trophic ecology. The relation between availability of resources and their exploitation by *G. pyrenaicus* is also studied.

STUDY AREA

The area studied is at the western end of the Pyrenees, in the Quinto Real mountains (in the north of the Iberian peninsula). The watercourses which drain this surface give rise to the Arga river (tributary of the Ebro). They are formed by 34 km of streamlets that, for most of their course, contain water throughout the year. The rock substrate is acidic. The area studied is between 660 m and 1458 m above sea level. Annual average precipitation is about 2138 mm with the highest levels in spring and autumn. Annual average temperature is 8.8°C. The highest average temperature is in August (16.6°C) and the lowest in January (2.9°C). The vegetation of the Quinto Real area may be attributed to the *Saxifrago hirsutae-Fagetum sylvaticae* association (BRAUN-BLANQUET, 1967) or to the regressive series linked to it.

MATERIAL AND METHODS

The fluvial macroinvertebrates were captured on a particular stretch of the river by a 1-foot-square cross-section Surber net (SOUTHWOOD, 1966). Eight samples were obtained every three months from different parts of the river. All the macroinvertebrates captured were measured and conserved in 60% alcohol for later use as a comparison collection. The volume of macroinvertebrates was calculated considering each animal as a revolution cylinder.

All animals were handled in compliance with the international policies of animal care and welfare. *Galemys pyrenaicus* is present in the 34 km of watercourses in the area studied, although ignorance of its density and the fact that it is a protected species nowadays argue against capturing more than two specimens per month. Captures per month (male/female) were: September 2/2, October 2/2, November 1/1, December 1/3, January 0/1, February 4/2, March 2/2, April 2/1, May 1/0, June 3/4, July 4/4, August 3/2, total 25/24. The analysis of the digestive tracts gave a result of 2629 prey items.

The digestive tract of each *G. pyrenaicus* was kept in 60% alcohol until it was analysed. Identification was done by direct analysis via binocular microscope. The minimum number of prey captured per tract was estimated on the basis of the series of remains identified in stomach and intestine. To express the importance of the different prey items, a matrix was made (table I). Rows represent different types of food and columns the distinct variables: appearance frequency in number (N) and percentage (%N), percentage of stomachs with a certain type of food (%P) and Simpson's dominance ratio ($D = \Sigma P_i^2$) ($1 \leq i \leq z$; z = total number of digestive tracts). P_i is the probability of a food unit from stomach *i* to belong to a certain type of food. $D' = D/z \times 100$

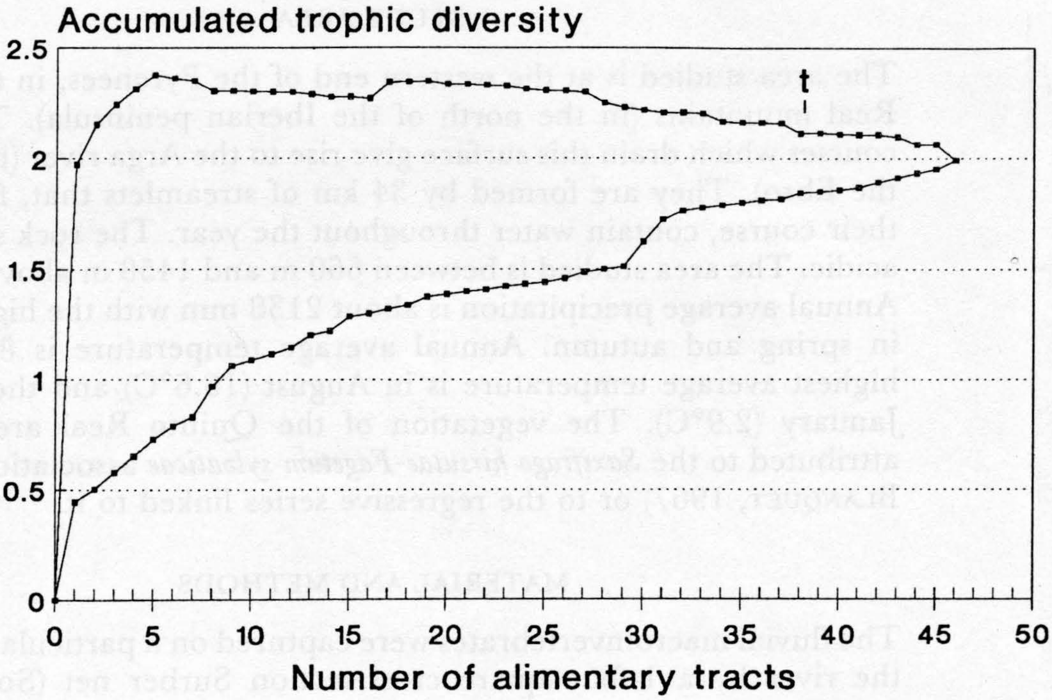

Fig. 1. Cummulative trophic diversity, arranging the digestive tracts (n = 46) according to their increasing (lower curve) and decreasing (upper curve) diversity order. Point t represents the tract where the curve becomes stable.

compares the different matrix indices. D'' = D'/ΣD' × 100 expresses the value of D' as a percentage.

Accumulated diversity curves were also constructed, ordering the stomachs in accordance with their diversities, in increasing and decreasing order. This enabled us to estimate, among other things, the representativeness of the sample studied. Brillouin's expression was used to calculate the diversity: $H = 1/N * (\log_2 N! - \Sigma \log_2 N_i!)$, as it is more appropriate for measuring a data collection's diversity than more commonly used expressions (PIELOU, 1975).

Proximity between diets in each of the four seasons was estimated by calculating Spearman's correlation coefficient. Comparison of diet between both sexes was done by the Kolmogorov-Smirnov test and by Spearman's correlation coefficient.

RESULTS

The stabilisation of diversity is considered after the accumulation of the contents of 38 digestive tracts (fig. 1). Therefore, it is possible to assess that the sample is representative of the species' diet. The mean

TABLE I

Trophic matrix of *Galemys pyrenaicus* for the annual diet. N: number of prey items determined; %N: percentage of total prey; %P: percentage of tracts with particular type of prey; $D = \Sigma p_i^2$: Simpson's index of dominance; $D' = D/z \times 100$: Simpson's transformed index; $D'' = D'/\Sigma D' \times 100$.

	N	*%N*	*%P*	*D*	*D'*	*D''*
Oligochaeta	6	0.2	8.7	0.002	0.004	0.009
Gastropoda	1	0.0	2.2	0.0002	0.0005	0.001
Chilopoda	1	0.0	2.2	0.0002	0.0005	0.001
Opiliones	1	0.0	2.2	0.0002	0.0004	0.001
Coleoptera adults	19	0.7	26.1	0.03	0.06	0.14
Coleoptera larvae	1	0.0	2.2	0.0003	0.0008	0.002
Diptera adults	5	0.2	8.7	0.003	0.006	0.01
Diptera larvae	350	13.3	87.0	1.76	3.84	9.67
Trichoptera larvae	607	23.1	100.0	5.18	11.26	28.38
Ephemeroptera larvae	1305	49.6	95.6	9.85	21.43	53.99
Plecoptera larvae	236	9.0	95.6	0.87	1.90	4.78
Amphipoda	55	2.1	45.6	0.16	0.35	0.89
Eggs of *Salmo trutta*	42	1.6	4.3	0.38	0.83	2.11

number of prey items determined per digestive tract is $\bar{x} = 56.98$ (n = 46, SE = 7.38).

Diet composition

Comparison of male and female diet does not show significant differences (DN = 0.385, p = 0.291; $r_s = 0.927$, n = 13, p = 0.001). Accordingly, identity in the diet between sexes is evidenced.

The greatest part of *G. pyrenaicus*' diet is made up of aquatic prey. The most numerous capture (table I) concerned Ephemeroptera larvae (mainly Heptagenidae), present in 95.6% of the stomachs, although this is not the food which contributes most biomass (fig. 2), given its small size. Trichoptera larvae are less numerous but constitute more than half of the biomass intake of the species. Diptera larvae are represented by Simulidae and Chironomidae and by other systematic groups of larger biomass (Limoniidae and Athericidae). They are the second prey in terms of biomass contribution. Plecoptera larvae are found in 95.6% of the tracts studied although their number is not very high. Their contribution to the diet in terms of biomass is also low. The remaining prey show little importance.

According to Simpson's transformed index (D'') the main importance of captures corresponds to Ephemeroptera larvae and Trichop-

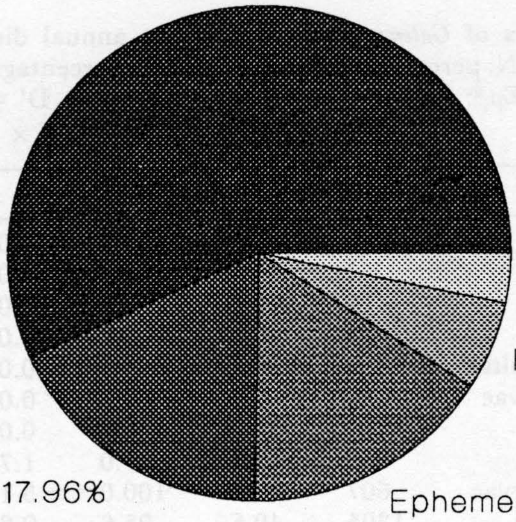

Fig. 2. Volume proportion in the components of *Galemys pyrenaicus* diet. l.: larvae.

tera larvae, followed by the Diptera larvae and Plecoptera larvae. The importance of the rest of the prey clustered together is less than 4%. Among these, terrestrial forms (Gastropoda, Chilopoda, Opilions and adult Diptera) were found although it was not possible to determine whether they were captured in a terrestrial environment or whether they emerged from the fluvial drift. In the tracts of two individuals trout eggs were found, the only vertebrate remains.

Seasonal variation in feeding

The diet is relatively constant throughout the year (table II). Ephemeroptera larvae and Trichoptera larvae make up the highest proportion in all four seasons (table III). Most variable were the Plecoptera larvae who increased from autumn to spring. In summer, Ephemeroptera larvae and Trichoptera larvae increase while Plecoptera larvae

TABLE II

Seasonal diet comparison with the Spearman correlation test. *: correlation significant for $p < 0.05$, **: correlation significant for $p < 0.01$.

	Spring	*Summer*	*Autumn*
Winter	0.848**	0.640*	0.729*
Spring		0.910**	0.926**
Summer			0.954**

TABLE III

Seasonal diet for *Galemys pyrenaicus*. N: number of prey items; %N: percentage of total prey items; n: sample size.

	Spring		*Summer*		*Autumn*		*Winter*	
Prey type	*N*	*%N*	*N*	*%N*	*N*	*%N*	*N*	*%N*
Oligochaeta	-	-	1	0.1	5	0.8	-	-
Gastropoda	-	-	-	-	-	-	1	0.1
Chilopoda	-	-	-	-	-	-	1	0.1
Opiliones	-	-	1	0.1	-	-	-	-
Coleoptera adults	1	0.5	5	0.4	12	1.9	1	0.1
Coleoptera larvae	-	-	1	0.1	-	-	-	-
Diptera adults	-	-	4	0.3	1	0.2	-	-
Diptera larvae	16	8.7	132	11.6	153	24.1	49	7.3
Trichoptera larvae	29	15.8	289	25.4	154	24.2	135	20.1
Ephemeroptera larvae	88	48.1	633	55.6	249	39.1	335	49.8
Plecoptera larvae	48	26.2	63	5.5	34	5.3	91	13.5
Amphipoda	1	0.5	9	0.8	28	4.4	17	2.5
Eggs of *Salmo trutta*	-	-	-	-	-	-	42	6.2
n	7		20		10		9	

TABLE IV

Comparison of the abundance of the most abundant trophic resources in the river and in the digestive tracts of *Galemys pyrenaicus* in each season. **: significant for p < 0.001; ns: not significant.

	Spring		*Summer*		*Autumn*		*Winter*		
	%N Stream	*%N Diet*	*%N Stream*	*%N Diet*	*%N Stream*	*%N Diet*	*%N Stream*	*%N Diet*	X^2
Ephemeroptera larvae	40.00	48.09	21.73	55.62	11.20	39.15	27.94	49.85	141.4**
Trichoptera larvae	4.00	15.85	10.72	25.39	15.20	24.21	13.23	20.09	64.1**
Plecoptera larvae	7.33	26.23	2.94	5.54	15.20	5.34	20.59	13.54	59.8**
Diptera larvae	10.00	8.74	11.75	11.59	15.20	24.06	7.36	7.29	5.3ns
Amphipoda	38.00	0.55	47.28	0.79	35.20	4.40	23.53	2.53	128.3**
Other	0.67	0.54	5.58	1.07	8.00	2.84	7.36	6.70	

decrease and, in winter, Diptera larvae are the most abundant while Ephemeroptera larvae decrease.

Resource exploitation

The comparison made between the number of individuals of each taxon collected from the river and found as prey in the different seasons of the year shows significant differences in all cases (Spring: $X^2 = 1960.4$, df = 4, $p \leq 0.001$; Summer: $X^2 = 18954.6$, df = 5, $p \leq 0.001$; Autumn: $X^2 = 337.2$, df = 5, $p \leq 0.001$; Winter: $X^2 = 129.2$, df = 5, $p \leq 0.001$). Ephemeroptera larvae and Trichoptera larvae are consumed in higher proportions than expected, based on their abundance in the river (table IV); consumption of Pleocoptera larvae is less than expected in Autumn and Winter and more than expected in Spring and Summer. Diptera larvae are consumed in expected proportions. Amphipoda are present in the diet in a significantly lower level than expected in all four seasons.

Prey length

Comparison of the length of the prey found in the digestive tracts and the macroinvertebrates captured in the river shows that *G. pyrenaicus* do not choose their prey on basis of its length ($X^2 = 5.840$, df = 13, $p > 0.95$).

DISCUSSION

The results obtained in this study concur with those of SANTAMARINA and GUITIAN (1988) as to the importance of the various groups found, althought the appearance frequency of Ephemeroptera larvae is notably higher in our study. Several authors (PEYRE, 1956; SAINT-GIRONS, 1973) have found trout (*Salmo trutta*) in the diet of *G. pyrenaicus*. RICHARD (1986) and NIETHAMMER (1970) postulate that, in captivity, the species is not able to capture a live trout in a good condition. No fishes were found in the digestive tracts analysed in our study.

RICHARD (1986) postulates that fish eggs do not form part of *G. pyrenaicus* diet; the presence of eggs of *Salmo trutta fario* in two specimens in our study modifies this opinion. It is not possible to know if the Pyrenean Desman has dug in fry places or has eaten eggs found on the river bed, discovered by superimposed spawns. The existence of terrestrial species in the diet, albeit occasionally, corroborates the data of PUISSEGUR (1935).

Galemys pyrenaicus feeds almost exclusively on aquatic prey. It does not select its prey on the basis of its length, rather on the type of prey. It negatively selects Amphipoda (all Gammaridae). Its slight presence in the diet coincides with the findings of SANTAMARINA and GUITIAN (1988) in Galicia. The reasons may lie in this prey's greater ability to flee and because this taxon has a high level of chitin in relation to available biomass. Taking into consideration that *Gammarus* is a well-spread genus in the Quinto Real mountain range, our results conflict with those of PUISSEGUR (1935), PEYRE (1956), SAINT-GIRONS (1973) and RICHARD (1986), who consider *Gammarus* as one of the principal prey items in *Galemys*' diet in the French watershed. Trichoptera larvae and Ephemeroptera larvae are positively selected. The abundance of Trichoptera larvae in the diet coincides with data by SANTAMARINA and GUITIAN (1988). Trichoptera larvae are relatively large and immobile prey. Ephemeroptera larvae (Heptagenidae) are small but very abundant. These results are to be expected and are consistent with the need to optimize the energy acquired per unit time (SCHOENER, 1971). *Galemys pyrenaicus* is a relatively small species (70 g) in which the energy needed to maintain homeotermia in the aqueous medium is high in relation to its weight. Hence the need to obtain a large quantity of biomass in proportion to the time spent searching for food may determine which rivers can be occupied by this species.

Its diet varies little from season to season. It is based on Trichoptera larvae and Ephemeroptera larvae all year round, although the presence of Plecoptera larvae is significant in spring and that of Diptera larvae in autumn.

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