

FEEDING BEHAVIOUR OF *BARBUS BOCAGEI* ASSESSED UNDER A SPATIO-TEMPORAL APPROACH

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Abstract

The feeding behaviour of *Barbus bocagei* was assessed in a lowland system by a two years survey of two contrasting sites, also taking into account, for the first time, diurnal changes of fish diet and benthos availability. This barbel feeds more or less continuously during the 24 hours upon the dominant and the most available benthic items, such as Diptera larvae (Chironomidae), Ephemeroptera nymphs (Caenidae), molluscs and plant material, switching to one or few items when they become common. Such a generalist and opportunistic behaviour was also demonstrated over time by scoring the benthos availability during the second year of this project. In fact, a high spatio-temporal homogeneity of prey was generally found, whereas significant differences in the gut contents occurred by sampling period and site. This lack of correlation may be explained by the existence of intraspecific variation in the feeding pattern, coupled with the existence of feeding migrations leading to exploitation of distinct zones from those prospected.

Key words: Iberian barbel, diet, intraspecific relations, diel cycles

Introduction

In the Central and Southern parts of Iberian Peninsula, the lotic systems are highly variable, constraining benthos availability to seasonal, local and diurnal changes. Therefore, fishes should be able to adapt their feeding behaviour to such variable condition and switch from one item to another in order to increase their specific foraging success (P y k e 1984).

This is apparently the case of the Iberian barbel *Barbus bocagei* Steindachner, 1865, which inhabits septentrional and central Iberian drainages. It has been studied both in lentic but also in lotic habitats (see M a g a l h ã e s 1992). Considering the latest systems, L o b ó n - C e r v i á & D e D i e g o (1988) correlated its feeding strategy with benthos composition in a northern river (Douro drainage), and M a g a l h ã e s (1992) first and G e r a l d e s et al. (1993) after, referred to the existence of ontogenetic variations in the diet composition of a population living in a central system, the River Sorraia.

In fact, the very preliminary data obtained by our team (G e r a l d e s et al. 1993) in five distinct sites of that Tagus tributary, suggested the existence of spatial and temporal differences in diet composition, and the necessity of reassessing such variations by enlarging the temporal scale for fish and benthos availability analyses.

So, we selected the two most contrasting sites and we processed them seasonally during two years for fish diet, and during the last year also for benthos availability. Finally, to check the validity of the adopted sampling hours, in order to avoid possible misinterpretations due to diurnal changes, the daily feeding

rhythm was for the first time analysed in the periods where abiotic factors such as water quality and flow may be more limiting in Iberian streams (summer and autumn). It is expected that these data will increase our understanding about the feeding behaviour of this common and widely distributed species.

Material and Methods

The study was conducted in the Sorraia system, which is described in Collares-Pereira et al. (1995) and Geraldes & Collares-Pereira (1995). The selected zones were the sites B and E here named as sites A and B respectively. Sampling was carried out in site B from October 1991 to October 1993 (Oct. 1991, Feb. 1992, May 1992, July 1992, Jan. 1993, Mar. 1993, June 1993, July 1993 and Oct. 1993), and in the same months with the exception of Jan. 1993, Mar. 1993 and June 1993 in site A. In these three months in this latter site, the number of individuals captured was not sufficient for analysis.

The fish were collected by electric fishing (350 V, 3-4 A, d.c) in a 50 m section at the same day period (10.00 h - solar hour) placed in ice immediately and frozen (-18°C) after. At least ten fish representative of the size range (40 to 273 mm of total length) of the species were examined in each period and at each site. For the diel feeding analysis fish from different sizes were collected in July 1993 and Oct. 1993 with two hours intervals during a 24 h period in the two sites.

To assess benthos availability, three to five samples of bottom fauna were collected in each site/period from Jan. 1993 to Oct. 1993 using a draw-net (mouth: 30 cm x 20 cm/mesh size 0.25 mm) by holding the net against the river bed and disturbing the area upstream during one minute, in several zones of the fish collecting sites. Sediment samples were also placed in ice and frozen.

Diet and Benthos Availability Analyses

The total gut contents of 535 fish was weighted (to nearest 0.001 g) and examined. A visual evaluation of the volume of plant material was made and categorised for absence (0%), presence (<50%) and dominance (>50%), and the presence of sand and mud were also recorded. Animal prey were identified by family and counted by reference to pieces that most often survive digestion. Relative importance of food categories including plant material and gravel was evaluated by calculating the percentage occurrence of all categories and the numerical percentage of each animal prey in the sample (Hyslop 1980). Variation in the mean total weight of gut contents relative to fish size (fullness index), and the total number of empty guts relative to total guts (vacuity index) were used to determine the seasonal activity pattern and the diel rhythm of feeding (Hyslop 1980).

Macroinvertebrates from benthic samples were identified to the family and counted. Benthos availability was evaluated by calculating the numerical percentage of each prey category per sampling period/site. The barbels were grouped into five length-classes according to Magalhães (1992) and Geraldes et al. (1993) to study the ontogenetic variation in diet composition. In relation to the spatio/temporal variation in the feeding activity and because our samples spanned in general the total size range in the collection, the data were gathered for analysis.

One way analysis of variance (ANOVA) was used to test for significant differences in the mean fullness index between sampled periods. Homogeneity of variances was tested by applying the Levene's test. An arcsine transformation of

the data was done (S o k a l & R o h l f 1981) to obtain uniform variance. When significant differences in the mean fullness index were detected, a multiple comparison test „Turkey b“ (Z a r 1984) was performed to distinguish differences between means from more than two groups. A G test for independence with William's correction (S o k a l & R o h l f 1981) was used to compare the absolute frequencies of empty guts across months. The same test was carried out to compare the frequencies of occurrence of plant material and the numerical frequencies of prey categories across seasons and across fish length-classes. When independence between variables was rejected, logical tests of subsets of rows and columns in the contingency table were carried out by a Simultaneous Test Procedure (STP). The Spearman rank correlation coefficient (Z a r 1984) was used to assess the relationship between the numerical percentage of prey in the gut contents and the numerical percentage of prey in benthos across months. It was also used to correlate the numerical percentage of prey in the benthos in all months and between both sites. The Strauss index (S t r a u s s 1979) was used to compare the diet with the availability of the potential food resources along months, and was calculated using numerical frequencies. The non-parametric Kruskal-Wallis test was used to test for significant differences in the mean fullness index along the diel cycles. Owing to the irregular captures during the 24 h period we gathered the cycle into three periods (morning 8-12 h; afternoon 14-20 h; and night 22-6 h). Significant differences between means were analysed through a „Turkey b“ test.

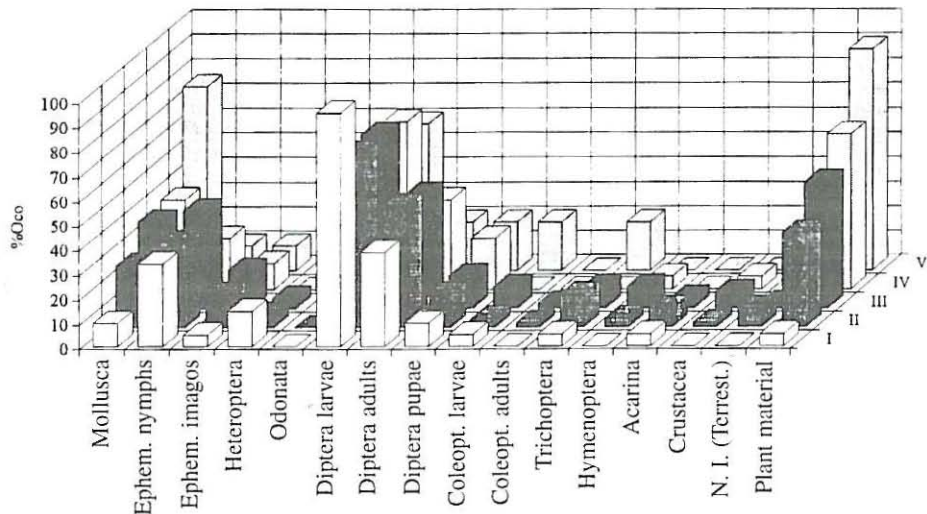


Fig. 1. Percentage occurrence of each item in the five length-classes of Iberian barbel *B. bocagei* at both sites combined. I (40-79 mm); II (80-119 mm); III (120-159 mm); IV (160-199 mm); V (>200 mm).

Results

Notable intraspecific variations in the diet composition of the five size-classes of barbel were found (Fig. 1, Table 1). The percentage occurrence of plant material, molluscs, and Diptera pupae increased with fish size (Fig. 1). Dipteran larvae we-

re the dominant prey items for every length-class, but were consumed in larger amounts by small fish. The ephemeropteran nymphs and dipteran adults occurred most frequently in the guts of medium-sized fish. Heteroptera occurred in higher frequencies in the smallest fish (class I), whereas Trichoptera and Coleoptera larvae occurred in the biggest (class V). Larger fish consumed predominantly molluscs, Trichoptera larvae and plant material, and the smaller fish took more dipteran larvae (Table 1). Some items like acarins, hymenopterans, coleopterans adults and larvae seem to be consumed in similar proportions by all size-classes due to the low numerical percentage found in gut contents.

Table 1. Intraspecific diet composition of Iberian barbel *B. bocagei*. Summary results of G-test of independence in both sites. Plant material (percentage occurrence); animal items (numerical percentage). The Simultaneous Test Procedure (STP) results are underlined. *P<0.05.

	I (40-79 mm)	II (80-119 mm)	III (120-159 mm)	IV (160-199 mm)	V (>200 mm)	GW	STP
Plant material	4.8	38.5	51.1	63.2	90.0	185.01*	<u>I II III V</u> IV
Mollusca (Sphaeriidae)	0.29	0.78	1.4	0.47	3.64	32.65*	IV <u>I II III V</u>
Ephemeroptera nymphs (Caenidae, Ephemerellidae, Baetidae)	3.5	4.4	3.7	2.0	0.26	41.92*	<u>V IV</u> I <u>II III</u>
Ephem. imagos	0.3	0.46	1.2	1.2	0.26	15.81*	<u>V IV I II</u> III
Odonata	0	0	0	0.036	0	0.92	<u>I II III IV V</u>
Heteroptera (Corixidae, Hebridae)	6.0	0.89	6.4	0	0	314.72*	<u>IV V I III</u> II
Diptera larvae (Chironomidae, Simuliidae, Ceratopogonidae, Dixidae)	87.2	85.9	81.2	82.0	87.5	36.19*	III IV V <u>I II</u>
Dipt. pupae	0.3	0.3	0.26	0.12	1.0	65.92*	<u>II I IV V</u> III
Dipt. adults	2.1	2.4	4.6	2.9	1.0	33.05*	<u>V I II IV III</u>
Coleoptera larvae	0.14	0.07	0.14	0	0.52	7.29	<u>I II III IV V</u>
Coleoptera adults	0	0.039	0.073	0	0	2.01	<u>I II III IV V</u>
Trichoptera (Hydropsychidae, Hydroptilidae, Ecnomidae)	0.14	0.54	0.47	0	4.7	71.78*	IV <u>I II III V</u>
Hymenoptera (Formicidae)	0	0.15	0.14	0.043	0	3.56	<u>I II III IV V</u>
Acarina	0.29	0.16	0.073	0	0	6.46	<u>I II III IV V</u>
Crustacea (Atyidae, Astacidae)	0	0.12	0.11	0.043	0	2.38	<u>I II III IV V</u>
N.I. (Terrest.)	0	0.16	0.036	0	0.26	6.03	<u>I II III IV V</u>

Spatio-Temporal Variation in the Diet Composition and Benthos Availability

The variation in the fullness index reflects some seasonal discontinuity in the barbel feeding activity (Fig. 2). At site A, the mean fullness index was significantly higher in July 1992 ($F = 10.1109$, $P < 0.01$). At site B, we could not detect a marked discontinuity, however some differences were found between the mean fullness index in Oct. 1991 and Mar. 1993 ($F = 2.4761$, $P < 0.05$). The high standard deviations observed suggested the existence of great individual differences in feeding intensity at all months but particularly in July 1992 at site A and in Oct. 1991 and June 1993 at site B. The vacuity index remained stable throughout the months (site A $G_w = 7.9020$ n.s. and site B $G_w = 13.0906$ n.s.).

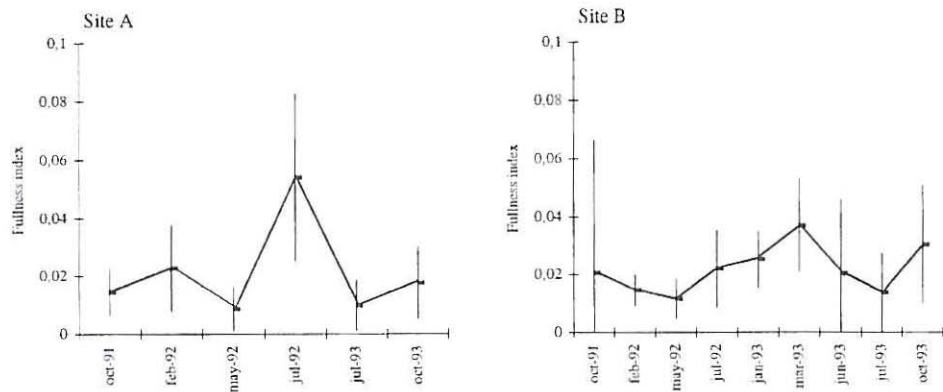


Fig. 2. Seasonal variation in the mean fullness index and respective standard deviations in Iberian barbel *B. bocagei* at sites A and B.

Plant material occurred more frequently in the diet during summer and autumn (Table 2) when it was more abundant. The major prey in barbel diet in every season were dipteran larvae. These larvae were consumed in higher proportions in winter months (Feb. 1992 at site A; Feb. 1992 and Jan. 1993 at site B). July 1992 and 1993 were the periods with lowest frequencies of dipteran larvae, corresponding exactly to an increase in the consumption of ephemeropteran nymphs. An increase in the consumption of these two last items was observed also in Oct. 1993 in site B. Dipteran adults were more common in the gut contents in July 1993 at site B, and in Feb. 1992 and Oct. 1993 at site A. Molluscs appear to have some importance in the feeding of the barbel, being consumed essentially in summer and autumn at site B, but in equal proportions in all months at site A. Coleoptera larvae were not very abundant, but were mostly consumed in July 1992 and Oct. 1993 at site A, and in lower proportions uniformly in all months at site B. Trichoptera larvae showed low frequencies in fishes captured in the winter (Feb. 1992) at both sites. Odonata, Heteroptera, Coleoptera adults and Crustacea were only present in the gut contents at site B. Heteroptera were consumed only in July 1992, and the remainder items were more rare and identically eaten during all months. The Hymenoptera and Acarina were also considered minor items, but consumed in similar quantities at both sites.

Table 2. Benthos availability (+ rare, ++ abundant, +++ very abundant) and seasonal diet composition of Iberian barbel *B. bocagei*. Summary results of the G-test of independence in site A and in site B. Plant material (percentage occurrence); animal items (numerical percentage). The Simultaneous Test Procedure (STP) results are underlined. *P<0.05.

Site A									
	Benth.	(1) Oct. 1991	(2) Feb. 1992	(3) May 1992	(4) July 1992	(5) July 1993	(6) Oct. 1993	GW	STP
Plant material		50.0	-	28.6	90.0	62.5	70.0	21.66*	<u>2 3 1 5</u> 4 6
Mollusca	+	0.1	0.4	0.6	7.7	5.4	2.4	11.05	<u>1 2 3 4 5 6</u>
Ephem. nymphs	+++	0.1	3.4	2.6	15.0	16.1	13.0	72.88*	<u>1 2 3 4</u> 5 6
Ephem. imagos		-	0.05	2.6	7.7	5.4	11.0	82.56*	<u>1 2 3</u> 4 5 6
Odonata	+	-	-	-	-	-	-	-	-
Heteroptera	+	-	-	-	-	-	-	-	-
Dipt. larvae	++	96.0	90.0	91.0	15.0	64.0	65.0	161.4*	<u>4 5 1 3</u> 6 2
Dipt. pupae	+	0.5	0.9	-	-	-	-	9.76	<u>1 2 3 4 5 6</u>
Dipt. adults	+	0.2	4.7	1.3	-	1.8	7.0	42.82*	<u>1 3 4 5</u> 2 6
Coleop. larvae	+	0.2	-	-	23.0	-	1.2	14.41*	<u>1 2 3 5 6</u> 4
Coleop. adults		-	-	-	-	-	-	-	-
Trichoptera	+	2.9	0.05	0.9	7.7	1.8	0.6	32.24*	<u>2 6 5 4 3</u> 1
Hymenoptera	+	-	-	-	7.7	1.8	-	2.52	<u>1 2 3 4 5 6</u>
Acarina	+	-	0.05	0.7	15.0	-	-	6.84	<u>1 2 3 4 5 6</u>
Crustacea	+	-	-	-	-	-	-	-	-
N.I. (Terrest.)	+	-	-	-	-	3.6	-	2.50	<u>1 2 3 4 5 6</u>

There was no significant difference between the benthic assemblages at the two sites (Spearman condition), and the only significant difference within a site was found between Oct. 1992 and June 1993 at site A ($r_s = 0.4461$). Significant differences were found between gut contents and benthos availability in each month/site.

The Iberian barbel showed positive selectivity (Table 3) for dipteran larvae in all months with the exception of July 1993 at site B ($s_i = -0.260$). The low availability of these larvae in July 1993 was correlated with an high positive selectivity for ephemeropteran larvae ($s_i = 0.211$) and dipteran adults ($s_i = 0.188$). In fact, barbel usually showed a negative preference for ephemeropteran larvae, but in summer (July 1993) this item seemed to have replaced the very rare dipteran larvae. Dipteran adults were usually consumed in the same proportion as they existed in the environment, but in summer (July 1993) they were positively selected. Conversely the dipteran larvae were positively selected in July 1993 at site A, and the ephemeropteran nymphs were not preferred in this month. Acarina was one of the most abundant item at site B, and was always negatively selected. All the other items were consumed nearly in the same proportion as they existed in the system, with the exception of molluscs which were negatively selected in Oct. 1993 ($s_i = -0.200$) at site B.

Table 2. (continued)

Site B

	Benth.	(1) Oct. 1991	(2) Feb. 1992	(3) May 1992	(4) July 1992	(5) Jan. 1993	(6) Mar. 1993	(7) June 1993	(8) July 1993	(9) Oct. 1993	GW	STP
Plant material		71.4	-	-	50.0	42.8	88.8	85.7	100.0	77.8	34.95*	<u>2 3 9 7 6 5 4 1</u> 8
Mollusca	+	2.2	0.1	0.7	0.5	0.9	1.0	7.0	3.5	3.0	66.86*	<u>2 3 4 5 6 1 7 9</u> 8
Ephem. nymphs	+	0.5	0.3	0.06	21.0	0.7	0.5	1.4	23.0	-	520.33*	<u>3 1 6 5 2 7 9</u> 4 8
Ephem. imagos		0.5	-	0.1	1.8	-	-	-	-	-	28.51*	<u>2 3 5 1 6 7 8 9</u> 4
Odonata	+	-	-	-	0.1	-	-	-	-	-	3.98	<u>1 2 3 4 5 6 7 8 9</u>
Heteroptera	+	-	-	-	32.9	-	-	-	-	-	992.25*	<u>1 2 3 5 6 7 8 9 4</u>
Dipt. larvae	++	94.0	97.0	89.0	41.0	96.0	92.0	83.0	35.0	79.0	1070.6*	<u>4 8 7 6</u> 1 6 9 2 5
Dipt. pupae	+	-	0.4	6.9	-	0.1	0.5	-	-	-	216.80*	<u>1 2 4 5 6 7 8 9</u> 3
Dipt. adults	+	2.2	2.6	3.4	2.5	2.3	3.8	3.9	19.0	9.0	20.79*	<u>4 9 5 1 2 3 6 7</u> 8
Coleop. larvae	+	-	-	-	-	-	-	0.3	-	0.3	12.85	<u>1 2 3 4 5 6 7 8 9</u>
Coleop. adults		-	-	0.1	-	-	-	-	3.2	-	10.93	<u>1 2 3 4 5 6 7 8 9</u>
Trichoptera	+	-	-	0.06	-	0.2	1.8	3.4	-	-	46.97*	<u>2 3 4 5 1 8 9</u> 6 7
Hymenoptera		0.5	-	0.1	-	-	-	0.3	9.7	-	8.21	<u>1 2 3 4 5 6 7 8 9</u>
Acarina	+++	-	-	0.06	-	0.1	-	-	3.2	-	9.62	<u>1 2 3 4 5 6 7 8 9</u>
Crustacea	+	-	-	-	0.8	-	-	0.3	-	-	10.62	<u>1 2 3 4 5 6 7 8 9</u>
N.I. (Terrest.)	+	-	-	-	-	-	0.3	-	3.2	6.0	8.92	<u>1 2 3 4 5 6 7 8 9</u>

Table 3. Values of electivity of Strauss index (Significant values are given in bold) for Iberian barbel *B. bocagei*.

	Site A		Site B				
	July 1993	Oct. 1993	Jan. 1993	Mar. 1993	June 1993	July 1993	Oct. 1993
Mollusca	-0.004	-0.061	-0.082	-0.077	-0.001	-0.122	-0.200
Ephem. nymphs	-0.379	-0.434	-0.313	-0.275	0.006	0.211	-0.105
Ephem. imagos	0.054	0.110	-	-	-	-	-
Odonata	-	-0.012	-0.003	-0.003	-	-0.002	-0.057
Heteroptera	0.054	-0.003	-0.015	-0.007	-	-	-
Dipt. larvae	0.280	0.421	0.647	0.670	0.538	-0.260	0.550
Dipt. pupae	-	-0.009	-0.017	-0.016	-0.004	-0.020	-0.066
Dipt. adults	0.018	0.070	0.023	0.038	0.039	0.188	0.09
Coleop. larvae	-	0.007	-0.003	-0.002	0.003	-	0.023
Coleop. adults	-	-	-	-	-	0.032	-
Trichoptera	0.014	-0.067	-0.024	0.005	0.032	-0.009	-0.019
Hymenoptera	0.014	-0.005	-	-	0.003	0.097	-
Acarina	0.025	-0.009	-0.198	-0.330	-0.610	-0.156	-0.260
Crustacea	-0.004	-0.002	-0.007	-	-0.002	-	-0.011
N.I. (Terrest.)	0.036	-	-0.001	0.001	-0.002	0.032	0.056

Diel Cycles

No significant differences were found in the feeding periodicity during the cycles with the exception for site A in July 1993 (Kruskall-Wallis $\chi^2 = 34.56$, d.f. = 12, $P < 0.01$) (Fig. 3). In this cycle, a significant difference was found between the fullness index at 18.00 h and the rest of the period (Turkey b test). This peak seems to be related with an occasional higher consumption of sand and gravel by all the individuals captured, leading to an important increase in the fullness index at that hour (Table 4).

The inexistence of significant differences among the three periods (morning, afternoon, night) in each cycle with the exception of site A/July 1993 as anteriorly referred to ($\chi^2 = 6.6953$, d.f. = 2, $P < 0.05$) were confirmed. In spite of the lack of a specific period of feeding activity, some differences in the consumption of distinct items through the three periods of the nyctemeral cycle were found. However, the slight differences in the consumption of some items through the three periods were not due to differences in the total length of the individuals captured in each period ($Gw_{\text{Site A/July 1993}} = 6.9034$ n.s.; $Gw_{\text{Site B/July 1993}} = 11.2918$ n.s.; $Gw_{\text{Site A/Oct. 1993}} = 15.2901$ n.s.; $Gw_{\text{Site B/Oct. 1993}} = 9.4733$ n.s.). It seems that the dominant prey item of the barbel's diet (dipteran larvae) was consumed essentially during the afternoon, with the exception of site B/Oct. 1993, and that the ephemeropteran nymphs were consumed in higher proportions in July 1993 as referred to and essentially during the morning and night periods. Other important items, like molluscs and trichopterans showed no consistent patterns as regards diel consumption.

Discussion

The observed feeding pattern in this Iberian barbel was characterised by the consumption of plant material and dipteran larvae and adults, associated to ephemeropteran nymphs, trichopteran larvae and molluscs. An identical general pattern was found by Granada-Lorenzo & Garcia-Novo (1981,

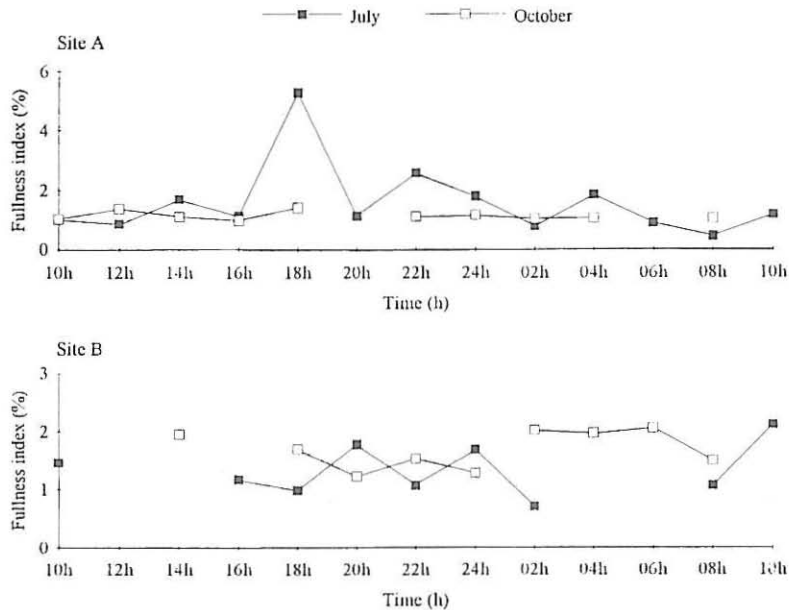


Fig. 3. Diel variation of fullness index in Iberian barbel *B. bocagei* at sites A and B.

Table 4. Mean percentage of occurrence of sand and gravel in the gut contents of Iberian barbel *B. bocagei* at each sampling hour along the diel cycles.

solar hours	July 1993		Oct. 1993	
	Site A	Site B	Site A	Site B
10.00 h	14.3	0	0	-
12.00 h	36.3	-	22.2	-
14.00 h	33.3	-	33.3	55.5
16.00 h	50.0	63.6	55.5	-
18.00 h	100.0	9.0	57.7	44.4
20.00 h	44.4	11.1	-	44.4
22.00 h	11.1	20.0	10.0	22.2
24.00 h	55.5	-	10.0	16.6
02.00 h	50.0	0	30.0	55.5
04.00 h	14.3	-	12.5	12.5
06.00 h	37.5	-	-	12.5
08.00 h	60.0	0	33.3	28.6
10.00 h	30.0	0	-	-

1986), Lobón-Cervía & De Diego (1988), Magalhães (1992, 1993), and Geraldés et al. (1993) for the same species. Similar results were also obtained for other *Barbus* species by Adámek & Obrdlík (1977), Kraiem (1980), Barak & Mohamed (1982) and Kumar et al. (1986). The ontogenetic differences in feeding activity seems, in fact, to be an effective mean to avoid intraspecific competition, as suggested by Magalhães (1992) for the same species, and for other *Barbus* species (Barak & Mohamed 1982; Kumar et al. 1986).

Although large barbel did not avoid small prey (dipteran larvae), they feed on greater amounts of large prey (molluscs, dipteran pupae) and on plant material. In fact, as reported by Magalhães (1992), we also observed that the percentage of occurrence of plant material, molluscs and dipteran pupae increased with fish size. Plant material was an abundant resource that allows a considerable drop in the cost of food searching, and may increase the growth rate and the densities of some species (Lessemark 1983; Persson 1983). The assimilation efficiency of plants by fish is low when compared with animal items, but this fact may contribute to reduce the intraspecific competition. According to Pinder (1986) and Magalhães (1992), the abundance of dipteran larvae in guts could be related to this later situation. Effectively, all size-classes exploit this most abundant item, but it was observed that these larvae were eaten in larger amounts by small fish, perhaps due to mouth morphology which can limit the ingestion of larger prey. The ephemeropteran nymphs and dipteran adults occurred most frequently in the guts of medium-sized fish (classes II to IV). These classes, especially class II (120-159 mm), showed a great variety of individual food preferences and a large diet spectrum, whereas smaller and larger ones showed a greater uniformity in prey utilization.

In the present study, some differences in spatio/temporal consumption of some items were found to occur independently of fish size. In relation to the principal items of barbel's diet, they were consumed in high quantities in both sites, although in a different way throughout the seasons. Dipteran larvae were consumed in higher proportion during winter months and with lower proportions during the summer. Conversely, plant material occurred more frequently in the guts during the summer and autumn, and less frequently in the winter. This temporal variation seems to be essentially related to changes of prey and plant availability in the system. The periods of low availability of aquatic invertebrates in temperate streams are summer and autumn (Hynes 1970), during summer is observed the emergence of the dipteran larvae (Oliveir 1971).

On the other hand, plant material during these seasons is found in great densities in temperate streams, due to algae and macrophytic blooms in summer and to the inputs of leaves and other plant material from the tree canopies in autumn. Other items like ephemeropteran nymphs and imagos clearly replace the consumption of dipteran larvae in summer. It seems that the increased consumption of Ephemeroptera during summer and autumn was directly related to the low availability of dipteran larvae in these seasons. Contrarily to what was described by other authors (Montañes & Lobón-Cerviá 1986; Lobón-Cerviá & De Diego 1988; Magalhães 1992), trichopteran larvae showed low frequencies during the winter (Feb. 1992). This fact can be explained because Feb. 1992 was an exceptionally dry month, possibly inducing an early emergence of the larvae.

In relation to the minor items, we could find some spatial differences in their consumption since Odonata, Heteroptera, and the Crustacea were never consumed by the barbels in site A. Geraldés et al. (1993) also did not find Heteroptera in the same site. However, as regards benthos availability, neither spatial nor temporal differences in the benthic assemblages were found, suggesting high spatial/temporal homogeneity of the prey, similar to the situation described by Lobón-Cerviá & De Diego (1988) for the River Moros (Douro drainage). However, significant differences were found between gut

contents and benthic availability in each month at each site, what may be explained by the existence of intraspecific variation in the feeding pattern and/or by the existence of feeding migrations coupled with a particular foraging behaviour in some months. Regarding the first aspect, in fact ontogenetic variations in the feeding pattern were found to occur, and for the second one according to Kraiem (1980), barbels can undertake short feeding migrations, allowing the exploitation of diversified food niches. Also a positive selectivity for dipteran larvae was seen in all months, with the exception of site B/July 1993, where a „non preference“ for these larvae, associated to a positive selectivity for ephemeropteran nymphs and dipteran adults, were detected. These two last items were usually not selected by the barbel in the other periods. The dipteran adults were in general consumed in the same proportion as they exist in the environment, but in July 1993 they were positively selected probably due to their high abundance resulting from the emergence of the dipteran larvae (Mason & MacDonald 1982). As described by several authors Iberian barbel does not show very selective food requirements but tends to eat the dominant available groups. This was suggested by Lobón-Cerviá & De Diego (1988), Magalhães (1992, 1993), Geraldés et al. (1993), and is supported by the present results.

In the two nyctemeral cycles studied the barbel fed throughout the 24 hours. The peak at 18.00 h in site A/July 1993 can be explained by an occasional consumption of sand and gravel by all the individuals captured at that time. These indigestible elements increased the gastrointestinal contents weight of these fishes increasing the mean fullness index. However in a similar study, also in a lotic system, Encina & Granado-Lorencio (1991) found that *B. sclateri* was a daylight feeder. The temporal cost of feeding is related to the type of food ingested, and the amount with the energy content of the diet. For fish consuming low energy diets, like the barbel, large amounts of food must be processed per energy gain unit. So these fish feed continuously or, at least, over long time periods relative to digestion time (Diana 1979; Encina & Granado-Lorencio 1991).

The temporal differences in the mean fullness index observed between summer and autumn in site A could be due to higher food consumption in this site (site with lower depth), especially during summer owing to the increase of water temperature, as demonstrated by Léonard & Poncin (1993) for other barbels. In conclusion, we have confirmed that this Iberian barbel feeds more or less continuously during the 24 hours period upon benthic resources. However, it has, in fact, an high ability to react to seasonal, local and diurnal changes of food availability and to switch to one or few items when they become common, even being of low energy supply. Such a generalist and opportunistic foraging behaviour may possibly explain the apparent success of this species in colonizing unstable habitats.

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