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Length relationships of cyprinid prey in diet analysis of Eurasian otter *Lutra lutra* in Mediterranean habitats

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A b s t r a c t . Relationships between bone size and body length are reported for common Iberian barbel *Barbus graellsii*, Iberian nase *Chondrostoma miegii* and chub *Leuciscus cephalus* from the Ebro River basin. Linear regression was used to analyse possible relationships between bone and fish length and multiplicative regression to investigate relationships between bone size and body weight. All generated regressions were highly significant and displayed high coefficients of determination (> 0.89). No differences were found between the generated regressions and other relationships reported for similar species. Therefore, we suggest that our regressions might be used for other Mediterranean species belonging to these genera.

Key words: dietary preferences, Ebro River basin, *Barbus graellsii*, *Chondrostoma miegii*, *Leuciscus cephalus*

Introduction

Identification of bones in faecal remains, pellets or guts is the most common method of analysing the diet of piscivorous species (e.g. E r l i n g e 1969, C h a n i n 1981, B r i t t o n & S h e p h e r d 2005). However, studies on feeding ecology generally require more information than just diet composition. The knowledge of the size of the prey is an essential tool in the study of a piscivorous species' dietary preferences and its interactions with prey species (H a n s e l et al. 1988, K l o s k o w s k i et al. 2000).

Indeed, prey size selection has been analysed for several ichthyofagous species, e.g. common kingfisher *Alcedo atthis* (Linnaeus, 1758) (C a m p o s et al. 2000) and pikeperch *Sander lucioperca* (Linnaeus, 1758) (T u r e s s o n et al. 2002). Regarding the Eurasian otter *Lutra lutra* Linnaeus, 1758, some recent studies consider prey size in otter diet analysis (e.g. T a a s t r o m & J a c o b s e n 1999, K l o s k o w s k i et al. 2000, C o p p & R o c h e 2003, B r i t t o n & S h e p h e r d 2005). Furthermore, the relationships between bone length and body measures have been obtained for various fish species (e.g. W i s e 1980, L i b o i s et al. 1987, L i b o i s & H a l l e t - L i b o i s 1988, C o p p & K o v á č 2003, H á j k o v á et al. 2003), which are common prey of otters in Central and North Europe.

In Iberian Mediterranean habitats, otter diet composition is different from that in the rest of Europe, demonstrating higher trophic diversity than in temperate areas, possibly in response to a reduction in the diversity and abundance of their main prey (C l a v e r o et al. 2003). Fish species diversity is lower than in the rest of Europe (R u i z - O l m o & P a l a z ó n 1997) being mainly cyprinids of the genera *Barbus*, *Chondrostoma* (R u i z - O l m o et al. 2001) and *Leuciscu*s in decreasing order of importance (with the latter species only in some places of Eastern Spain; e.g. R u i z - O l m o & P a l a z ó n 1997).

In the present study, common Iberian barbel *Barbus graellsii* Steindachner, 1866, Iberian nase *Chondrostoma miegii* Steindachner, 1866 and common chub *Leuciscus cephalus* Linnaeus, 1758 from the Ebro River basin (NE of Spain) were selected as representative models of the respective genera in Iberia (see D o a d r i o 2001), since they are the most representative prey species in the diet of otters in this region (R u i z - O l m o et al. 2001). The present study attempts to determine relationships between bone length and body measures in these species, with particular emphasis in otter diet in the Ebro basin (R u i z - O l m o & P a l a z ó n 1997).

Material and Methods

Specimens of *B. graellsii* were collected in February 1992 from the River Arga (Falces, Navarra 42º 23' N 1º 47' W), *C. miegii* from the River Araquil (Ibero, Navarra 42º 48' N 1º 46' W) in February 1992, and *L. cephalus* from the River Anyet (Sant Climent Sescebes, Girona 42º 25' N 2º 58' E) in March 1994.

Fish were captured by electrofishing and preserved on ice, but not frozen. In the laboratory, the specimens were measured to the nearest mm for standard length (SL) and nearest 0.001 g for weight. Subsequently, the fish were boiled until the flesh was easily removed; the labelled bones were left to air dry and then were stored in the Zoology Museum of the University of Navarra (Pamplona, Spain).

We measured the dentaries, maxillae, premaxillae and pharyngeals as recommended by P r e n d a & G r a n a d o - L o r e n c i o (1992), and the cleithra and opercula as per H a n s e l et al. (1988), along the longest axis, as described in the literature (see C o p p & K o v á č 2003 and H á j k o v á et al. 2003). The bones were viewed using a binocular magnifying glass and Zeiss clear camera. Images were measured to the nearest 0.01 mm using a digitising tablet (Genius HISKETC 1212 model; IDRISI program). Measurements of the right and left bones were tested for significant differences (paired students' t-test).

Standard length (SL) and weight (W) were regressed against bone lengths. Linear regressions were generated for the SL relationships ($SL = bBL + a$), and multiplicative ($W = aBL^b$) for the weight relationships, where BL is the bone length (mm), a is the intercept of the regression curve and b the regression coefficient.

Results and Discussion

Significant differences were found between some of the paired bones from nase (cleithrum $t = 3.94$, $df = 39$, $p = 3.27 \times 10^{-4}$; pharyngeal $t = 4.21$, $df = 45$, $p = 1.19 \times 10^{-4}$) and chub (cleithrum $t = 3.73$, $df = 43$, $p = 4.60 \times 10^{-4}$; operculum $t = 5.90$, $df = 43$, $p = 5.03 \times 10^{-7}$), and regressions were considered independently for both sides. Asymmetric growth and development of cyprinids has been widely described (e.g. R a c z y n s k i & Z d z i s l a w 1997) and it seems common to these species of fish , although similar studies found no significant differences between different sides (e.g. H a n s e l et al. 1988, C o p p & K o v á č 2003).

All generated regressions (Table 1) were highly significant and displayed high coefficients of determination (> 0.89).

Similar relationships for closely related species (*Barbus sclateri*, *Chondrostoma wilkommii* and *Leuciscus pyrenaicus*) have been reported by P r e n d a & G r a n a d o - L o r e n c i o (1992) and by C o p p & K o v á č (2003) and B r i t t o n & S h e p h e r d (2005)

Table 1. Number of specimens, regression slope, intercept values, and coefficients of determination for linear and multiplicative relationships of standard length (SL) and body weight (W) regressed against bone sizes (mm) for the left and right sides of Iberian barbel and nase and common chub from the River Ebro basin, Spain.

			Independent variables											
			pharyngeal		cleithrum		operculum		dentaries		maxillae		premaxilae	
Species			right	left	right	left	right	left	right	left	right	left	right	left
Ebro	SL	N	75	78	76	78	78	59	63	62	55	59	45	42
barbel		r^2	0.985	0.984	0.991	0.991	0.988	0.986	0.986	0.987	0.985	0.985	0.975	0.973
		a	-5.165	-2.172	-4.408	-4.203	7.723	6.639	9.235	7.441	16.608	16.969	24.605	25.077
		b	11.810	11.628	6.769	6.814	9.149	9.220	14.827	15.017	11.687	11.597	15.196	15.215
	W	r^2	0.987	0.982	0.990	0.990	0.987	0.986	0.978	0.979	0.982	0.983	0.976	0.974
		a	0.019	0.025	0.004	0.004	0.027	0.025	0.089	0.084	0.082	0.086	0.270	0.266
		b	3.188	3.081	3.117	3.120	2.867	2.888	2.961	2.986	2.776	2.756	2.653	2.663
Ebro	SL	N	46	46	43	43	42	40	33	32	23	22	20	19
nase		r^2	0.942	0.920	0.973	0.972	0.980	0.979	0.937	0.929	0.938	0.948	0.944	0.952
		a	-0.645	-1.706	-9.993	-12.867	-3.209	-4.421	-31.456	-33.052	-25.092	-24.973	-27.798	-26.581
		b	13.021	12.608	7.088	7.144	11.395	11.479	21.132	21.311	22.024	22.036	25.201	24.766
	W	r^2	0.938	0.929	0.972	0.973	0.976	0.978	0.892	0.891	0.925	0.938	0.909	0.934
		a	0.035	0.030	0.002	0.002	0.017	0.017	0.027	0.028	0.017	0.018	0.022	0.023
		b	3.042	3.077	3.356	3.388	3.139	3.136	3.550	3.524	3.987	3.970	4.075	4.037
chub	SL	N	45	45	44	45	45	44	26	26	28	27	25	27
		r^2	0.994	0.989	0.997	0.997	0.996	0.995	0.982	0.981	0.976	0.980	0.978	0.967
		a	-1.474	-3.859	-3.320	-2.814	-0.722	-1.008	-8.204	-8.547	-6.256	-8.872	-11.277	-5.456
		b	11.831	11.921	6.354	6.437	10.228	9.982	15.965	16.073	16.423	16.878	19.937	18.666
	W	r^2	0.991	0.990	0.995	0.994	0.995	0.990	0.967	0.961	0.953	0.954	0.944	0.943
		a	0.028	0.020	0.003	0.003	0.019	0.020	0.071	0.069	0.082	0.074	0.092	0.112
		b	3.051	3.171	3.160	3.130	3.040	2.988	2.960	2.975	2.961	3.020	3.142	3.003

for *Leuciscus cephalus*. No particular differences are found on the comparisons of those and the values obtained in this study. According to C o p p & K o v á č (2003), this indicates that the relationships between bone and body measurements are relatively stable within species or closely related species, independently of their geographic origin. Common barbel and nase of the Ebro basin are abundant, although endemic to this basin; the chub is widely spread over Eurasia (B ă n ă r e s c u 1999), but in the Iberian Peninsula it is only distributed on the Northeast (D o a d r i o 2001). However, the skeletal morphology of these and other species of Mediterranean barbel, nase and chub (see D o a d r i o 2001) is very similar (E l v i r a 1997, M i r a n d a & E s c a l a 2003, 2005). In the absence of species specific relationship for body-to-bone lengths (except those reported by P r e n d a & G r a n a d o - L o r e n c i o 1992), our regressions may be use to estimate the size of species of the some genus or family.

A c k n o w l e d g e m e n t s

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