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THE DIET OF INTRODUCED LARGEMOUTH BASS, *MICROPTERUS SALMOIDES*, IN THE NATURAL PARK OF THE RUIDERA LAKES, CENTRAL SPAIN

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ABSTRACT

The diet of largemouth bass, *Micropterus salmoides*, was investigated in the Natural Park of the Ruidera Lakes, Guadiana River basin, central Spain, where it has been stocked since 1963. Stomachs of 226 largemouth bass (fork length range 3.6 to 41.0 cm, mean 14.67 cm; weight range 0.8 to 1460 g, mean 97.48 g) were examined. The frequency of empty stomachs was low (30.5%) and the diet consisted of crustaceans (Cladocera, Decapoda chiefly the introduced red swamp crayfish, *Procambarus clarkii*, and Notostracea), insect larvae and adults (chiefly Diptera, Ephemeroptera, Coleoptera and Homoptera), other invertebrates (Oligochaeta, Aranea and Acari) and fish (chiefly the introduced pumpkinseed, *Lepomis gibbosus*, and the native freshwater blenny, *Blennius fluviatilis*). Cladocera and insects were important prey in terms of numbers and frequency of occurrence for young largemouth bass. However, fish and crayfish became increasingly important for large specimens, being almost the only prey for largemouth bass longer than 20 cm.

Key words: largemouth bass, *Micropterus salmoides*, feeding, introductions, predation, Spain

1. INTRODUCTION

The largemouth bass or black bass, *Micropterus salmoides* (Lacépède), as well as other truly predaceous fish was originally absent from the Iberian Peninsula, where it was first stocked for angling purposes in 1955 (Elvira 1995a). The present distribution in Spain includes most of the large river basins (Doadrio *et al.* 1991; Elvira 1995b).

The largemouth bass is known to become increasingly piscivorous as it grows (Heidinger 1976) and is considered to be a serious threat to native Spanish fishes (Elvira 1990, 1995a, b, c, 1996). However, detailed studies on its diet in Spain (Sánchez-Isarria *et al.* 1988, 1989, Rodríguez-Jiménez 1989) and Portugal (Godinho, Ferreira 1994) are still scarce. Further data on its biology (i.e. length-weight relationships, age and growth) in the Iberian Peninsula were given by Sánchez-Isarria *et al.* (1990) and Godinho, Ferreira (1993).

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The fish community of the Natural Park of the Ruidera Lakes consists of nine native species (eight of them Iberian endemics), and six well-acclimatized, introduced species (Almodóvar, Elvira 1994). Largemouth bass were introduced in Ruidera in 1963 (Elvira, García-Utrilla 1991) and are presently widespread and common (Almodóvar, Elvira 1994). The aim of this research was to study both diet and predator-prey interactions of largemouth bass with native and exotic fishes.

2. MATERIAL AND METHODS

The Natural Park of the Ruidera Lakes is a protected territory comprising fourteen lakes and a reservoir joined by short streams. It forms part of the upper Guadiana River basin (central Spain; 39°00' N, 3°00' W). Biotic and abiotic characteristics of the area are extensively described in Almodóvar, Elvira (1994) and Elvira *et al.* (1996).

Largemouth bass were caught in running waters by electrofishing, between Rey Lake and Peñarroya Reservoir, from September 1991 to May 1993. This is a highly disturbed area where native fishes are now nearly extinct (see Almodóvar, Elvira 1994). All fish were measured for fork length (to within 1 mm) and weight (to within 1 g), before being injected with and placed into a 8% formalin solution.

The stomachs of 226 largemouth bass (fork length range 3.6 to 41.0 cm, mean 14.67 cm; weight range 0.8 to 1460 g, mean 97.48 g) from all seasons were dissected. Prey were identified as far as possible, counted and weighed (wet weight).

Frequency of occurrence was determined omitting empty stomachs. Numerical frequencies of each prey category were also calculated and together with their weight were expressed as a percentage (Hyslop 1980). The relative importance index (RI) was used (Hyslop 1980), as follows:

$$RI = 100\ AI / \sum_{1}^{n} AI$$

where: AI – % occurrence + % total numbers + % total weight, and n – number of prey categories.

Four arbitrary size intervals of largemouth bass were considered for data analysis: less than 10 cm (N = 35), 10.1 to 15 cm (N = 67), 15.1 to 20 (N = 33), and greater than 20 cm (N = 21). A G-test (Zar 1984) was used to compare the frequencies of empty stomachs across seasons, and the RI values of main prey groups across seasons and along the different size intervals.

3. RESULTS

The overall frequency of empty stomachs was 30.5%. Seasonal variation showed a significant discontinuity ($G = 47.72$, $p < 0.001$) in largemouth bass feeding activity. Winter appeared as the period of less activity, with 58.8% of empty stomachs.

The diet of largemouth bass comprised 21 food categories (Table I). Red swamp crayfish, *Procambarus clarkii* (Girard), were the most common prey (32.48% occurrence); followed by Cladocera (28.02%); pumpkinseed, *Lepomis gibbosus* (L.), (19.74%); Diptera (17.83%); Ephemeroptera (15.29%), and freshwater blenny, *Blennius fluviatilis* Asso, (12.10%). Numerical frequency of Cladocera (85.95%) was significantly the highest, followed by Diptera (6.82%), with the remaining prey categories representing fewer than 2%. Pumpkinseed

were the most common prey in wet weight (59.92%), followed by crayfish (29.61%) and freshwater blenny (6.43%).

Table I. Diet of 226 largemouth bass from the Ruidera Lakes, central Spain. Frequencies of occurrence (Fq.), numbers (No.), wet weights (Wt) and relative importance index (RI) are indicated for each prey category

Prey category	Fq. (%)	No. (%)	Wt (%)	RI
Oligochaeta	0.64	0.03	0.31	0.28
Aranea	0.64	0.05	$6.4 \cdot 10^{-4}$	0.20
Acari	1.27	0.05	$1.3 \cdot 10^{-3}$	0.38
Crustacea				
Notostracea	0.64	0.03	$6.4 \cdot 10^{-4}$	0.19
Cladocera	28.02	85.95	1.67	33.07
Decapoda				
Procambarus clarkii (Girard)	32.48	1.59	29.61	18.21
Insecta				
Ephemeroptera (nymphs)	15.29	1.80	0.07	4.91
Odonata (nymphs)	1.91	0.08	0.01	0.57
Ortoptera	0.64	0.03	0.02	0.20
Plecoptera	0.64	0.03	$6.4 \cdot 10^{-4}$	0.19
Hemiptera	3.18	0.18	0.05	0.98
Homoptera	4.46	0.68	0.06	1.49
Coleoptera (larvae, adult)	5.09	0.37	0.17	1.61
Diptera (larvae, pupae, adult)	17.83	6.82	0.26	7.12
Himenoptera	1.91	0.34	0.13	0.68
Insecta indet.	0.64	0.03	$6.4 \cdot 10^{-4}$	0.19
Osteichthyes				
Cyprinidae	0.64	0.03	$6.4 \cdot 10^{-4}$	0.19
Lepomis gibbosus (L.)	19.74	1.23	59.92	23.13
Micropterus salmoides (Lacépède)	0.64	0.03	1.21	0.54
Blennius fluviatilis Asso	12.10	0.63	6.43	5.48
Teleostei	1.27	0.05	0.04	0.39

The relative importance index (RI), emphasized significant differences between larger largemouth bass (greater than 20 cm) and the smaller specimens (Fig. 1A). Cladocera had a great importance for the first three sizes ($G = 61.25$; $p < 0.001$). While insects were important prey for smaller largemouth bass ($G = 38.82$; $p < 0.001$), they were present in all sizes. Crayfish and fish were also present in all sizes, but rose in importance with increasing fish size ($G = 32.56$; $p < 0.001$). For largemouth bass greater than 20 cm, crayfish and fish were the most important prey (RI = 97.30% as a whole).

Figure 1B shows the change of the relative importance index of main prey groups across seasons. Insects were significant prey in spring and summer

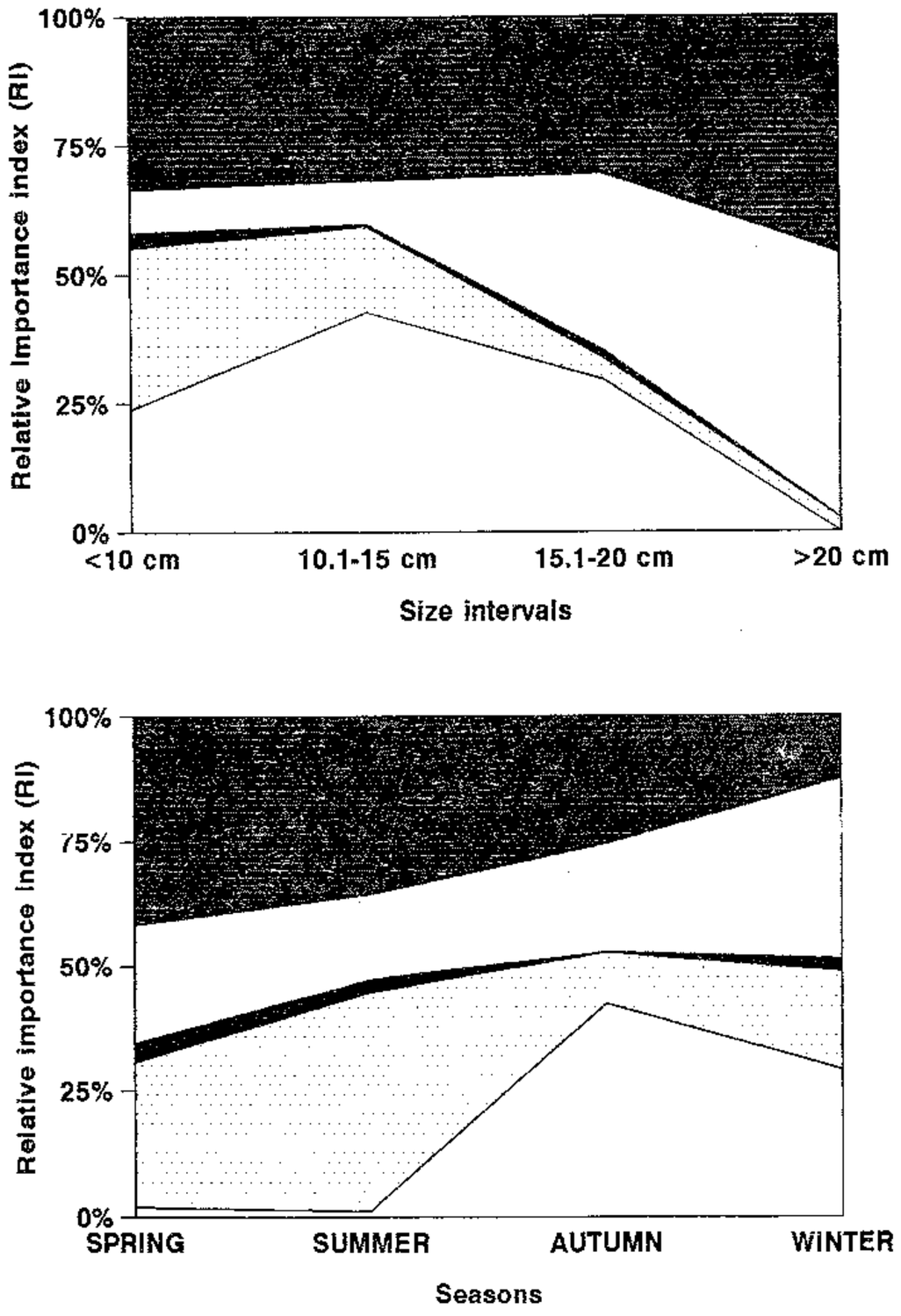

Fig. 1. Relative importance index (RI) of main prey groups with respect to (A) four size groups of largemouth bass, and (B) four seasons

(G = 24.12; $p < 0.001$), while Cladocera were in autumn and winter (G = 82.57; $p < 0.001$). The RI values of crayfish did not vary significantly throughout the year, with the highest value in winter. Meanwhile, the importance of fish declined significantly from spring to winter (G = 18.71; $p < 0.001$).

4. DISCUSSION

The present study considered a mostly riverine largemouth bass population in lower streams of the Natural Park of Ruidera, where native cyprinid populations are currently absent (Almodóvar, Elvira 1994), but pumpkinseed and red swamp crayfish are quite abundant and can be an easy prey for largemouth bass. The pumpkinseed was first reported in Ruidera by Elvira, García-Utrilla (1991), where it may have been stocked during the 1980s. Meanwhile, the red swamp crayfish was first stocked in Spain in 1973.

The present results are similar to those found by Godinho, Ferreira (1994) in four reservoirs of southern Portugal, where, however, the fish prey were all exotic (*Lepomis gibbosus* and *Micropterus salmoides*). Furthermore, the minimum size of piscivory found in Ruidera was low (6.3 cm) and close to that reported by Traxler, Murphy (1995).

One of the most remarkable findings of this study was that the native freshwater blenny, an endangered fish in Spain (Elvira 1995c, 1996) was frequently taken even though this bottom-living and evasive fish is probably not an easily available prey for the largemouth bass. For this reason, control and monitoring of the largemouth bass population, as well as of pike, *Esox lucius* L. (Elvira *et al.* 1996), have to be urgent measures of conservation to be implemented in the Natural Park.

Rodríguez-Jiménez (1989) studied the feeding habits of largemouth bass in a reservoir of the lower Guadiana River basin, Spain, where the present fish assemblage is similar to that found in Ruidera. There, small specimens predominantly consumed invertebrates, and only occasionally mosquito fish, *Gambusia holbrooki* (Girard), and red swamp crayfish. Unfortunately, Rodríguez-

-Jiménez (1989) failed in his attempt to determine the eventual predation of largemouth bass on fish, because he did not sample specimens longer than 18 cm.

Elsewhere in Spain, Sánchez-Isarria *et al.* (1988) described the diet of largemouth bass from two reservoirs of the Llobregat River basin, and Sánchez-Isarria *et al.* (1989) from a reservoir of the lower course of the River Ebro. In both cases, largemouth bass longer than 20 cm preferently fed on fish and amphibians. Many of the fish prey were native species of the genera *Barbus*, *Chondrostoma* and *Leuciscus*.

After the former known data and the results presented here, it can be concluded that introduced largemouth bass in the Iberian Peninsula mainly feed on invertebrates when young and shift to prey on fish and crayfish when adult. Common prey fish are endemic cyprinids (*Barbus*, *Chondrostoma*, *Leuciscus*, etc.), but in disturbed environments, where native fish are scarce or have been removed, larger largemouth bass prey on other successfully introduced species, such as the pumpkinseed and the red swamp crayfish. In fact, such feeding behaviour has already been documented in its natural and other recently colonized habitats (Heidinger 1976). Thus, Hickley *et al.* (1994) studied the diet of largemouth bass acclimatized in Lake Naivasha, Kenya. There, the introduced red swamp crayfish was also the principal food for largemouth bass over 26 cm (52% occurrence, 63% abundance). The fish community of that lake was also highly disturbed, since the only native species is extinct and the five species currently present are introduced.

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