TROPHIC ECOLOGY OF THE TENCH, *TINCA TINCA* IN TWO DIFFERENT HABITATS IN NORTH-WEST OF SPAIN

by

Gustavo GONZÁLEZ, Raquel A. MAZÉ, Josefa DOMÍNGUEZ & José C. PENA (1)

ABSTRACT. - The habitats preferred by the tench are characteristically sheltered and shallow with abundant vegetation. Two typical habitats were selected: a river branch and a lake where this cyprinid is abundant. With the aims to understand the relationship between tench food and the macroinvertebrate community and to detect the possible feeding differences between the two populations studied throughout the year, samplings were carried out seasonally and the physico-chemical characteristics of the water and the abundance and biomass of the macroinvertebrates were analyzed. Tench were caught by electro-fishing in order to examine gut contents. Chironomid larvae are the preferential prey in both habitats. Also preferential are the gastropods in the river branch and small crustaceans in the lake. The results obtained suggest that tench is a rather unselective, generalist predator on the invertebrate community.

RÉSUMÉ. - Écologie trophique de la tanche, *Tinca tinca*, dans deux habitats différents du nord-est de l'Espagne.

Les habitats préférés par la tanche sont les eaux peu profondes avec une abondante végétation. Deux habitats typiques ont été sélectionnés: un bras mort d'une rivière et un étang naturel peuplé de Cyprinidae. Les objectifs de cette étude étaient de comprendre la relation entre nourriture et proies (macroinvertébrés présents dans le milieu), et d'estimer les possibles différences existant entre les deux populations de tanches étudiées. L'échantillonnage a été saisonnier. Les caractéristiques physico-chimiques de l'eau, l'abondance et la biomasse des macroinvertébrés on été analysées. Les tanches ont été capturées par pêche électrique et les contenus stomacaux étudiés. Dans les deux lieux d'étude les larves de Chironomidae constituent les proies préférentielles. Les groupes-proies suivant sont les Gastéropodes dans le bras mort et les micro-crustacés dans l'étang. Les résultats obtenus confirment que la tanche est un poisson généraliste vis-à-vis des invertébrés colonisant ces milieux.

Key words. - Cyprinidae - *Tinca tinca* - Spain - Trophic ecology.

Tench, *Tinca tinca* (Linnaeus, 1758), is widely distributed in Europe and Asia, and has been introduced into America, South Africa and Australia (Rosa, 1958). More specifically this species is appreciated from a sport-fishing viewpoint and has traditionally been cultivated in Great Britain and Central Europe (Wright and Giles, 1991). Lozano (1935) mentions the tradition in Spain, mainly in Salamanca and Extremadura, of cultivating it in ponds because of its excellent flesh. This has favoured its wide distribution by human translocation (Velasco *et al.*, 1997). Nevertheless, natural propagation of this species is difficult due to some environmental and biological limiting factors (Fernández San Juan, 1995).

---

(1) Universidad de León, Departamento de Biología Animal, Campus de Vegazana, 24071 León, SPAIN. [dbajpa@unileon.es]

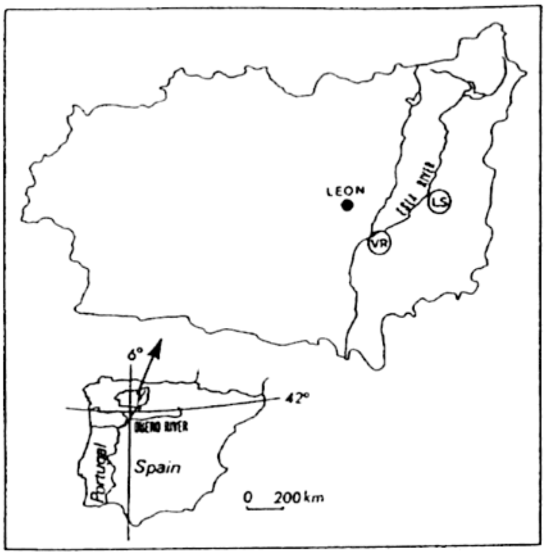

Fig. 1. Situation of sampling sites. VR: Villarroañe, SL: Sentiz lake.

In spite of this and although it is nowadays quite common in Europe, *Tinca tinca* is considered a species whose habitat must be preserved if we do not wish to run the risk of having to artificially support its natural population (Lelek, 1987).

Few studies have dealt with tench biology and none in Spain, except when it has been included in general ones (Granado Lorencio and García Novo, 1981, 1986) or in experimental systems (Pérez Regadera *et al.*, 1995).

The aim of this study is to contribute to a better knowledge of the trophic ecology of the tench.

Two sites representative of typical tench habitats were chosen in the province of León, the north-western limit of their distribution in Spain: a lake system and a river branch. We have analysed the relationships between tench diet and the existing macrobenthic community, and tried to detect differences in diet between tench populations in these two habitats.

Description of the study site

The two sites chosen for this study are located in the province of León (NW Spain). They are characteristic of those habitats considered ideal for *Tinca tinca*: sheltered and shallow waters with abundant vegetation (Wright and Giles, 1991).

Villarroañe: the chosen stretch is a branch of the river Esla, a tributary of the Duero (Fig. 1) at the Villarroañe junction (M.T.U. coordinates 30T TN 9306, 796 m above sea level), which receives the waters from an irrigation channel. It is approximately 130 m long, 2 to 15 m wide, and on average 1.4 m deep. The substrate consists in a large accumulation of mud and the dominant hydrophyte vegetation is composed of *Ceratophyllum demersum* L. with *Ranunculus penicillatus* (Dumort.) only in areas with some current. On the margins, vegetation is dominated by the helophytes *Sparganium erectum* L. and, to a lesser extent, *Typha latifolia* L., *Veronica anagallis-aquatica* L., *V.*

becabunga L., and the hydrophytes *Lemna minor* L. and *Callitriche* spp. Woody vegetation of the *Salix* genus exists on both banks.

The fish community consists of tench, pike, *Esox lucius* L., and gudgeon, *Gobio gobio* (L.), which represent on average 46%, 26% and 28%, respectively, of the fish assemblage. Carp, *Cyprinus carpio* L., is occasionally found.

Sentiz lake: this small lake, measuring approximately 5 hectares, is near Valdepolo (M.T.U. 30T UN 1814) (Fig. 1). It is located on an easily erodible ground at a height of 940 m a.s.l.. Fed by a spring it only dries up completely in years of very pronounced drought, which is exceptional.

The dominant vegetation are hydrophytes, mainly *Myriophyllum alterniflorum* DC. *Scirpus lacustris* L. subsp. *lacustris* is found to a lesser extent, especially in the western area of the lake. It is surrounded by two plant belts; the outer one is composed of *Juncus* sp., *Agrostis stolonifera* L. and *Carex hirta* L., as the most representative species; the inner one are helophytes and they basically consists of *Eleocharis palustris* (L.) and *Antinoria agrostidea* (DC.), with *Glyceria fluitans* (L.), *Polygonum amphibium* L., *Ranunculus peltatus* Schrank and *Potamogeton natans* L. occasionally being found (Fernández Aláez, 1984).

The fish community consists only of tench and red roach, *Rutilus arcasii* (Steindachner), that represent on average 63% and 37%, respectively, of the fish assemblage.

MATERIALS AND METHODS

Four sampling points were selected in the Sentiz lake and two in the Villarroañe branch. These stations were sampled seasonally: winter, spring, beginning of summer, end of summer and autumn.

Physico-chemical parameters

Water was collected from each sampling point for later analysis in the laboratory using normalized methods (APHA-AWWA-WPCF, 1989). In addition, temperature, pH, conductivity and oxygen were determined directly at each sampling point.

Macroinvertebrates

Samples were taken to study the macroinvertebrate fauna at the same points, and also seasonally. The soft bottoms were sampled using a 500 cm^3 volume, 226 cm^2 attack surface van Veen grab, with three replicates being collected at each sampling point. At the same time, the macroinvertebrates associated with the submerges macrophytes were collected by dragging three times each point with a plankton net.

Macroinvertebrates were separated in a 0.3 mm mesh sieve and using a binocular magnifying lens. Determination was up to the taxonomic level that was estimated a priori as sufficient to compare with the gut contents.

The Shannon index (Shannon and Weaver, 1949) was used to calculate diversity, and the Pielou method (1966) for uniformity.

Ordination and classification of the taxa and sampling points at the different times of the year was carried out using a two-way indicator species analysis -TWINSPAN- (Hill, 1979) and a Canonical Correspondence Analysis -CCA- with the CANOCO programme (Ter Braak, 1991). The abundance of the taxa collected with the grab and determined at the lowest level, including only those that appeared in more than one sample,

Table I. - Physico-chemical characteristics of both localities studied following the seasons. T: Temperature; Cond: Conductivity; O_2: Oxygen content; TSS: Total suspended solids; COD: Chemical demand of oxygen; T.H.: Total hardness; SO_4: Sulphates; CL^-: Chlorides; NO_3^-: Nitrates; NH_4: Ammonium; TKN: Kjeldahl total nitrogen; P_T: Total phosphorus.

	Sentiz lagoon					**Villarroañe**					
	Winter	**Summer**	**Late summer**	**Autumn**	**$\overline{X}$ (± SD)**	**Winter**	**Spring**	**Summer**	**Late summer**	**Autumn**	**$\overline{X}$ (± SD)**
T (ºC)	7.7	19.4	22.0	11.0	15.0 (± 5.9)	5.7	13.6	14.8	17.0	10.3	12.3 (± 3.9)
pH	8.3	8.3	8.4	8.2	8.4 (± 0.2)	7.9	8.0	7.8	7.8	8.0	7.9 (± 0.1)
Cond. (µS/cm)	274.0	262.0	446.0	572.0	389.0 (± 129)	460.0	441.0	226.0	220.0	327	335.0 (± 102)
O_2 (mg/l)	8.0	8.9	6.4	8.1	7.9 (± 0.9)	9.2	5.8	6.2	8.4	7.9	7.5 (± 1.3)
TSS (mg/l)	17.7	24.0	30.0	26.0	22.4 (± 4.5)	0.5	56.7	21.0	28.0	55.0	32.2 (± 21.3)
COD (mg/l)	16.9	57.0	62.9	40.8	44.4 (± 17.8)	1.7	9.2	18.8	3.0	8.0	8.2 (± 6.0)
T.H. (mg/l)	5.6	3.6	5.6	7.5	5.6 (± 1.4)	4.9	6.9	4.9	3.7	4.3	4.9 (± 1.1)
$SO_4^=$ (mg/l)	3.1	5.0	2.5	1.8	3.1 (± 1.2)	9.1	19.1	1.5	7.4	8.6	9.2 (± 5.7)
Cl^- (mg/l)	73.0	55.0	105.0	136.0	92.0 (± 31)	21.0	14.0	5.0	4.0	5.0	10.0 (± 7)
NO_3^- (mg/l)	4.8	4.6	5.3	5.6	5.1 (± 0.4)	13.3	8.9	5.8	5.7	6.7	8.1 (± 2.9)
NH_4^+ (mg/l)	0.05	0.19	0.01	0.31	0.14 (± 0.12)	0.05	0.07	0.07	0.002	0.18	0.07 (± 0.06)
TKN (mg/l)	1.40	2.99	2.82	2.64	2.50 (± 0.6)	0.77	1.10	0.78	1.78	0.67	1.0 (± 0.4)
P_T (µM/l)	0.29	0.63	0.14	0.28	0.34 (± 0.18)	0.17	0.00	0.40	0.17	1.14	0.38 (± 0.40)

was used for both analyses with a resulting total of 30 taxa and 9 samples. All the environmental variable data obtained, except for pH, were transformed using log (x+1).

Macroinvertebrate biomass is expressed as ash free dry weight/m^2. This was calculated according to the Mason *et al.* (1983) methodology.

The BMWP' biotic index proposed by Alba Tercedor and Sánchez Ortega (1988) was calculated.

Tench diet

The tench were caught by electro-fishing. Specimens with symptoms of food regurgitation were rejected. The stomach contents were obtained using a stomach pump based on a modification of the technique proposed by Petridis and O'Hara (1988). The stomach contents of 104 individuals: 69 from Villarroañe and 35 from Sentiz lake, have been examined.

The contents were preserved in individual jars in 4% formol until analysis in the laboratory. They were filtered and diluted in distilled water for their examination in successive samples under the binocular magnifying lens, determining the lowest possible taxonomic level.

The method of frequency of occurrence (Hyslop, 1980) was used for diet analysis.

Because of the difficulty in quantifying the number of specimens of determined taxa (especially gastropods and bivalves because they are usually triturated) (Mann, 1973), we have decided to use the rank method (Hynes, 1950) to determine relative abundance and to make comparison with the results obtained in the analysis of macroinvertebrate community.

The ranks used were: Rank 1, less than 5 specimens counted, considered very scarce. Rank 2, between 5 and 10 specimens, considered scarce. Rank 3, between 11 and 25 specimens, considered abundant. Rank 4, between 26 and 100 specimens, considered very abundant. Rank 5, more than 100 specimens.

The Spearman correlation coefficients were calculated between taxa found in the environment and taxa found in guts, for each habitat and season. The relative abundance distributed by ranks were used in both cases.

RESULTS

Physico-chemical parameters

The physico-chemical characteristics of the water in the Villarroañe branch and Sentiz lake are shown in table I. The variables that best define the two study sites are pH, COD (Chemical Oxygen Demand), chlorides and TKN (Total Kjeldahl Nitrogen).

Macroinvertebrate communities

Table II shows the macroinvertebrates found in Villarroañe and Sentiz lake.

Figures 2 and 3 show the results of the TWINSPAN analysis. The five samplings taken from Villarroañe are clearly separated from the four samplings from Sentiz lake; Sphaeriidae, a family only appearing in Villarroañe and at a relatively high densities besides, is the indicator taxon. In addition to this taxon those grouped in VR1 and VR2 are significant for this site (Fig. 2). Group VR2 that agglutinates three Trichoptera species, *Calopteryx* and *Atrichops* as well as the Glossiphoniidae, stands out especially; all of them are considered typically lotic and most of them are characteristic of clean waters. In Sentiz lake (SL) the most significant species of the benthic macroinvertebrate community are lentic and they can stand in higher contamination levels.

The larvae of Chironomidae and Oligochaeta constitute more than 80% of total specimens captured at certain times of the year. They stand out at both sites in terms of relative density (Table II). In contrast, the taxa in decreasing numerical importance are different. In Villarroañe the bivalves (Sphaeriidae) reach a maximum of 24%. The following stand out seasonally: *Hydra* at the beginning of summer, Hirudinea and Simuliidae larvae at the end of summer, Planorbiidae and Zygoptera and Ephemeroptera nymphs in

Table I. Macroinvertebrates found in Sentiz and Villarroañe. *: Taxa only present in Villarroañe; #: Taxa only present in Sentiz.

- **CNIDARIA**
  - Hydrozoa
    - Hydridae
      - *Hydra* sp.
- **ANNELIDA**
  - Oligochaeta
    - Naididae
      - *Chaetogaster* sp.
      - Other
    - Lumbricidae
    - Other
  - Hirudinea
    - Glossiphoniidae
      - *Glossiphonia complanata* (L.)
    - Other
- **MOLLUSCA**
  - Gastropoda
    - Ancylidae
      - *Ancylus fluviatilis* (Müller)*
    - Lymnaeidae
      - *Lymnaea palustris* (Müller)
      - *L. auricularia* (L.)
    - Planorbiidae
      - *Gyraulus crista* (L.)
      - *G. albus* (Müller) *
      - *Planorbis* spp.
    - Hydrobioidea *
  - Bivalvia
    - Sphaeridae
      - *Pisidium* spp. *
- **ARTHROPODA**
  - Crustacea
    - Branchiopoda
      - Daphnoidea
    - Copepoda
    - Ostracoda #
    - Malacostraca
      - Amphipoda
        - Gammaridae *
  - Arachnida
    - Acari
      - Hydracarina
    - Araneae #
  - Insecta
    - Ephemeroptera
      - Baetidae
        - *Baetis* sp.
        - *Cloeon* sp. #
        - *Procloeon* sp. #
      - Caenidae
        - *Caenis luctuosa* (Burmeister)
      - Siphlonuridae
        - *Siphlonurus* sp. *
    - Odonata
      - Zygoptera
        - Coenagrionidae
        - Calopterygidae
          - *Calopterix* sp. *
        - Platycnemidae
          - *Platycnemis* sp.
      - Anisoptera
        - Libellulidae
    - Heteroptera
      - Corixidae
      - Naucoridae *
    - Coleoptera
      - Haliplidae
        - *Haliplus* sp.*
      - Dytiscidae
        - *Agabus* sp. *
        - *Ilybius* sp. #
      - Elmidae
        - *Oulimnius* sp. *
      - Hydrophilidae #
    - Megaloptera
      - Sialidae
        - *Sialis lutaria* (L.)
  - Trichoptera
    - Leptoceridae
      - *Ceraclea* sp. *
      - *Leptocerus* sp.
      - *Mystacides azurea* (L.)
      - *Athripsodes albifrons* (L.)
      - *Athripsodes* sp. *
    - Hydropsichidae
      - *Hydropsiche* sp. *
      - *H. pellucidula* (Curtis) *
    - Polycentropodidae
      - *Polycentropus* sp.*
      - *P. flavomaculatus* Pictet *
    - Thremmatidae
      - *Thremma* sp. *
    - Phryganidae
      - *Phrygana* sp. *
  - Diptera
    - Ceratopogonidae
    - Chironomidae
      - Tanypodinae
      - Orthocladinae
      - Chironominae
    - Simuliidae *
    - Limonidae
    - Culicidae #
    - Psichodidae #
    - Dolichopodidae
    - Empididae
      - Atalantinae
    - Athericidae
      - *Atrichops* sp. *
    - Stratiomydae #
  - Lepidoptera

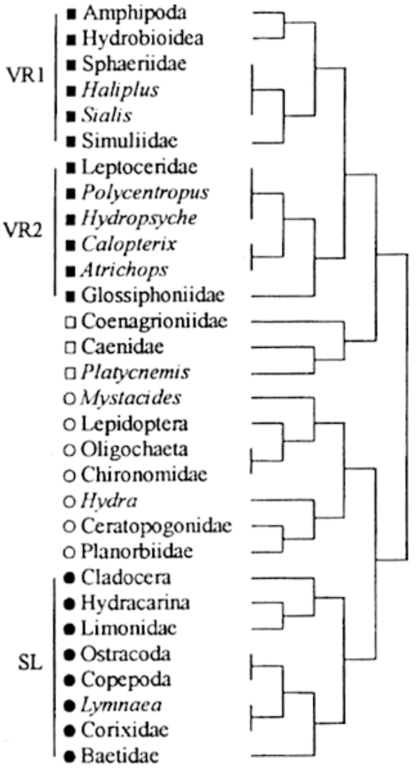

Fig. 2. TWINSPAN classification of taxa, showing the most significative taxa of Villarroañe (VR1 and VR2) and Sentiz lake (SL), grouped by the symbols □ ■ and ○ ● respectively; black symbols indicate more affinity.

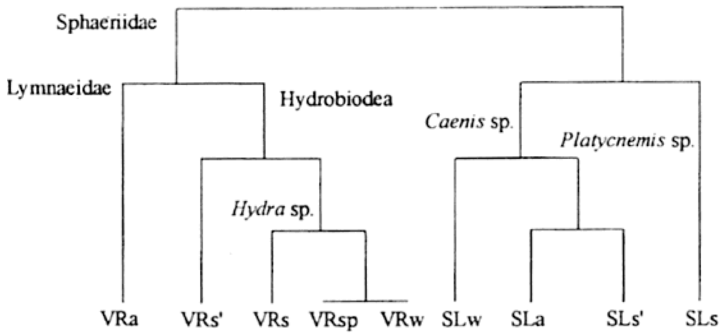

Fig. 3. TWINSPAN classification of samples, with the indicative species of each division. Villarroañe (VR) and Sentiz lake. (SL). a: Autumn; s: Summer; s': Late summer; sp: Spring; w: Winter.

autumn. In Sentiz, the high frequency taxa, besides those already mentioned, are Copepoda and Gastropoda (especially *Lymnaea* 3-8%) in the summer months, Cladocera in autumn and Planorbiidae in winter.

Table III. – Relative densities of macroinvertebrates in both localities studied following the seasons.

Villarroañe	Grab					Net			
	Winter	Spring	Summer	Late summer	Autumn	Winter	Spring	Summer	Autumn
Hydridae	-	-	9.01	0.28	-	-	-	10.69	-
Oligochaeta	25.54	11.90	15.12	55.16	37.54	1.33	15.79	20.99	29.01
Hirudinea	0.66	1.19	1.63	7.88	3.75	-	-	-	-
Gastropoda	1.98	2.38	0.65	0.84	8.19	0.66	-	0.76	1.66
Bivalvia	13.51	24.40	2.19	3.19	4.78	-	0.66	-	0.55
Copepoda	-	-	-	-	-	-	19.74	4.20	20.72
Cladocera	0.17	1.49	0.33	-	-	4.64	31.58	4.20	12.16
Amphipoda	-	0.30	0.09	-	-	-	-	-	-
Hydracarina	-	-	0.05	0.09	-	-		-	-
Ephemeroptera	3.13	2.68	1.82	0.66	8.19	2.65	2.63	1.53	11.05
Zygoptera	0.17	0.89	0.28	0.84	8.53	-	1.32	-	3.32
Anisoptera	-	-	-	0.09	-	-	-	-	-
Corixidae	-	-	-	-	-	7.29	1.97	1.15	6.35
Other Hemiptera	-	-	-	-	-	-	0.66	-	-
Coleoptera	2.14	0.30	0.42	0.56	-	-	-	-	0.55
Neuroptera	1.65	2.38	0.42	0.66	1.02	-	-	-	-
Trichoptera	0.33	0.30	2.19	0.09	9.56	0.66	1.97	1.15	1.66
Ceratopogonidae	1.15	0.30	0.05	-	0.34	-	-	-	-
Chironomidae	48.93	51.19	65.66	24.58	17.41	82.78	23.68	55.34	12.98
Simuliidae	-	-	0.05	4.50	-	-	-	-	-
Other Diptera	0.33	-	0.05	0.47	0.34	-	-	-	-
Lepidoptera	0.33	0.30	-	0.09	0.34	-	-	-	-

Sentiz lagoon	Grab				Net	
	Winter	Summer	Late summer	Autumn	Winter	Summer
Hydridae	2.78	-	0.47	0.32	0.28	0.17
Oligochaeta	38.32	13.68	16.56	38.61	4.36	0.50
Hirudinea	0.38	0.14	0.28	0.22	-	-
Gastropoda	7.31	9.87	4.21	1.72	1.42	2.18
Copepoda	0.68	7.69	9.92	21.64	53.85	66.11
Cladocera	0.94	0.56	2.90	10.53	6.27	-
Ostracoda	2.14	4.80	1.68	3.12	-	9.56
Hydracarina	1.67	4.02	1.50	0.54	1.42	7.38
Ephemeroptera	2.22	0.42	5.80	4.83	3.70	6.04
Zygoptera	0.34	0.21	1.96	0.43	-	1.34
Anisoptera	0.09	0.07	-	-	-	-
Corixidae	0.04	0.43	0.37	-	-	1.34
Trichoptera	0.04	-	0.19	-	-	-
Ceratopogonidae	2.39	0.35	0.28	0.32	-	-
Chironomidae	40.20	57.12	52.10	17.24	26.50	5.37
Other Diptera	0.30	0.56	0.94	0.48	-	-
Lepidoptera	1.17	0.70	0.84	-	0.28	-
Coleoptera	-	-	0.09	-	2.28	-

Table IV. Relative biomass of macroinvertebrates in both localities studied following the seasons.

Villarroañe	**Grab**					**Net**			
	Winter	**Spring**	**Summer**	**Late summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**
Hydridae	--	--	2.59	0.03	--	--	--	1.10	--
Oligochaeta	16.39	1.17	7.44	19.76	14.06	0.31	1.62	6.08	1.92
Hirudinea	16.83	14.59	1.62	25.49	11.40	--	--	--	--
Gastropoda	0.44	5.84	0.94	0.64	48.63	0.31		1.10	1.92
Bivalvia	12.40	8.02	7.11	1.91	2.09	--	0.23	--	0.96
Copepoda	--	--	--	--	--	--	2.55	1.66	1.44
Cladocera	0.09	0.07	0.48	--	--	12.40	2.55	8.84	1.44
Amphipoda	--	1.46	0.32	--	--	--	--	--	--
Hydracarina	--	--	0.03	0.03	--	--	--	--	--
Ephemeroptera	0.62	0.73	9.70	0.96	1.14	0.93	1.16	23.76	2.59
Zygoptera	0.44	2.19	5.82	0.96	12.54		6.96	--	23.01
Anisoptera	--	--	--	0.29	--	--	--	--	--
Corixidae	--	--	--	--	--	74.50	23.20	22.10	62.80
Other Hemiptera	--	--	--	--	--	--	55.68	--	--
Coleoptera	1.33	0.73	1.94	1.59	--	--	--	--	1.82
Neuroptera	26.57	37.93	1.13	27.41	3.80	--	--	--	--
Trichoptera	0.93	0.07	22.02	0.32	0.72	0.31	0.46	16.57	1.44
Ceratopogonidae	0.22	0.07		0.03	0.04	--	--	--	--
Chironomidae	20.37	26.99	38.47	17.21	4.18	11.20	5.57	18.78	1.63
Simuliidae	--	--	0.06	1.91	--	--	--	--	--
Other Diptera	0.27	--	0.32	0.19	1.14	--	--	--	--
Lepidoptera	3.10	0.15	--	1.27	0.27	--	--	--	--

Sentiz lagoon	**Grab**				**Net**	
	Winter	**Summer**	**Late summer**	**Autumn**	**Winter**	**Summer**
Hydridae	0.36	--	0.55	0.15	0.54	0.12
Oligochaeta	21.23	21.58	19.73	37.16	1.08	0.61
Hirudinea	4.39	1.20	1.92	2.18	--	--
Gastropoda	32.19	26.38	26.85	3.48	8.06	2.42
Copepoda	0.04	0.48	0.55	3.63	13.44	6.67
Cladocera	0.24	0.24	1.37	0.87	4.30	--
Ostracoda	0.32	1.44	0.27	0.29		2.42
Hydracarina	0.28	0.96	1.64	0.15	2.69	6.02
Ephemeroptera	0.08	0.48	10.41	0.87	32.80	35.20
Zygoptera	1.42	5.76	1.92	1.02	--	34.60
Anisoptera	0.16	0.24	--	--	--	--
Corixidae	0.08	0.48	2.19	--	--	6.67
Trichoptera	0.04	--	--	--	--	--
Ceratopogonidae	3.04	1.44	1.64	1.31	--	--
Chironomidae	35.78	35.25	25.75	47.46	17.74	5.54
Other Diptera	0.12	3.84	2.19	1.45	--	--
Lepidoptera	0.24	--	0.82	--	2.15	--
Coleoptera	--	--	2.19	--	17.74	--

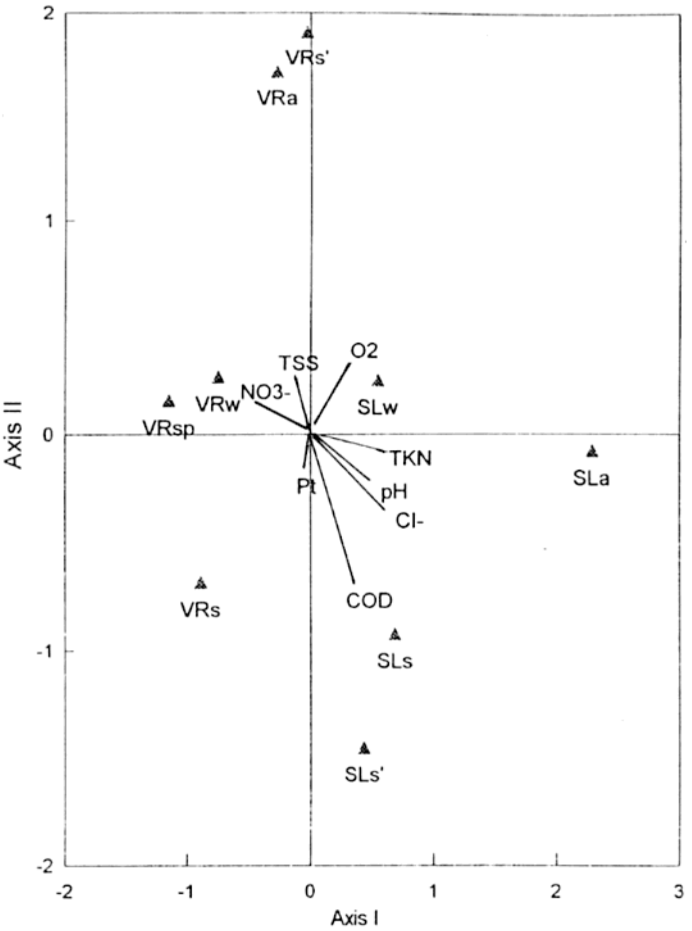

Fig. 4. Representation of samples and environmental variables on the planes defined by canonical axes I and II. Abbreviations: Villarroañe (VR) and Sentiz lake (SL); a: Autumn; s: Summer; s': Late summer; sp: Spring; w: Winter; O_2: Oxygen content; TSS: Total suspended solids; COD: Chemical demand of oxygen; CL^-: Chlorides; NO_3^-: Nitrates; TKN: Kjeldahl Total nitrogen; P_T: Total phosphorus.

In terms of relative biomass (Table IV), Chironomidae larvae are more than 20% of the total in almost all the samples, reaching 47% in Sentiz in autumn. In this lake the Oligochaeta, Gastropoda (Lymnaeidae and Planorbiidae) and Ephemeroptera nymphs are the next most important taxa.

In Villarroañe the biomass percentages are more divided among the different taxa. Besides the already mentioned Chironomidae larvae, *Sialis* larvae and Hirudinea are important. On the other hand a higher total biomass in Villarroañe than in Sentiz lake has to be highlighted (Table V).

The comparison of the structural parameters in both communities shows no great differences (Table V). Total richness is higher in Villarroañe and heterogeneity is low in both (0.24 in Sentiz and 0.12 in Villarroañe), given the great relative abundance of Chironomidae larvae and Oligochaeta.

The BMWP' biotic index obtains the highest values in Villarroañe in summer and autumn, and the lowest in Sentiz lake, particularly in autumn.

The canonical correspondence analysis allows taxa and environmental variables in the different samplings to be related (Figs 4, 5). In order to avoid multicolinearity situations temperature, conductivity, sulphates, ammonia and hardness data were not taken into account in this analysis.

The first two axes explain 57.1% of the total variance and their autovalues are 0.283 and 0.197. The first axis is related to TKN, Cl^- and pH in the positive side. The second axis is related to COD in a negative one (Table VI).

The samplings carried out in Sentiz lake and Villarroañe branch are clearly separated (Fig. 4). The samples from Villarroañe and the taxa (Fig. 5) indicated as representative of this area in the dendrogram of figure 2 are grouped together in the second and third quadrants. The samples collected from Sentiz lake during summer and autumn, and the corresponding taxa are in the fourth quadrant. Lastly, the sample corresponding to Sentiz in winter is situated close to the coordinate origin and those taxa present in both locations for most of the year are in that position in figure 5.

Food

The percentage of empty guts reached 28.9% for Villarroañe and 8.6% for Sentiz lake. Diet is richer in Villarroañe than Sentiz lake (Table VII). The Chironomidae larvae are preferential preys (f > 50%) in both environments and throughout the year. The Gastropoda are also preferential preys in Villarroañe, where they constitute an important part of the diet in spring, summer and late summer. Among the habitual prey (25 < f < 50%) Coleoptera are consumed throughout the year whilst Copepoda show a decrease in ingestion frequency from winter to autumn. Cladocera, Trichoptera and Ephemeroptera nymphs are similarly recorded, although the maximum stands out in summer. Other habitual preys are Corixidae, Bivalvia, more important in summer, and the group formed by the other Diptera.

In Sentiz lake the preferential preys, apart from the already mentioned Chironomidae, are Copepoda and Cladocera. The most frequently occurring habitual preys (25 < f < 50%) are Ostracoda, which indicates a clear inclination of tench towards small crustaceans. The Gastropoda and Ephemeroptera nymphs are also important preys taxa in this lake, especially in autumn.

Table V. – Data of macroinvertebrates communities in both localities studied following the seasons. AFDW: Ash free dry weight.

	Villarroañe					**Sentiz lagoon**			
	Winter	**Spring**	**Summer**	**Late summer**	**Autumn**	**Winter**	**Summer**	**Late summer**	**Autumn**
Density (ind/m^2)	26.90	14.90	94.80	47.20	13.00	51.70	31.40	23.60	41.10
Biomass (g AFDW/m^2)	10.10	6.10	13.40	14.00	11.60	11.20	1.90	1.60	3.10
Richness	17.00	17.00	22.00	21.00	20.00	22.00	19.00	22.00	17.00
Diversity	2.14	2.14	1.75	1.99	3.10	2.20	2.16	2.53	2.50
Uniformity	0.52	0.52	0.40	0.45	0.72	0.49	0.51	0.57	0.61
BMWP'	61.00	64.00	84.00	88.00	88.00	71.00	52.00	60.00	50.00

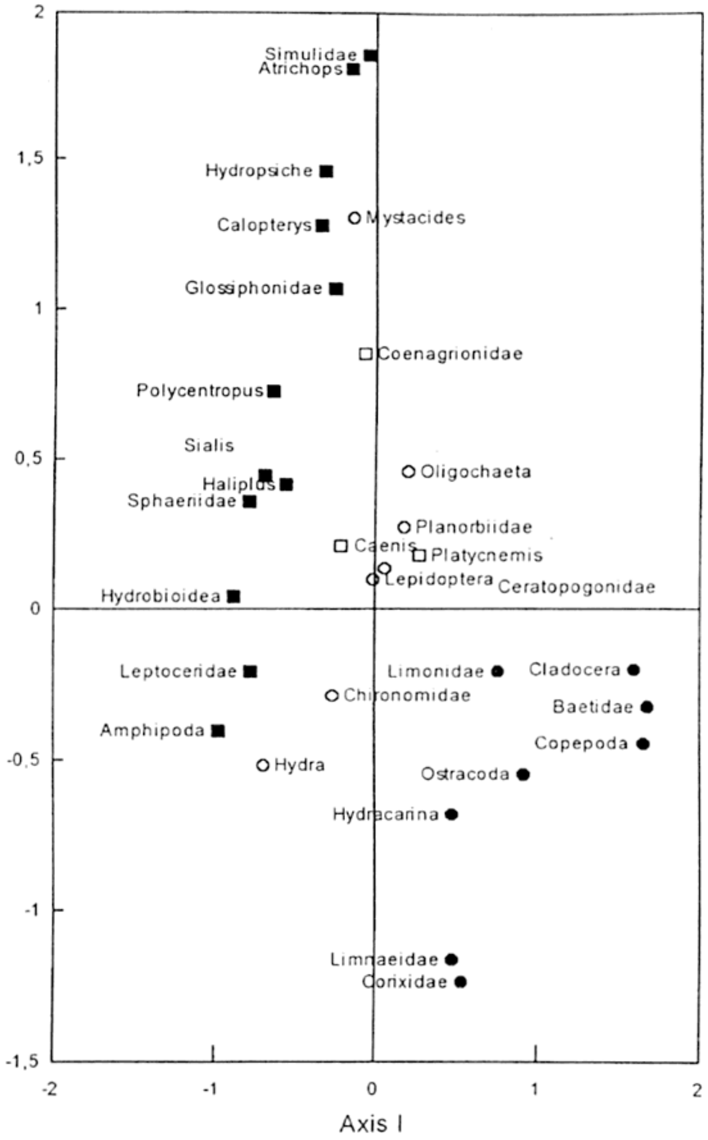

Fig. 5. — Representation of taxa on the planes defined by canonical axes I and II.

A great abundance of vegetation is present in the diet throughout the year and at both sites.

	AXIS I	AXIS II
pH	0.6864 *	-0.2642
O_2	0.4403	0.3888
TSS	-0.0967	0.3287
COD	0.4808	-0.7660 **
Cl^-	0.7504 *	-0.3216
NO_3^-	0.3632	0.1956
TKN	0.8175 **	-0.1132
P_T	-0.0354	-0.2414

Table VI. – Correlation between environmental variables and axes I and II. * = $p < 0.05$; ** = $p < 0.001$. Abbreviations as in table I.

Table VII. – Frequency of occurrence of preys in gut contents for both localities and following the seasons.

	Villarroañe					Sentiz lagoon			
	Winter	Spring	Summer	Late summer	Autumn	Winter	Summer	Late summer	Autumn
Hirudinea	16.7	--	25	--	--	46.2	--	--	--
Bivalvia	25.0	36.4	75	5.0	12.5	46.2	--	20	28.6
Gastropoda	16.7	72.7	100	64.3	25.0	38.5	14.3	20	42.9
Copepoda	66.7	81.8	50	21.4	25.0	84.6	85.7	60	85.7
Cladocera	58.3	54.5	75	21.4	--	61.5	42.9	20	71.4
Ostracoda	8.3	9.1	--	21.4	--	53.8	14.3	60	57.1
Amphipoda	41.7	--	25	7.1	12.5	--	--	--	--
Hydracarina	--	--	25	7.1	--	7.7	--	--	--
Neuroptera	33.3	9.1	25	--	--	--	--	--	--
Ephemeroptera	58.3	45.5	100	35.7	--	38.5	14.3	20	57.1
Plecoptera	16.7	--	--	21.4	--	--	--	--	--
Odonata									
Zygoptera	16.7	9.1	25	28.6	12.5	15.4	--	20	14.3
Anisoptera	33.3	18.2	75	14.3	--	15.4	--	--	14.3
Heteroptera									
Corixidae	33.3	54.5	75	35.7	--	--	--	--	14.3
Other Hemiptera	8.3	9.1	25	14.3	--	--	28.6	--	--
Tricoptera	33.3	36.4	75	21.4	37.5	23.1	28.6	--	--
Coleoptera	66.7	54.5	50	50.0	12.5	--	--	--	19.3
Diptera									
Ceratopogonidae	33.3	45.5	50	21.4	--	30.8	14.3	20	--
Chironomidae	100.0	90.9	100	57.1	50.0	76.9	57.1	60	71.4
Simuliidae	--	--	--	--	12.5	--	--	--	--
Other Diptera	8.3	45.5	50	42.9	12.5	30.8	14.3	20	14.3

DISCUSSION

Habitat

The ordination of the environmental variables in the CCA (Fig. 4), the macroinvertebrates found, and the calculation of the BMWP' biotic index indicate that Villarroañe is more oligotrophic than Sentiz lake, especially in summer and autumn. In winter the lake has a lower degree of eutrophication and in summer the organic material contributions increase. This can be explained by the type of terrain, the hydrological regime and the different uses to which they are subjected.

Sentiz lake depends on rainfall and the large livestock burden in summer, in addition to low water, causes an increase in organic material. This is reflected in higher ammonium and TKN values during autumn. Moreover gradual salinization of the lake was registered throughout the study period.

In contrast, in Villarroañe a more oligotrophic condition exists with periods of mineralization in winter and spring; it receives water either from the river or the irrigation channel throughout the year and keeps it for a short time.

Food and available preys

The tench food in both habitats studied is roughly similar to literature data (see Perrow, 1996). The percentage of empty guts was lower than previously recorded (O'Maoileidigh and Bracken, 1989; Brönmark, 1994). The presence of plant material is considered an accidental ingestion when catching preys as already stated (Weatherley, 1959; Kennedy and Fitzmaurice, 1970).

The preferential prey items are Chironomidae larvae at both sites, which concurs with Perrow's results (1996) for tench in an English lake. The second most important prey taxon in the river branch is gastropods, although this does not mean that tench can be considered a specialized forager of molluscs, as stated by Brönmark (1994).

The preference for small crustaceans in the Sentiz lake compared to Villarroañe is probably due to difference in age of tench. In Sentiz the oldest tench are 5 year-old (with an average length of 162 ± 26 mm) whilst in Villarroañe they are 11 year-old (with an average length of 269 ± 75 mm). This value coincides with what was stated by Weatherley (1959) in Tasmania, O'Maoileidigh and Bracken (1989) in Ireland and Copp and Mann (1993) in France and England.

The diet generally reflects the seasonal distribution of macroinvertebrates in the environment. Weatherley (1959), O'Maoileidigh and Bracken (1989), Copp and Mann (1993) and Giles *et al.* (1990) have already pointed out that the diet of tench coincides with the availability of environmental food, although only the last mentioned have quantified the available taxa.

This is supported by the calculated correlation coefficients (Table VIII), all of them significant, although not with the same probability, except for that corresponding

Table VIII. Correlation coefficients between diet and available preys for both localities studied following the seasons. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

	Winter	Spring	Summer	Late summer	Autumn
VR	0.643**	0.467*	0.595**	0.572**	0.661*
SL	0.884***		0.508*	0.436	0.797***

to late summer in Sentiz. Perhaps this is not very trustworthy due to the reduced number of gut contents that have been analysed for this site and season.

The fact that two groups, Ostracoda and Plecoptera, were not caught in Villarroañe environment but appear in the diet should be pointed out. The presence of the former is residual. In the case of Plecoptera we have to consider that the sampling techniques were not suitable for detecting them.

The opposite occurred with Oligochaeta and *Hydra*. The former were not detected in the diet but are very abundant in the environment. Weatherley (1959) records the appearance of Oligochaeta remains in the gut contents of one of the populations he studied, though not in another. Petridis (1990) stated that the presence of chaetae remains was only detected by electron microscope analysis of detritus present in gut contents. This means that tench could consume Oligochaeta when they are available in the environment, although they were not detected in gut contents according to Giles *et al.* (1990). The absence of *Hydra* in gut contents is not strange, despite their abundance in the environment at some times of the year in Villarroañe as well as in Sentiz, due to the lack of any skeletal structure. This could also explain the habitual presence of Hirudinea in the environment and its very sporadic detection in the digestive tracts studied. In fact it does not appear as a prey of tench in any of the papers consulted. It should not be forgotten that cyprinids possess a pharyngeal apparatus that triturates food rapidly. The softest components in the diet (e.g., Oligochaeta and *Hydra*) are digested fast in contrast to others that can remain in the gut for a long time (e.g., mollusc shells).

Considering our results and previous observations (Weatherley, 1959; Kennedy and Fitzmaurice, 1970; O'Maoileidigh and Bracken, 1989), it can be concluded that tench is a poor selective predator of prey.

Acknowledgements. We would like to thank Dr. Lobón-Cerviá for his comments on an early version. Diputación de León funded this study.

REFERENCES

ALBA TERCEDOR J. & A. SÁNCHEZ ORTEGA, 1988. Un método rápido y simple para evaluar la calidad biológica de las aguas corrientes basado en el de Hellawell (1978). *Limnetica*, 4: 51-56.

APHA-AWWA-WPCF, 1989. Métodos estandarizados para el Análisis de Aguas potables y residuales. 17ª Edit. traducida. 1461 p. Madrid: Díaz de Santos.

BROENMARK C., 1994. Effects of tench and perch on interactions in a freshwater benthic food chain. *Ecology*, 75(6): 1818-1828.

COPP G.H. & R.H.K. MANN, 1993. Comparative growth and diet of tench *Tinca tinca* (L.) larvae and juveniles from river floodplain biotopes in France and England. *Ecol. Freshw. Fish.*, 2: 58-66.

FERNÁNDEZ ALÁEZ M., 1984. Distribución de la vegetación macrófita y evaluación de factores ecológicos en sistemas leníticos de la provincia de León. Tesis Doctoral, 307 p. Univ. León.

FERNANDEZ SAN JUAN J., 1995. Limiting factors in the development of natural tench (*Tinca tinca* (L.)) populations in Spanish reservoirs. A review. *Pol. Arch. Hydrobiol.*, 42(1-2): 19-25.

GILES N., STREET M. & R.M. WRIGHT, 1990. Diet composition and prey preference of tench, *Tinca tinca* (L.), common bream, *Abramis brama* (L.), perch, *Perca fluviatilis* L., and roach, *Rutilus rutilus* (L.), in two contrasting gravel pit lakes: Potential trophic overlap with wildfowl. *J. Fish Biol.*, 37(6): 945-957.

GRANADO LORENCIO C. & F. GARCÍA NOVO, 1981. Cambios ictiológicos durante las primeras etapas de la sucesión en el embalse de Arrocampo (Cuenca del Tajo. Cáceres). *Bol. Inst. Esp. Oceanogr.*, 6: 224-243.

GRANADO LORENCIO C. & F. GARCÍA NOVO, 1986. Feeding habits of the fish community in a eutrophic reservoir in Spain. *Ekol. Pol.*, 34(1): 95-110.

HILL M.O., 1979. TWINSPAN: A Fortran Program for arranging multivariate Data in an ordered two-way Table by Classification of the Individuals and Attributes. 90 p. New York: Cornell Univ., Ithaca.

HYNES H.B.N., 1950. The food of freshwater sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in studies of the food of fishes. *J. Anim. Ecol.*, 19: 36-58.

HYSLOP E.J., 1980. Stomach contents analysis - A review of methods and their application. *J. Fish Biol.*, 17: 411-429.

KENNEDY M. & P. FITZMAURICE, 1970. The biology of tench *Tinca tinca* (L.) in Irish waters. *Proc. R.I. A. Sect. B*, 69(3): 31-82.

LELEK A., 1987. Threatened Fishes of Europe. The freshwater Fishes of Europe. 343 p. Wiesbaden: AULA Verlag.

LOZANO REY L., 1935. Los Peces fluviales de España. Tomo V, 390 p. Memorias de la Academia de Ciencias Exactas, Físicas y Naturales de Madrid. Serie Ciencias Naturales.

MANN R.H.K., 1973. Observations on the age growth, reproduction and food of the roach *Rutilus rutilus* (L.) in two rivers in southern England. *J. Fish Biol.*, 5: 707-736.

MASON W.T. Jr., LEWIS P.A. & C.I. WEBER, 1983. An evaluation of benthic macroinvertebrate biomass methodology. Part 1. Laboratory analytical methods. *Environ. Monit. Assess.*, 3: 29-44.

O'MAOILEIDIGH N. & J.J. BRACKEN, 1989. Biology of the tench, *Tinca tinca* (L.) in an Irish lake. *Aquacult. Fish. Manag.*, 20(2): 199-209.

PEREZ REGADERA J.J., MARTIN GALLARDO J., GARCIA CEBALLOS E. & J.C. ESCUDERO GARCIA, 1995. Model development for the determination of final *preferenda* in freshwater species. Application in tench *Tinca tinca* (L.). *Pol. Arch. Hydrobiol.*, 42(1-2): 27-34.

PERROW M.R., JOWITT A.J.D. & S.R. JOHNSON, 1996. Factors affecting the habitat selection of tench in a shallow eutrophic lake. *J. Fish Biol.*, 48: 859-870.

PETRIDIS D., 1990. The influence of grass carp on habitat structure and its subsequent effect on the diet of tench. *J. Fish Biol.*, 36: 533-544.

PETRIDIS D. & K. O'HARA, 1988. Assessment of diet in two cyprinids using a modified stomach flushing technique. *Aquacult. Fish. Manag.*, 19: 63-68.

PIELOU E.C., 1966. The measurements of diversity in differents types of biological collections. *J. Theoret. Biol.*, 13: 131-144.

ROSA H., 1958. A synopsis of the biological data on the tench, *Tinca tinca* (L., 1758). FAO 58/2/951, 26 p. Rome: FAO.

SHANNON C.E. & C.D. WEAVER, 1949. The mathematical Theory of Communication. 111 p. Urbana: Univ. of Illinois Press.

TER BRAAK C.J.F., 1991. CANOCO (version 3.12): A Fortran program for canonical community ordination by / partial / detrended / canonical / correspondence analysis. Wageningen: T.N.O.

VELASCO MARCOS J.C., PERIS ÁLVAREZ S.J., POLLO MATEOS C.J. & N. GONZÁLEZ SÁNCHEZ, 1997. Los Peces de la Provincia de Salamanca. Atlas de Distribución. 172 p. Salamanca: Ediciones Univ.

WEATHERLEY A.H., 1959. Some features of the biology of the tench, *Tinca tinca* (L.) in Tasmania. *J. Anim. Ecol.*, 28: 73-87.

WRIGHT R.M. & N. GILES, 1991. The population biology of tench, *Tinca tinca* (L.) in two gravel pit lakes. *J. Fish Biol.*, 38(1): 17-28.

Reçu le 17.08.1998.
Accepté pour publication le 17.02.2000.