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POPULATION DYNAMICS OF THE CHANNEL CATFISH, *ICTALURUS PUNCTATUS* (RAFINESQUE, 1818), IN THE OMBRONE RIVER (TUSCANY, ITALY)

Abstract - A naturalized population of the channel catfish, *Ictalurus punctatus* (Rafinesque, 1818) (Siluriformes, Ictaluridae), was reported in the Ombrone River, in the southern part of Tuscany (Central Italy). The investigation, funded by the Amministrazione Provinciale of Grosseto, provided some information on the population dynamics of the species in the Ombrone River. A total of 167 channel catfish specimens, ranging from 5.5 to 33.5 cm of total length (TL), was caught by means of experimental samplings. Females were more abundant than males: the *sex ratio* was 65%. The analysis of length-frequency distribution outlined the presence of three modal classes, corresponding to age class 0, I, and II, respectively. This observation was confirmed by the age estimation provided by the analysis of the otoliths. The von Bertalanffy growth curve fitted from age-length data was characterized by the following parameters: L_∞ = 43.8 cm, k = 0.33, t_0 = -0.49 years. A mean size of about 17 cm TL was estimated at age 1 year. The collection of juveniles (≤ 10 cm TL) at the end of September and of adults with spent gonads in July suggested the concentration of the spawning period in late spring. The analysis of stomach contents highlighted that fishes play a dominant role in the diet of the channel catfish.

Key words - *Ictalurus punctatus*, freshwater fish, alien species, population dynamics, growth.

Riassunto - *Dinamica di popolazione del pesce gatto punteggiato,* Ictalurus punctatus *(Rafinesque, 1818), nel Fiume Ombrone (Toscana, Italia).* Una popolazione di pesce gatto punteggiato, *Ictalurus punctatus* (Rafinesque, 1818), è stata individuata nel fiume Ombrone. L'indagine, finanziata dall'Amministrazione Provinciale di Grosseto, ha permesso di mettere in luce alcuni aspetti della dinamica di popolazione di questa specie, recentemente introdotta nel fiume Ombrone. Nel corso dei campionamenti sperimentali è stato catturato un totale di 167 esemplari di pesce gatto punteggiato, compresi tra 5,5 e 33,5 cm di lunghezza totale (LT). Le femmine sono risultate più abbondanti dei maschi, con una *sex ratio* del 65%. L'analisi della distribuzione di frequenza di taglia ha evidenziato la presenza di tre classi modali, corrispondenti, rispettivamente, alle classi di taglia 0, I e II. Questa osservazione è supportata dai risultati della determinazione dell'età attraverso l'analisi degli otoliti. I parametri della curva di crescita secondo il modello di von Bertalanffy sono risultati i seguenti: L_∞ = 43,8 cm, k = 0,33, t_0 = -0,49 anni. Dalla curva è stata stimata una taglia media al primo anno di vita di circa 17 cm LT. La cattura di esemplari giovani (≤ 10 cm LT) a fine settembre e di esemplari adulti con gonadi in stadio di post-deposizione in luglio suggerisce che il periodo riproduttivo della specie nel fiume Ombrone si concentra in tarda primavera. L'analisi dei contenuti stomacali ha permesso di evidenziare per la specie una dieta prevalentemente piscivora.

Parole chiave - *Ictalurus punctatus*, pesci di acqua dolce, specie alloctone, dinamica di popolazione, accrescimento.

INTRODUCTION

Biological invasions have caused considerable disruption to native ecosystems around the world. Both the introductions of alien species and the loss of natural habitats are the main factors responsible for the extinction of animal species in the last centuries. Aquatic ecosystems disturbed by human activities seem to be particularly vulnerable to these invasions.
Alien species may affect indigenous species by competing for resources, preying on native fauna, transferring pathogens, or significantly altering habitat. The introduction of exotic freshwater fishes is one of the main threats to the survival and genetic integrity of native fishes around the world; Moyle *et al.* (1987) have labelled the impact of introduced fishes on native species as the «Frankenstein effect» because the consequences of introductions tend to be negative in unpredictable ways.
Alien fishes have been introduced for a variety of reasons: ornament, sport, aquaculture, biological control, and by accident (Elvira & Almodóvar, 2001; Copp *et al.*, 2005). A range of reasons are cited for introducing fish species for the «improvement» of wild stocks. The major motivation is to introduce some element that is perceived as lacking from the fauna of a water body: this is usually termed to fill a «vacant niche» (Elvira & Almodóvar, 2001). Although not strictly in line with the niche concept, which sees the niche as a property of the organism, the idea of a vacant niche is used to describe the perception that there are resources within a water body which are not being used efficiently for lack of a suitable species.
There are about 40 exotic fish species introduced in Europe, and many more have been trans-located among European countries (Elvira & Almodóvar, 2001). In Italy, 39 of the 82 freshwater fish species are alien, while the 70% of native species became extinct (Copp *et al.*, 2005). Italy has been a country long interested in the introduction of alien freshwater fishes. The first of these probably occurred during the Roman period, and several species traditionally considered as native could be of non-native origin in view of their bioecological and biogeographical features (Bianco, 1998). A

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rapid evolution of Italian freshwater fish communities is in progress: in the past 30 years there have been processes of «padanization», with transplantation of native species from north to central Italy, followed by «danubization», with introduction of Danubian species throughout Italy (Bianco & Ketmaier, 2001); the current process could be termed «globalization» with the establishment of Iberian, Albanian, eastern Asian and North American elements.

The channel catfish, *Ictalurus punctatus* (Rafinesque, 1818) (Siluriformes, Ictaluridae), is a species native to the southern and central regions of North America. The channel catfish is the key species in American aquaculture; the production is estimated in 600,000 tonnes (Rezk *et al*., 2003; Tucker & Hargreaves, 2004; Simmons *et al*., 2006). A number of life history traits make this species suitable for commercial exploitation, including rapid growth, high fecundity, polytrophism, resistance to extreme environmental conditions, *etc*. The channel catfish is a voracious predator, which can reach 100 cm of length and 10 kg of weight.

In Europe, this species was introduced for aquaculture purposes in 1990s (Elvira & Almodóvar, 2001). In Italy, the channel catfish was introduced in order to increase the supply of both aquatic food and game resources for sport fishing (Copp *et al*., 2005). The report of channel catfish in northern and central Italy, in particular in the Po and Arno River, is mainly based on occasional collected specimens probably originated from the accidental or deliberate stockings (Gandolfi *et al*., 1991; Marconato *et al*., 2000; Turin, 2000; Bianco & Ketmaier, 2001; Copp *et al*., 2005; Porcellotti, 2005).

In the framework of an investigation supported by the Amministrazione Provinciale of Grosseto, and focused on the characterization of the fish fauna of the Ombrone River, consistent catches of channel catfish were obtained. The present paper provides the first information on the population dynamics of a naturalized population of *I. punctatus* in Italy.

Materials and methods

The study area was located in the reach of the Ombrone River contained between the confluence of the Orcia River into the Ombrone and the urban centre of Grosseto (Fig. 1). Fifteen experimental samplings using a 200 m gill net were performed between July and October 2006. The gill net was spread to close the river reach downstream; then it was spread zigzag in upstream direction. The net was leaved fishing for 15-20 minutes. The specimens collected were identified to the species level; for each species, the total number of specimens and the total weight were recorded. Then the specimens were released. The channel catfish specimens were retained and transferred for laboratory analyses. Total length (TL) and weight of the specimens were measured to the nearest 0.5 cm and to the nearest 0.5 g, respectively; sex and maturity stage were determined by the macroscopic observations of the gonads. Maturity stage was assigned according to Holden & Raitt (1974).

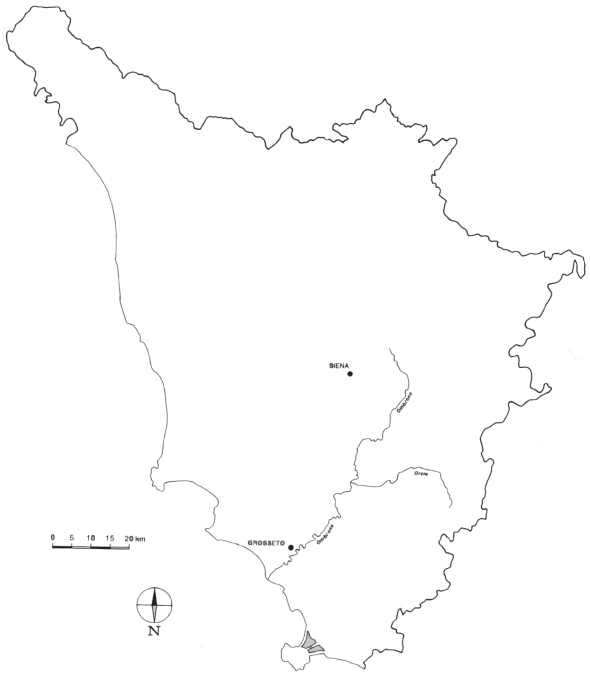

Fig. 1 - The investigated area was located between the confluence of the Orcia River into the Ombrone River and the urban centre of Grosseto.

The length-frequency distribution was computed and analysed using the Bhattacharya's method performed by the software FAO-ICLARM FiSAT II (Gayanilo & Pauly, 1997) to decompose the distribution into modal classes. The *sex ratio* (% females/females + males) was computed; the results were tested by means of the Chi-Square test (χ^2). The weight-length relationship was analysed according to the formula $W = a \cdot TL^b$, where W was the weight (g). The isometry of the relationship ($b = 3$) was tested by means of the Student's t test.

The diet of *I. punctatus* was characterized by means of stomach content analysis, with particular attention to changes in the diet due to size. Stomachs were sampled according to two size classes (≤ 20.0 cm TL and > 20.0 cm TL); twenty stomachs for each size class were collected. The contribution to the diet of each taxonomic group was examined in terms of frequency of occurrence (F), percentage respect to the total number of preys (N), and percentage respect to the total weight of preys (W).

The age determination was performed by means of the analysis of otolith annual rings. Otoliths (*sagittae*) were removed, cleaned, and stored dry in vials. Otoliths were read using a dissection microscope under reflected light; the microscope was connected to an image analysis software through a video camera. The otoliths of 19 small sized specimens (≤ 12.0 cm TL) were prepared in order to perform the daily increment analysis (Pannella, 1971). The otoliths were prepared in order to obtain thin frontal sections, as described by

Belcari *et al.* (2006). Otolith sections were analysed under a compound green light-polarising microscope with planapochromatic objectives, connected to the image analysis software. The age in days estimated by the analysis of daily increments was used to back-calculate the date of birth from the date of capture (Belcari *et al.*, 2006). Age and length data were used to compute the von Bertalanffy growth formula (VBGF) in order to estimate the growth of *I. punctatus*:

$$L_t = L_\infty \cdot (1 - e^{(-k \cdot (t - t_0))})$$

where L_t is the mean total length at age t (years) (the ages estimated in days were converted in years), L_∞ is the asymptotic length, k is the instantaneous growth coefficient, t_0 is the age at length 0. The VBGF parameters (L_∞, k and t_0) were calculated from age-length data using the package FAO-ICLARM FiSAT II.

RESULTS

A total of 167 specimens of channel catfish was caught. The specimens presented the typical characteristics of the channel catfish: four pairs of white to dusky chin barbells around the mouth; scales absent; stout and jagged spines at the origin of dorsal and pectoral fins; rounded anal fin; tail deeply forked. The body colour was olive on back and side, white below; fins were similar in colour to adjacent body. Scattered dark spots were present on back and side; juveniles lacked spots. The smallest specimen collected was a juvenile of 5.5 cm TL and of 1.5 g of weight. Females ranged from 14.5 to 33.5 cm LT in size, and from 19.0 to 263.5 g in weight, while males from 13.5 to 33.0 cm LT, and from 15.0 to 298.0 g. A total of 19 specimens ranging from 5.5 to 10.0 cm TL was caught between the end of September and October.

The *sex ratio* was 65.1%; thus, females were significantly more abundant than males ($\chi^2_1 = 6.81$, $p < 0.05$). Eight specimens, both males and females, between 25.0 and 33.5 cm TL, with spent gonads (stage V) were caught in July.

The length-frequency distribution is shown in Figure 2. As outlined by the Bhattacharya's analysis three cohorts were found (Tab. 1). The three cohorts should correspond to three different age classes: the age class 0, that is the group of specimens in their first year of life, the age class I, that is the specimens in their second year of life, and the age class II. The scarce number of specimens > 28 cm TL avoided to highlight additional modal classes.

The estimated weight-length relationship was $W = 0.007 \cdot TL^{3.050}$ (null hypothesis: $b = 0$, $F_{1,165} = 9132.2$, $p < 0.01$; $R^2 = 0.982$) (Fig. 3); the relationship was isometric ($t_{165} = -1.46$, $p > 0.05$).

The diet composition analysis did not revealed clear differences per size class. The most important role in the diet of *I. punctatus* was played by the fishes of the family Cyprinidae, which represented the dominant group both in terms of frequency of occurrence (65% in specimens ≤ 20.0 cm TL, 70% in specimens > 20.0 cm TL), and percentage respect to the total weight of preys (62% in specimens ≤ 20.0 cm TL, 66% in specimens > 20.0 cm TL). In terms of percentage respect to the total number of preys, the larval forms of the order Odonata played the most important role (28% in specimens ≤ 20.0 cm TL, 39% in specimens > 20.0 cm TL).

The maximum age observed by means of the otolith analysis was three years. The analysis of the 13 otoliths by means of daily increment reading gave the following

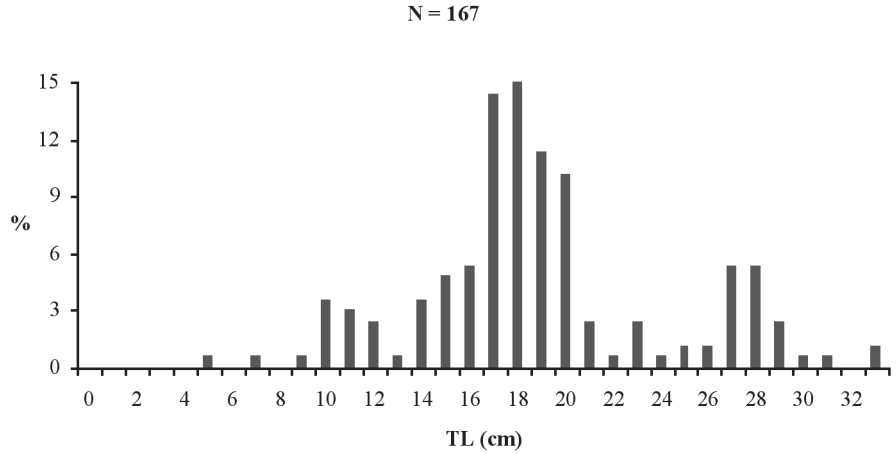

Fig. 2 - Length-frequency distribution.

Tab. 1 - Modal decomposition by means of the Bhattacharya's method; for each modal class identified, the modal length is expressed as total length (cm).

Modal class	TL (cm)	SD	R^2	N	SI
1	11.0	1.0	0.879	20	n.a.
2	18.2	1.5	0.873	103	2.8
3	27.8	1.0	0.952	28	2.7

SD = standard deviation; R^2 = determination coefficient; N = number of specimens; SI = separation index.

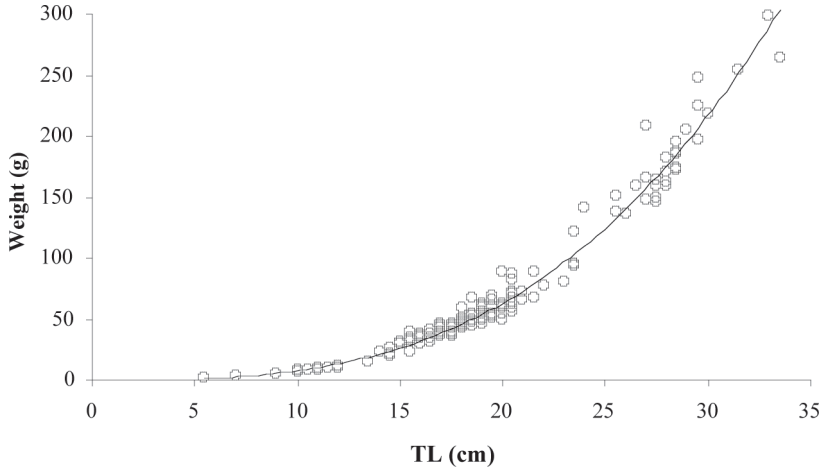

Fig. 3 - Weight-length relationship in *I. punctatus* (○: observed values; —: fitted curve).

results: the age estimations ranged from 84 days, for a specimen of 5.5 cm TL, to 130 days, for a specimen of 12.0 cm TL. The results of the back-calculation of the birth-date are summarized in Table 2, and indicate a birth period in June-July. The VBGF parameters estimated for *I. punctatus* were L_∞ = 43.8 cm, k = 0.33, t_0 = -0.49 years. The growth curve is shown in Figure 4. According to the growth model, a mean length of 17.0 cm TL is reached at the end of the first year of life; at two years of life *I. punctatus* reaches a mean length of about 24.5 cm TL, at three years about 30.0 cm TL.

DISCUSSION

Despite the small extension of the investigated area, the present results provide the first source of information on the biology and ecology of a naturalized population of *Ictalurus punctatus* in Italy. The presence of a reproductive population of channel catfish in the Ombrone River, after those reported from the northern Italy and from the Arno River, has to be considered a further step in the framework of the «globalization» process (Bianco & Ketmaier, 2001) involving the freshwater fish communities in Italy.

The investigated river reach was characterized by runs over hard sand and rocks; as a matter of fact, the catches of channel catfish were in association with the Iberian barbel, *Barbus graellsii* Steindachner, 1866, the Danubian barbel, *B. barbus* (Linnaeus, 1758), the both introduced species (Bianco & Ketmaier, 2001), and the autochthonous species *Leuciscus cephalus* (Linnaeus, 1758), known as chub. This observation confirms that *I. punctatus* can live in the reach of streams and rivers characterized by fast and well oxygenated waters and pebbly and rocky bottoms, as well as in lakes, ponds, and brackish waters (Tucker & Hargreaves, 2004; Porcellotti, 2005), unlike the black bullhead, *Ameiurus melas* (Rafinesque, 1820).

The population investigated was well structured, and characterized by the presence of adult and mature specimens, and juveniles; females were more abundant than males as outlined by the *sex ratio*. Three modal classes were highlighted by means of the length-frequency analysis. The first modal class was composed by the juveniles caught in September-October, and showed a modal length of about 11.0 cm TL. This group represent the age class 0 (first year of life), as supported by the age determination through the otolith daily increment analysis, which showed estimates of age between

Tab. 2 - Back-calculation of the date of birth from the estimate of age and the date of capture.

LT (cm)	Age (days)	Date of capture	Date of birth
5.5	84	23/9/06	01/07/06
7.0	92	23/09/06	23/06/06
9.0	106	12/10/06	28/06/06
10.0	120	12/10/06	14/06/06
10.0	112	12/10/06	22/06/06
10.0	110	12/10/06	24/06/06
11.0	109	12/10/06	25/06/06
12.0	108	12/10/06	26/06/06
10.0	118	31/10/06	05/07/06
10.0	111	31/10/06	12/07/06
10.5	113	31/10/06	10/07/06
11.0	122	31/10/06	01/07/06
11.0	121	31/10/06	02/07/06
11.5	119	31/10/06	04/07/06
12.0	130	31/10/06	23/06/06
12.0	128	31/10/06	25/06/06
12.0	114	31/10/06	09/07/06
12.0	112	31/10/06	11/07/06

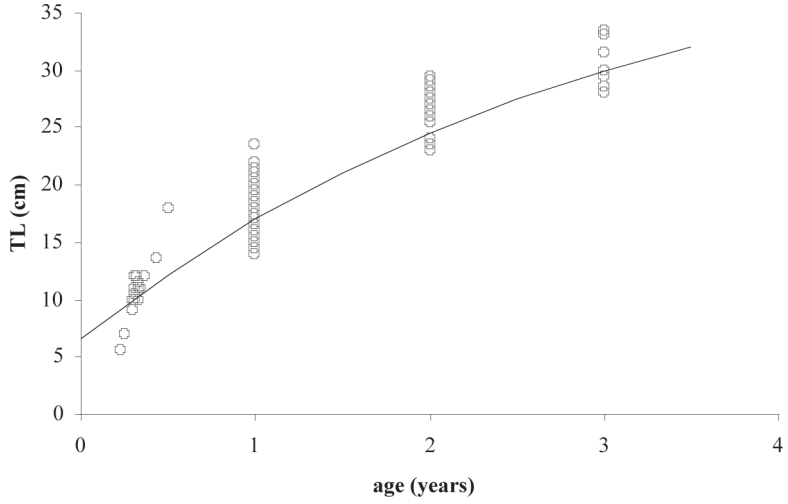

Fig. 4 - Growth curve of *Ictalurus punctatus* (○: observed values; —: fitted curve).

84 and 130 days. The back-calculation highlighted a period of birth in June-July. These results, together with the observation in July of several specimens with spent gonads (stage V), support the hypothesis of the occurrence of the spawning period of *I. punctatus* in the Ombrone River in late spring-summer. This observation is confirmed by the information available on the reproduction behaviour of the channel catfish in the areas of origin (Irwin *et al.*, 1999; Tucker & Hargreaves, 2004).

The growth curve estimated according to the von Bertalanffy model described a fast growth of *I. punctatus*, which acquires a mean size of 17 cm TL at the end of first year of life. The rapid growth, together with other

life history traits, such as high fecundity, resistance to extreme environmental conditions, and resistance to diseases, makes this species suitable for commercial cultivation (Tucker & Hargreaves, 2004), but also contributes to the success in the naturalization of populations in the areas of introduction.

The age determination through otolith analysis showed the presence of specimens which are three years old at most. The age and the size (33.5 cm TL at most) of the specimens caught in the Ombrone suggest that the introduction of *I. punctatus* in river should be relatively recent. The information collected from the associations of recreational fishermen and from the available literature (Bianco & Ketmaier, 2001) confirms this hypothesis: catches of channel catfish specimens have been pointed out since 5-6 years. On the contrary, specimens of more than 70 cm TL and 5 kg of weight are commonly caught in the Arno River (Cuoco, pers. comm.).

As obtained by the analysis of stomach contents, the channel catfish in the Ombrone River showed a mostly piscivorous diet. The feeding habit of the channel catfish makes the species a potential risk factor for the fish communities of such an oligotrophic ecosystem, such as the Ombrone River, where large predators have never existed (Bianco & Ketmaier, 2001).

Therefore, further investigations are requested in order to improve the knowledge on the distribution of the species in the Ombrone River, and in its affluent rivers, and to evaluate the impact of the naturalization of *I. punctatus* on the consistence and biodiversity of the fish communities.

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