Size selectivity of gill-nets and growth of roach *Rutilus rutilus* (Linnaeus, 1758) an alien species in Piediluco lake (Italy)

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ABSTRACT

Key-words:
*growth,
gill-net
selectivity,
alien species,
euthrophic lake,
fisheries
management*

The analysis of catch selectivity of fishing equipment is a crucial step for the management of alien species in freshwater ecosystems. Roach *Rutilus rutilus* was introduced in many waterways in Italy often becoming the dominant species of the fish community and it is now considered potential pest. In Piediluco lake the species was first found in 2004 and its abundance has increased at a level that creates concern for the other fish species present in the lake. The growth of *R. rutilus* and the selectivity of gill-nets on its population were examined in Piediluco lake by analysing the selectivity of gill-nets of different mesh size. Sampling was conducted from January 2011 to October 2012 by means of gill-nets of different-sized mesh (8, 10, 12.5, 15.5, 19.5, 24, 28, 35, 45 and 55 mm). The results showed that *R. rutilus* in Piediluco lake had a growth faster and higher than in many other lake environments. The results of gill-nets selectivity gave important information to design a plan to control this species and confirmed that the use of suitable fishing techniques could be useful to manage the population of this alien species in Piediluco lake as well as in other similar environments.

RÉSUMÉ

Sélectivité en taille des filets maillants et croissance du gardon *Rutilus rutilus* (Linnaeus, 1758), une espèce exotique au lac de Piediluco (Italie)

Mots-clés :
*croissance,
sélectivité,
filet maillant,
espèce exotique,
lac eutrophe,
gestion
des pêches*

L'analyse de la sélectivité des captures du matériel de pêche est une étape cruciale pour la gestion des espèces exotiques dans les écosystèmes d'eau douce. Le gardon *Rutilus rutilus* a été introduit dans de nombreux cours d'eau en Italie, devenant souvent l'espèce dominante de la communauté de poissons et il est maintenant considéré comme nuisible potentiel. Dans le lac de Piediluco l'espèce a été découverte en 2004 et son abondance a augmenté à un niveau qui suscite des inquiétudes pour les autres espèces de poissons présents dans le lac. La croissance de *R. rutilus* et la sélectivité des filets maillants sur la population ont été examinées au lac de Piediluco par l'analyse de la sélectivité des filets maillants de maillages différents. L'échantillonnage a été effectué de janvier 2011 à octobre 2012 au moyen de filets maillants de différentes mailles (8, 10, 12.5, 15.5, 19.5, 24, 28, 35, 45 et 55 mm). Les résultats ont montré que *R. rutilus* du lac de Piediluco a connu une croissance

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plus rapide et plus élevée que dans beaucoup d'autres milieux lacustres. Les résultats de la sélectivité des filets maillants ont donné des informations importantes pour concevoir un plan pour contrôler cette espèce et a confirmé que l'utilisation de techniques de pêche appropriées pourrait être utile pour gérer la population de cette espèce étrangère dans le lac de Piediluco, ainsi que dans d'autres environnements similaires.

INTRODUCTION

The introduction of alien species has dramatically changed many ecological communities and contributed to species extinctions (Byers *et al*., 2002). In recent times this phenomenon has become particularly widespread in aquatic ecosystems due to the increase in aquaculture and stocking programs and it is considered to be one of the greatest threats for biodiversity and for the integrity of native communities (Mack *et al*., 2000; Helfman, 2007).

In the last two centuries, alien fish species have been introduced into European freshwater systems for purposes of sport, aquaculture and ornament (Welcomme, 1988). Once established, many introduced species expand their geographical ranges within the region of introduction with both direct and indirect effects that can cause both economic damage and irreversible ecological changes (Andersen *et al.*, 2004). When alien species are introduced, biodiversity generally declines. The result is that only a few species, proliferate: the less specialist and more able to adapt to a broad range of habitats, (McKinney and Lockwood, 1999) affecting the indigenous or less adaptable ones (Giannetto *et al*., 2012)

In Italy, the introduction of alien fish species has brought a progressive loss of the zoogeographic identity of native fish assemblages (Bianco and Keitmaier, 2001). With regard to Piediluco lake (Central Italy), the original composition of the fish population has undergone significant changes in recent years, mainly as a result of environmental deterioration due to the eutrophication of water (Cioffi and Gallerano, 2000) and the introduction of alien species (Lorenzoni *et al.* 2009). While some species such as European perch *Perca fluviatilis* Linnaeus, 1758 and whitefish *Coregonus lavaretus* (Linnaeus, 1758) were introduced in order to sustain commercial fishing (Riccardi, 1955), others, including roach *Rutilus rutilus* (Linnaeus, 1758), were accidentally introduced into the lake.

R. rutilus is a member of the Cyprinidae and is native in Europe (north to Pyrenees and Alps, eastward to Caspian basin; Aegean basin in Pinios, Vardar, Vegoritis, Kastoria, Struma and Maritza drainages) and Asia (Marmara basin and lower Sakarya in Anatolia, Aral basin, and Siberia from Ob eastward to Lena drainages) (Kottelat and Freyhof, 2007). The species is dominant in many mesotrophic and eutrophic European lakes (Persson, 1993; Persson and Eklov, 1995) and its high adaptive capacity to lentic, lotic and estuarine environments make it one of the most widespread species in Europe (Kottelat and Freyhof, 2007).

Because of its feeding habits, *R. rutilus* can have a significant impact on water quality through accentuating the effects of nutrient enrichment (Ferguson, 2008). Many authors reported that the species has led to a reduction in populations of several fish species through competitive superiority (Johannson and Persson, 1986): rudd *Scardinius erythropthalmus* (Linnaeus, 1758) have been displaced due to both hybridization and competition (Cragg-Hine, 1973; Griffiths, 1997) and in Ireland the introduction of *R. rutilus* has been linked to local extinction of the Arctic charr *Salvelinus alpinus* (Linnaeus, 1758) and to the severe decline in pollan *Coregonus pollan* Thompson, 1835 (Ferguson, 2008).

For all these reasons, Froese and Pauly (2013) listed *R. rutilus* as a potential pest based on information in Kottelat and Freyhof (2007).

In Italy *R. rutilus* was locally introduced for recreational aims and its presence was first noticed in Tuscany and later in the Po River Basin (Delmastro and Balma 1991) where it is currently present in subalpine lakes, reservoirs and rivers (Volta and Jepsen, 2008); in Maggiore lake, for example, its abundance increased at a level inducing concern for commercial
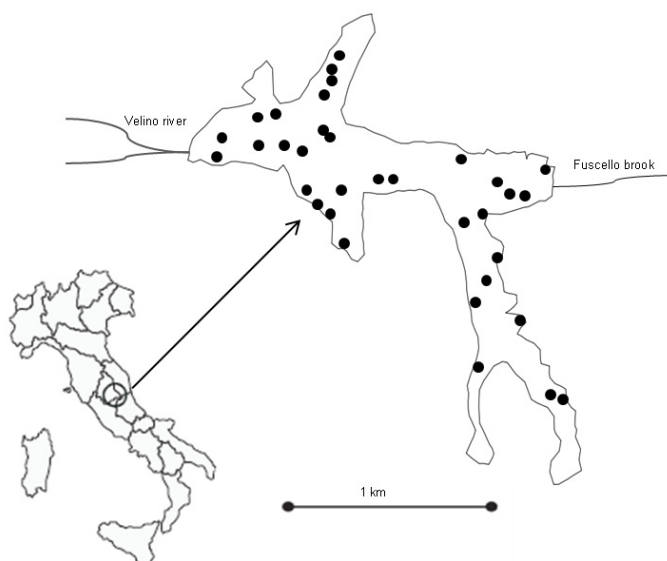
Figure 1
Study area and locations of sampling stations in Piediluco lake.

fishery (Volta, 2007). For Piediluco lake the first record for the species was reported in 2004 (Lorenzoni *et al*., 2005) and nowadays it is the species most caught in the lake (Lorenzoni *et al*., 2012).

Knowledge on growth features and determination of catch rates and selectivity of the fishing equipment are crucial steps for the management of an alien species in freshwater ecosystems (Louette and Declerk, 2006). However, in Italy *R. rutilus* has no commercial interest and commercial fishermen generally avoid catching the species. As a result, very little is known on the size selectivity of the capture methods on the population dynamics of this species.

The aim of this research was to collect information on growth of *R. rutilus* and selectivity of gill-nets on this species that could be useful to design a plan to reduce the abundance of this species in Piediluco lake, as well as in other similar environments.

STUDY AREA

Piediluco lake is a natural lake located in Central Italy (longitude: 0°17′21″0°19′17″ E; latitude: 42°30′54″–42°32′28″N) (Figure 1). With a surface area of 1.67 km^2, this lake (mean depth = 10.90 m; max. depth = 21.48 m) is the second largest natural lake in Umbria Region. Piediluco lake is a regulated lake which has been used for the production of hydroelectric power since 1908. The alkalinity of the lake is 301 mg·L^{-1} CaCO$_3$ (on surface) and 373 mg·L^{-1} CaCO$_3$ (on the bottom). The trophic condition of the lake has undergone a rapid change since the 1980s as indicated by total phosphorus data (Cioffi and Gallerano, 2000): the lake was classified as mesotrophic in 1980 (40 μg·L^{-1}) (according to the classification proposed by Vollenweider (1965)), eutrophic in 1989 (80 μg·L^{-1}) and hypertrophic in 1994 (110 μg·L^{-1}) (according to the classification proposed by OECD (1982) (Cioffi and Gallerano, 2000) mainly due to an increase in inflow nutrients from its drainage basin (Lorenzoni *et al*., 2007; La Porta *et al*., 2010). To date the lake is classified as eutrophic (ARPA, 2013).

The change in water quality and the gradual transition toward a eutrophic status has led to a drastic change in the native fish communities of Piediluco lake (Lorenzoni *et al*., 2006): only 6 species of the original community (Table I) are still present [eel *Anguilla anguilla* (Linnaeus, 1758) Southern pike *Esox cisalpinus* Bianco and Delmastro, 2011, brown trout *Salmo trutta* Linnaeus,1758, Italian rudd *Scardinius hesperidicus* Bonaparte, 1845, cavedano chub *Squalius squalus* (Bonaparte, *1837*) and tench *Tinca tinca* (Linnaeus, 1758)] while Italian roach *Rutilus rubilio* (Bonaparte, *1837*) and three-spined stickleback *Gasterosteus aculeatus*

Table I
Temporal evolution of fish community of Piediluco lake from 1996 to 2012.

Family	Species	Origin	1996	2004	2012
Anguillidae	*Anguilla anguilla* (L.,1758)	Native	X	X	X
Centrarchidae	*Lepomis gibbosus* (L.,1758)	Introduced	X	X	X
Cyprinidae	*Abramis brama* (L.,1758)	Introduced			X
	Alburnus arborella (Bp, 1841)	Introduced	X	X	X
	Carassius auratus (L.,1758)	Introduced			X
	Cyprinus carpio (L.,1758)	Introduced		X	X
	Rutilus rutilus (L.,1758)	Introduced		X	X
	Rutilus rubilio (Bp, 1837)	Introduced	X		
	Rutilus aula (Bp, 1841)	Introduced	X	X	X
	Scardinius hesperidicus Bp, 1845	Native	X	X	X
	Squalius squalus (Bp, 1837)	Native	X	X	X
	Tinca tinca (L., 1758)	Native	X	X	X
Esocidae	*Esox cisalpinus* Bianco & Delmastro, 2011	Native	X	X	X
Percidae	*Gymnocephalus cernua* (L.,1758)	Introduced	X	X	X
	Perca fluviatilis L.,1758	Introduced	X	X	X
Salmonidae	*Coregone lavaretus* (L.,1758)	Introduced	X	X	X
	Salmo trutta L.,1758	Native	X	X	X

Linnaeus, 1758 can be considered extinct (Lorenzoni *et al.*, 2006); the remaining 11 are all introduced (Lorenzoni *et al.*, 2012). In the 1980s the most commonly caught species were *A. anguilla*, *P. fluviatilis*, *C. lavaretus* and *E. cisalpinus* (Giovinazzo, 1988), but to date the population of *P. fluviatilis* has decreased and the dominant species in the lake consists mainly of omnivorous cyprinids (Lorenzoni *et al.*, 2012). Among these, *R. rutilus* has successfully acclimatized and now can be considered a stable member of the lake fish community (Lorenzoni *et al.*, 2012).

MATERIALS AND METHODS

> *DATA COLLECTION*

Fish specimens were collected from January 2011 to October 2012 through gill-nets placed seasonally throughout the lake (Figure 1). The sampling was conducted following the protocol of the Lake Fish Index (LFI) (Volta, 2009) that is a multimetric index proposed for the evaluation of the ecological status of Italian lakes according to the EU Water Framework Directive 2000/60 (EU Water Framework Directive, 2000). The LFI sampling protocol is based on a stratified random sampling of the water column and on the definition of random sampling stations (Volta, 2009). The gill-nets used were monofilament multimesh gillnets in nylon (each one 1.5 m high and 30 m long) assembled from 12 panels of different-sized mesh arranged in the following sequence: 43, 19.5, 6.25, 10, 55, 8, 12.5, 24, 15.5, 5, 35, 29 mm (CEN, 2005; Volta, 2009). In addition to the gill-nets suggested in the LFI sampling protocol, two additional mesh sizes (28 and 45 mm), set as single panels (CEN, 2005) were used.

According with the LFI protocol, the number of sampling stations and gill-nets were determined on the basis of the area and the maximum depth of the lake (Volta, 2009). A total of 34 sampling stations, randomly located throughout the lake, were selected in Piediluco lake. One benthic gill-net was set at each sampling station perpendicularly to the shore and left for one night (12 h).

For all specimens, the total length (TL) was measured to the nearest 0.1 mm, the weight to the nearest 1 g (Anderson and Neumann, 1996) and a sample of scales was collected for each specimen for the determination of age by the scalimetric method (Bagenal, 1978). Aging determination was further validated by means of length-frequency distribution (Britton *et al.*, 2004). After all measurements were completed, specimens of roach were retained for further analyses and no fish was released back to lake.

> GROWTH ESTIMATION

The regression between total length (*TL*) and total weight (*W*) of the specimens was calculated for the total sample of roach by means of the logarithmic equation:

$$\log_{10} W = a + b \log_{10} TL \text{ (mm)}.$$

Growth was estimated by the von Bertalanffy growth curve model (von Bertalanffy, 1938):

$$TL_t = L_\infty(1 - e^{-k(t-t_o)})$$

where TL_t is the total length of the fish at time *t*, L_∞ theoretical maximum length (cm), *k* is a constant expressing the rate of approach to L_∞ and t_0 is the theoretical age at which $TL_t = 0$. The index of growth performance (Φ') was calculated with the equation of Pauly and Munro (1984):

$$\Phi' = \log_{10} k + 2 \log_{10} L_\infty$$

where *k* and L_∞ are the growth parameters of von Bertalanffy model.

> CATCH PER UNIT EFFORT

The data obtained were used to calculate the "fishing effort" (CPUE = catch per unit effort) (Degerman *et al.*, 1988; Wilderbuer and Kappenman, 1998). The CPUE were calculated separately for each mesh size: the fishing effort was calculated considering both the nets area and the soaking-time. It was also expressed in terms of both number (CPUEs *N* = ind·m²·h⁻¹) and biomass (BPUEs = B·m⁻²·h⁻¹) by means of the following formulas: (Mascarenhas Alves *et al.*, 1998):

$$\text{CPUE N} = \text{N/t S}$$

and

$$\text{BPUE} = \text{B/t S}$$

where:
N = number of fish caught; *B* = biomass in grams (g) of fish caught; *S* = area (m²) of the nets; *t* = soaking-time in hours (h) of nets.

> ANALYSIS OF SIZE SELECTIVITY

The selectivity analyses were accomplished by means of the indirect method proposed by Holt (1963) as modified by Sparre and Venema (1992). This method allows fitting the gill-net selectivity curves when the size rate of the population under study is unknown Through the indirect method it is possible to assess the selectivity parameters comparing the quantity of fish caught by two different mesh sizes (m_a and m_b) for the same length class (*L*) (Sparre and Venema, 1992). According to the method, the contact-selection curves (Millar and Fryer, 1999) was calculated as the natural logarithm (ln) of the number of fish caught for each length-group (C_a and C_b) by two different mesh sizes with a similar dimensions (m_a and m_b) were related to total-length (*L*) of the specimens through the linear regression (Holt, 1963):

$$\ln(C_b/C_a) = a + bL$$

where *a* and *b* are parameters of the linear regression.
Then, for the mesh sizes m_a and m_b, the optimum lengths (Lm_a and Lm_b), the selection factor (*sf*) and the standard deviation (sd) were calculated on the basis of the equations (Sparre and Venema, 1992):

$$Lm_a = -2(a\, m_a)/[b(m_a + m_b)];$$
$$Lm_b = -2(a\, m_b)/[b(m_a + m_b)];$$
$$sf = -2a/[b(m_a + m_b)];$$
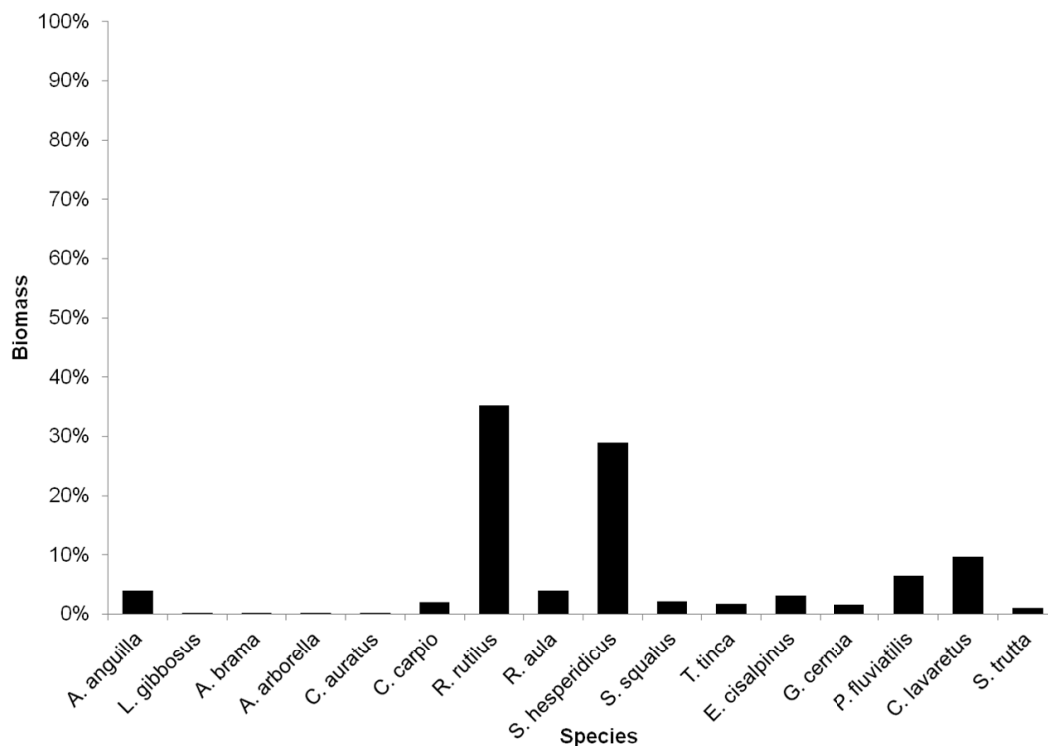$$sd = \{-2a(m_a + m_b)/[b(m_a + m_b)]\}^{1/2}.$$

Figure 2
Biomass of each species caught in Piediluco lake by means of gill-nets.

As the number of mesh sizes was greater than two, the common selectivity factor (SF) was accomplished by the formula provided by Sparre *et al.* (1989):

$$SF = -2 \sum ((a_i/b_i)(m_i + m_{i+1}))/ \sum (m_i + m_{i+1})^2) \text{ for } i = 1 \text{ to } n-1$$

and the standard deviation (SD) was computed as the mean value calculated for each consecutive pair of mesh sizes m_a and m_b (Sparre and Venema, 1992):

$$SD = (1/(n-1) \sum ((2a_i(m_{i+1} - m_i))/(b^2(m_i + m_{i+1})))^{1/2}.$$

The optimum length (*Lm*) represented the 100% probability of capture for each mesh and it was determined for each mesh size m using the equation (Sparre and Venema, 1992):

$$Lm = SF\ m.$$

Finally, assuming a normal curve of selection the probability of capture (P) for a given length *L* in a gill-net with a mesh size m was calculated by the relationship (Sparre and Venema, 1992):

$$P = \exp -((L - Lm)^2/2SD^2).$$

RESULTS

A total of 16 fish species and 9837 individual fish were captured during the study using gill-nets (Figure 2). A total of 1963 *R. rutilus* were captured representing 35.20% of the total biomass. The sample of *R. rutilus* ranged in length from 5.0 cm to 42.4 cm (mean ± SD = 19.57 ± 8.34 cm) (Figure 3a), in weight from 1.50 g to 1190 g (mean ± SD = 162.06 ± 184.94 g) and in age from 0+ to 9+ years (Figure 3b).
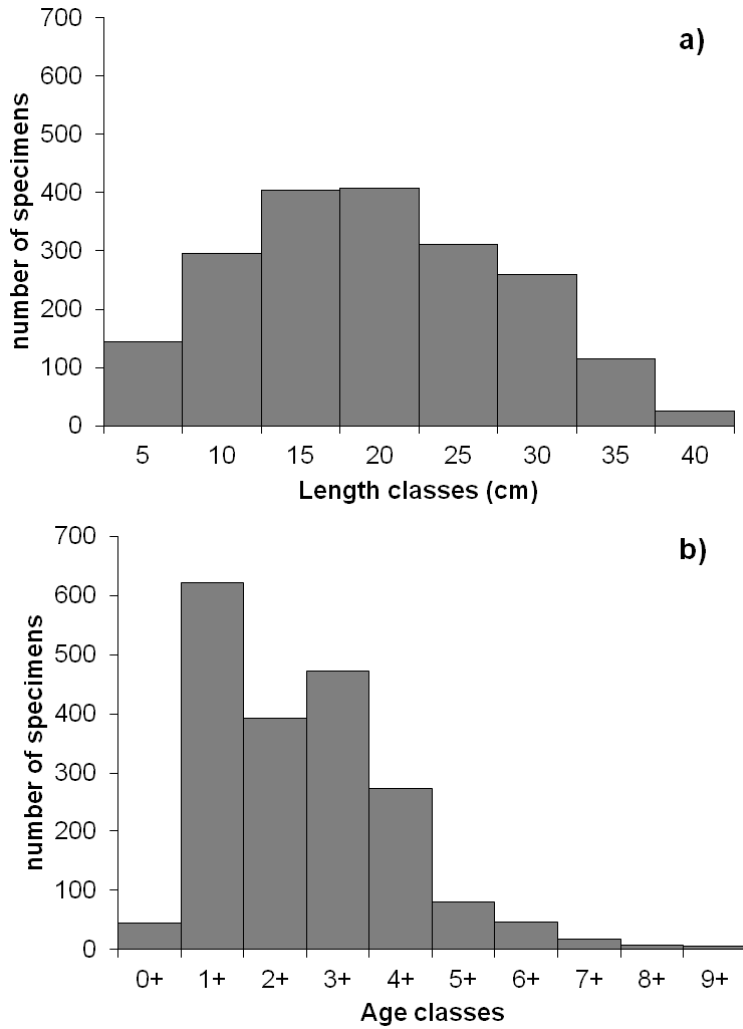
Figure 3
Length (a) and age (b) frequency distribution of roach in Piediluco lake.

The logarithmic *TL*-*W* equation for the total sample of roach was:

$$\log_{10} W = -2.138 + 3.194 \log_{10} TL (R^2 = 0.994).$$

The resulted Von Bertalanffy growth function for roach was:

$$TL_t = 47.820(1 - e^{-0.237(t-0.302)})(R^2 = 0.931).$$

The growth performance index Φ' for roach resulted 2.734.

The mean value of CPUE was 0.244 ind·h^{-1}·m^{-2} while the mean value of BPUE was 39.438 g·h^{-1}·m^{-2} for *R. rutilus*.

By analysing the percentage of *R. rutilus* caught for each age class by each mesh size (Table II), the panels with a small mesh size were more selective than those with a large mesh size: the nets of 35, 45 and 55 mm mesh size caught fish belonging to different age-classes (1+ to 9+) while the nets with a smaller mesh size caught mostly younger specimens. It confirmed that the age of the specimens caught increase with the mesh size used.

Regression parameters (slope and intercept), coefficient of optimum length and selectivity parameters (selection factors and standard deviation) were assessed for each combination of mesh size and were reported in Table III. The common selectivity factor (SF) for roach was 7.53 while the common standard deviation (SD) was 4.33. The optimum selection lengths

Table II
Percentage of specimens of roach caught with each mesh size divided by age-classes (Age) on Piediluco lake.

Age	Mesh size									
	8	10	12.5	15.5	19.5	24	28	35	45	55
0+	91.02	70.73	10.22	–	0.77	–	–	–	–	–
1+	8.98	25.61	89.78	96.30	67.69	23.62	–	1.04	–	–
2+	–	2.44	–	1.23	22.31	60.63	12.11	4.66	–	–
3+	–	1.22	–	1.85	3.08	8.66	67.37	39.90	4.69	16.67
4+	–	–	–	–	2.31	4.72	16.32	43.01	38.54	25.00
5+	–	–	–	0.62	3.85	0.79	2.63	7.77	30.73	8.33
6+	–	–	–	–	–	1.57	1.58	3.11	15.10	25.00
7+	–	–	–	–	–	–	–	–	5.73	16.67
8+	–	–	–	–	–	–	–	–	3.13	–
9+	–	–	–	–	–	–	–	0.52	2.08	8.33

Table III
Selectivity parameters of gill-nets used for catch roach in Piediluco lake.

Mesh size		Selectivity parameters						
m_a	m_b	a	b	R^2	Lm_a	Lm_b	Sf	Sd
8	10	–4.236	0.476	0.681	7.902	9.877	9.877	4.146
10	12.5	–18.552	1.663	0.986	9.913	12.392	9.913	1.489
12.5	15.5	–12.703	0.995	0.774	11.400	14.136	9.120	2.750
15.5	19.5	–11.565	0.735	0.862	13.931	17.526	8.987	4.889
19.5	24	–2.299	0.133	0.312	12.322	15.166	7.949	26.898
24	28	–4.417	0.224	0.597	18.188	21.220	7.578	13.520
28	35	–5.903	0.221	0.671	23.755	29.694	8.484	26.884
35	45	–6.184	0.215	0.516	25.216	32.421	7.205	33.573
45	55	–8.340	0.246	0.592	30.463	37.232	8.769	35.590

Table IV
Optimum selection lengths for each mesh size estimated by the model for roach of Piediluco lake.

	Mesh size									
	8	10	12.5	15.5	19.5	24	28	35	45	55
Lm	6.025	7.531	9.413	11.673	14.685	18.074	21.086	26.358	33.889	41.419

estimated by the model for each mesh size were summarized in Table IV while the resulted selection curve of gill-nets yielded by the probability of capture were illustrated in Figure 4. A linear relationship was observed between the total length of the specimens and the mesh size of the gill-net:

$$m = 1.138 \, TL \, (\text{cm}) + 0.608 \, (R^2 = 0.715; p < 0.001).$$

This confirms that the size of *R. rutilus* caught rose with the increasing of the net mesh size. The resulting relationship was statistically significant ($p < 0.001$).

DISCUSSION

Currently *R. rutilus* is one of the most widespread fish species in Europe (Kottelat and Freyhof, 2007). Because of the high ecological adaptability and the small interest by commercial fishermen, the species is able to acclimatize successfully in new environments and can become predominant in fish community. *R. rutilus* can competes with other species such as *S. erythrophthalmus* (Niederholzer and Hofer, 1980; Volta and Jepsen, 2008) more sensitive to environmental changes (Garcia-Berthou and Moreno-Amich, 2000; Ravera and Jamet, 1991). In Piediluco lake the population of *R. rutilus* has significantly increased in recent years: in 1999 the species was absent in the lake; in 2004 it represented only 4.82% (Lorenzoni *et al*., 2012),
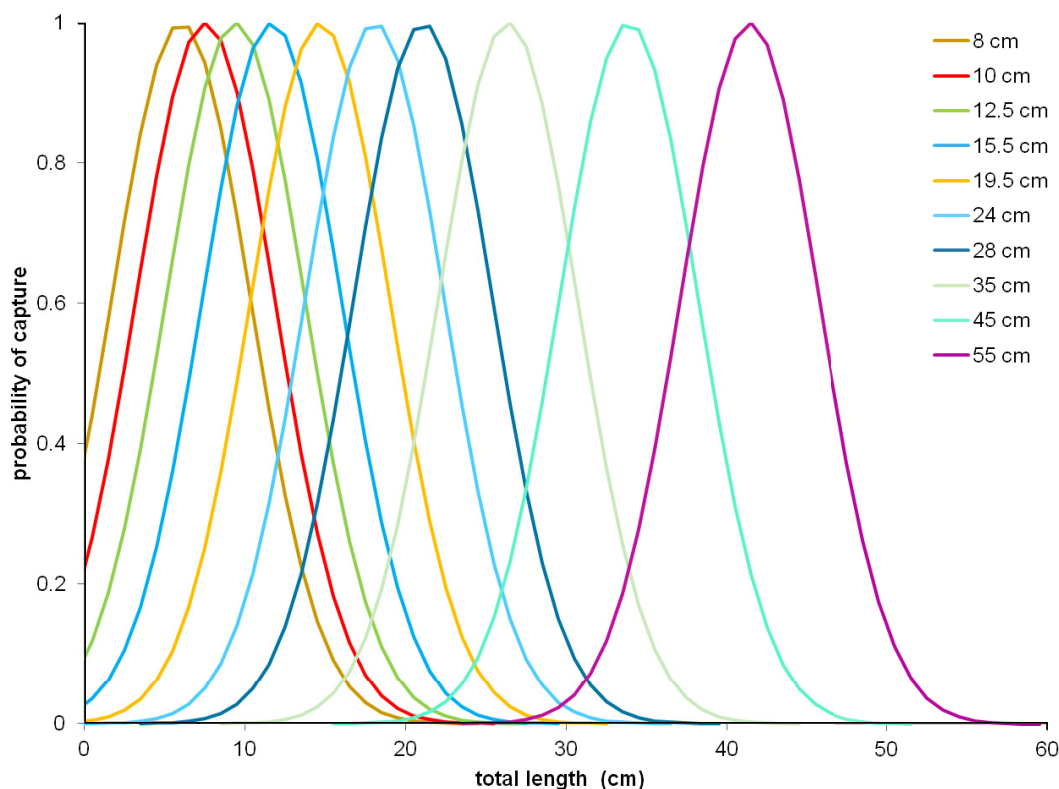
Figure 4
Selectivity curves of gillnets.

Table V
Parameters of the von Bertalanffy regressions and Φ′ values for roach populations from different countries. (L.= lake).

Country	Locality	L∞ (cm)	K	t$_o$	Φ′	References
France	Geneve L.	34.400	0.210	–0.260	2.400	Ponton and Gerdeaux, 1990
Greece	Volvi L.	33.300	0.080	–1.300	1.950	Kleanthidis and Stergiou, 2006
Italy	Piediluco L.	47.820	0.237	0.302	2.734	present research
Italy	Maggiore L.	35.750	0.290	–0.400	2.550	Volta and Jepsen, 2008
Kazakhstan	Aral L.	51.300	0.100		2.420	Pauly, 1978
Poland	Dabie L.	26.300	0.156	–1.172	2.030	Wiesky and Zalachovsky, 2000
Romania	Razim L.	40.000	0.210	–	2.530	Staras et al., 1995
Russian Fed.	Petschora	42.500	0.080	–	2.160	Pauly, 1978
Switzerland	Lugano L.	36.800	0.300	–	2.610	Guthruf, 2002

while in the present research *R. rutilus* reached 35.20% of total biomass captured. While in 2004 only 5 age classes were found (Lorenzoni *et al.*, 2012), in the present research 10 age classes were found The parameters of the von Bertalanffy equation of the population in Piediluco lake also showed a rapid growth: the growth of *R. rutilus* was higher and faster than in other lakes (Table V). In Piediluco lake, the value of Φ′ (that indicated the quality of the growth) also was higher than those of others populations inhabiting eutrophic lake environments (*i.e.* Geneva lake (Ponton and Gerdeaux, 1987) and Lugano lake (Guthruf, 2002)). However, this could be due to differences in other parameters (*i.e.*: alkalinity class or size category) since the growth of fish can also change with increasing alkalinity The value of Φ′ found for roach in Piediluco lake was also higher than that reported for the roach population of Maggiore lake (Volta and Jepsen, 2008) in Northen Italy (the only value available in

literature for Italian populations of roach). However these differences can also depend on the different trophic status being Maggiore lake oligo-mesotrophic (Volta and Jepsen, 2008). The high value of Φ′ found in the present research, confirmed the species ability to expand and to adapt to the environmental conditions of Piediluco lake. This ecological trait of roach represents a threat for this environment, as this could lead to a further worsening of water quality through predation of *R. rutilus* on zooplankton (Lorenzoni *et al.,* 2006). Moreover this expansion of *R. rutilus* also represents a strong threat for those fish species such as *S. esperidicus* that were firstly advantaged by the change in the trophic status of the lake. To this regard, Lorenzoni *et al*. (2012) reported that the small number of young specimens of *S. esperidicus* caught in Piediluco lake indicated a structure typical of a population in regression despite the abundance of the specie resulted constant over time.

The determination of monofilament gillnet selectivity parameters is an important tool for the management of a species (Ozekinci *et al*., 2007).

Gillnet selection curves for roach were estimated by other authors (*i.e.*: Borgstrøm, 1989; Kurkilahti and Rask, 1998; Kurkilahti, 1999; Prchalová *et al*., 2009) by means of the "two-peaked model" (Hovgård and Lassen, 2000). In the present study, the classical "bell-shaped model" (Holt, 1963) modified by Sparre and Venema (1992) was used.

For each of the mesh size combinations the selection factors ranged between 7.20 and 9.91 while the common selectivity factor was 7.53. These values are in line with Andreev (1962) who asserted that this parameter generally varies between 5 and 10.

Knowledge on selectivity of the nets represents one of the most important tools for fishery management (Louette and Declerk, 2006; Ozekinci *et al.*, 2007). The high selectivity of gill nets permits to use specific mesh sizes to catch a suitable narrow size range of fish (Hamley, 1975; Borgstrøm, 1989; Petrakis and Stergiou, 1995). With regard to invasive species, this information is very useful to allow fishery managers to catch the size classes that mainly contribute to population recruitment (Lorenzoni *et al.*, 2010)

Currently no detailed information is known on the reproductive biology of *R. rutilus* in Piediluco lake but the results of other studies (conducted in other environments where the species was introduced) reported that the species reached sexual maturity at 12.3 cm for male and 15 cm for female (2+ age class) in Sapanca lake (an oligotrophic lakes in Turkey) (Tarkan, 2006); at the age class of 1+ for male and 2+ for female in Volvi lake (an eutrophic lake in Greece) (Papageorgiou, 1979). The only information available in literature for Italy refers to Maggiore lake (an oligo-mesotrophic lake) where the species reaches the sexual maturity at a total length of 17.0 cm for male and 19.3 cm for female (at 2+ age-class) (Volta and Jepsen, 2008). According to these results, the nets showing the highest probability to catch specimens that have reached the sexual maturity (1+ and 2+ age classes) were those of 24 mm, 19.5 mm and 15.5 mm. On the contrary, gill nets with a mesh size bigger than 28 mm caught specimens belonging to the older classes.

The choice of the best strategy for the management of an invasive species often results difficult. In such cases it is important to compare costs/benefits against the probability of success (Myers *et al*., 2000). According to this, the first step to design a plan to control an invasive species is a preliminary analysis of the practical possibilities to use the catching tools and the knowledge of their true effectiveness in the field (Koehn, 2003).

The present study represented this preliminary analysis. The results provided useful information on growth of *R. rutilus* in Piediluco lake and the determination of monofilament gill-nets selectivity parameters. This study had an extra value because it represents the first reference on size selectivity of gill-nets for the roach in Italy, the most southern region where the species is present.

Further knowledge on reproductive biology of this species, together with the extension of size selectivity analysis to the other dominant fish species present in Piediluco lake, will allow fishery managers to design a plan for the management of *R. rutilus* population thereby reducing its abundance and limiting its impact on other fish species.

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