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ORIGINAL PAPER

Animal xenodiversity in Italian inland waters: distribution, modes of arrival, and pathways

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Abstract The paper provides a list of the non-indigenous animal species occurring today in Italian inland waters. Xenodiversity was found to amount to 112 species (64 invertebrates and 48 vertebrates), which contribute for about 2% to the inland-water fauna in Italy. Northern and central regions are most affected, and Asia, North America, and the rest of Europe are the main donor continents. The large majority of non-indigenous species entered Italy as a direct or indirect effect of human intervention. A difference between invertebrates and vertebrates was found for their mode of arrival (unintentional for invertebrates and intentional for vertebrates). Accidental transport, in association with both fish (for aquaculture or stock enhancement) and crops, has been the main vector of invertebrate introductions, whereas vertebrates were mostly released for stocking purposes. Overall stock enhancement (47.92%) and culture (37.5%) prevailed over the other pathways. Seventeen and 7 species of our list are included among the 100 worst invasive species of Europe (DAISIE) and of the world (IUCN), respectively. For some (but not all) non-indigenous species recorded in Italy the multilevel impact exerted on the recipient

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communities and ecosystems is known, even if rarely quantified, but knowledge on their chronic impact is still missing. Additional research is needed to provide criteria for prioritizing intervention against well established invaders and identify which new potential invader should be targeted as “unwanted”.

Keywords Inland waters · Italy · Mode of introduction · Non-indigenous species · Pathway · Vector · Xenodiversity

Introduction

There is a large consensus today that the human-mediated introduction of species outside their natural range is one of the main threats to biodiversity and the second leading cause of animal extinctions (Millennium Ecosystem Assessment 2005). Indeed, several non-indigenous species (NIS) have been beneficial to humans (e.g. corn, wheat, rice, plantation forests, and others) (Ewel et al. 1999) and many cause minimal environmental impacts, as predicted by the often cited “tens rule” (Williamson and Fitter 1996; but see Jerscke and Strayer 2005). So, the fraction of NIS that may yield problems is small, but these although few species have had catastrophic impacts. Following their introduction into the wild, they soon turned out to be “invasive” (for definitions of “invasiveness” see Gherardi 2006a), becoming numerically and ecologically prominent, spreading from the point of introduction and being often capable to dominate indigenous populations and communities (Kolar and Lodge 2001); ultimately, they had a profound effect on indigenous species, ecosystem processes, economic interests, and public health (e.g. Ricciardi et al. 1998). The economic costs produced by the various attempts to control NIS and to mitigate their impact may be high, although seldom assessed (for a short review see McNeely 2004).

Inland waters have been the theatre of spectacular invasions. Well-known examples are the introduction of the Nile perch *Lates niloticus* (Linnaeus) into Lake Victoria followed by the elimination of about 200 species of haplochromine cichlids (Craig 1992) and the alteration of the Laurentian Great Lakes communities and ecosystems by the sea lamprey *Petromyzon marinus* Linnaeus and the zebra mussel *Dreissena polymorpha* (MacIsaac et al. 2001). Other less celebrated dramas are ongoing in many freshwater systems of the world with the intervention of previously unsuspected actors, such as *Lepomis gibbosus* among fish, *Dikerogammarus villosus* among crustaceans, or *Rana catesbeiana* among amphibians (Gherardi 2007a).

These and other examples (cfr. Leppäkoski et al. 2002a; Gherardi 2007b) confirm that, compared to terrestrial systems, inland waters are highly vulnerable to either inadvertent or deliberate introductions of species and to their subsequent spread. This vulnerability is the effect of the intensive human uses (Ricciardi 2001), on the one hand, and of the natural linkages among streams and lakes, the effects of water flow, and the dispersal capability of aquatic organisms, on the other.

As a result, several NIS dominate some vast waterscapes of the world (e.g. the red swamp crayfish, *Procambarus clarkii*, dominating many waterbodies of southern Europe; Gherardi 2006b). Xenodiversity (*sensu* Leppäkoski et al. 2002b) may be extraordinarily high in, for example, large rivers of developed countries (e.g. the Hudson; Strayer et al. 2005) and largely affects many taxa (e.g. fish; Lehtonen 2002).

Species originating from diverse bio-geographical areas now coexist in several basins. In the Rhine, for example, indigenous crustaceans [*Gammarus pulex* (Linnaeus)] occur together with North American species (e.g. *Gammarus tigrinus* Sexton), Mediterranean species (the freshwater shrimp *Atyaephyra desmaresti* Millet), and Ponto-Caspian species (e.g. *D. villosus*) (Beisel 2001). Biotic homogenization—i.e. the ecological process leading to an increased similarity of formerly disparate biota over time (Olden and Rooney 2006)—is constantly accelerating (Clavero and García-Berthou 2006; Rahel 2007) and some freshwater systems, such as the Great Lakes, function as “hotspots” of xenodiversity (e.g. MacIsaac et al. 2001).

Finally, many freshwater invaders are moved within and among continents in association with economic activity and trade globalization that benefit millions worldwide (Lodge and Shrader-Frechette 2003). The inevitable tension between two often competing goals—increasing economic activity and protecting the environment from invasive species—makes it difficult to justify the need for decision makers to contain the spread of these species and to mitigate the environmental risks they pose (Gherardi 2006a).

All this implies the need to improve our understanding of the dynamics of species introductions with the purpose to prevent or control future invasions and to predict and reduce their effects (Shea and Chesson 2002). When engaged in this effort, the main steps to undertake are, first, to identify the NIS occurring in a given area and, second, to individuate the vectors of their introduction and the pathways they followed to enter that area. Inventories of NIS have had the potential to lay the basis for describing patterns of invasion at both global (e.g. Lonsdale 1999) and regional scales (e.g. Rabitsch and Essl 2006; Gollasch and Nehring 2006). An accurate knowledge of xenodiversity is also needed to develop policies to cope with the problems associated with biological invasions. Ultimately, an understanding of the mechanisms of previous invasions may help protect aquatic ecosystems from the impacts of future invaders.

This paper is the first attempt to draw a list of the animal NIS occurring today in the inland waters of Italy. Here, we also aimed at identifying the current distribution of these species in Italy, and the times and modes of their introduction. Finally, we analyzed the data to extract more general information that might provide suggestions about the approach to undertake for managing freshwater NIS in Italy and for setting priorities.

Materials and methods

The list has been compiled gathering the information available so far from the scientific literature and processing it after their validation and implementation. Here we report only species introduced by humans but cases of possible natural dispersal are also analyzed. Following the "Guidelines for the reintroduction and restocking of animal species of Community concern" (Italian Ministry of Environment, February 14, 2006), NIS are here regarded as those species that entered Italian waterbodies following the discovery of America by Columbus in 1492 (cfr. Copp et al. 2005). Some cases of single and sporadic occurrences are cited separately. We analyzed here amphibians, reptiles, birds, and mammals that need freshwater systems to complete their life cycle, and invertebrates (free-living and parasitic) and fish inhabiting inland water systems. Inland waters are here defined as all standing or flowing water on the surface of the land (Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy). The analyzed NIS are "foreign" (i.e. species non native to Italy; Copp et al. 2005) and not "translocated" species (i.e. species introduced from other basins).

NIS have been classified according to several categories, i.e. their native range, the date of their (first) introduction into the wild, their current distribution in Italy, mode/s of their arrival in Italy (unintentional or intentional introduction), and vector/s and pathway/s of their first introduction. Dates of NIS first introduction refer to either the exact or the approximate year reported in scientific publications or, when this was not available, to the year of the first record. To reduce the bias due to both approximation and the obvious delay between species introduction, data gathering, and publication of these data, the analysis has been done on 10-year intervals. To describe the distribution of NIS, Italy has been divided into five regions, North-west (NW, including: Aosta Valley, Liguria, Lombardy, and Piedmont), North-east (NE, including: Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige, and Veneto), Center (C, including: Abruzzo, Latium, Marches, Molise, Tuscany, and Umbria), South (S, including: Apulia, Basilicata, Calabria, and Campania), and Islands (I, including: Sardinia and Sicily). Vectors of introductions have been classified into: dispersal, if NIS entered Italy as the result of range expansion by active or passive means from populations of neighboring countries; escape, if they escaped from captivity; release, if they were deliberately released into the wild; and transport, if they were transported accidentally by human means.

Finally, pathways of NIS introductions, independently of their being target or non-target species for that pathway, have been classified into: biocontrol, when NIS have been released in the wild as control agents of other species; culture, when they have been originally imported in association with aquaculture and farming, this category also including specie inadvertently introduced with crops; ornamental, when they have been imported in association with aquariophily or for ornamental purposes; stock enhancement (or stocking), when they have been introduced to increase wild production in association with professional or sport fishing, this category also including species used as fish food or fish bait; shipping, when they have been introduced via ship hulls and in ballast water or sediments. When no documentation is available for a given category or it is dubious or anecdotal we deemed it as "unknown".

Statistical comparisons were made using Wilks' test after Williams' correction (statistic: G). The level of significance at which the null hypothesis was rejected is $\alpha = 0.05$.

Results

The invertebrate and vertebrate species introduced into Italian inland waters since the XVI century reach a total of 112 (Appendices 1 and 2). Our list also includes *Cyprinus carpio*, since its often cited introduction in Roman ages is still under debate (S. Zerunian, pers. comm.). The occurrence of several other species is reported as sporadic, such as the octochaetid earthworm *Dichogaster modiglianii* (Rosa) at Abano spa in Veneto (Omodeo et al. 2005), the mollusc gastropod *Helisoma anceps* (Menke) (Henrard 1968) in Tuscany (Cianfanelli et al. 2007), the Chinese mitten crab *Eriocheir sinensis* H. Milne Edwards in the Lagoon of Venice (Mizzan 2005), and the reptiles *Chelydra serpentina* (Linnaeus), *Mauremys caspica* (Gmelin), *M. leprosa* (Schweigger), *Pseudemys concinna* Le Conte, and *Graptemys versa* Stejniger in several Italian regions (Andreone and Sindaco 1998; Bernini et al. 2004; Bologna et al. 2000, 2003; Scalera 2001, 2003; Sindaco et al. 2006). The crayfish *Cherax destructor* Clark (with the associated ectocommensal Platyhelminthes *Temnocephala minor* Haswell) is currently confined in aquaculture facilities (Quaglio et al. 1999) and the marble crayfish *Procambarus* sp. (Souty-Grosset et al. 2006) in pet shops (N. Crigna, pers. comm.). The taxonomic status of some populations is still uncertain; for instance, some frog populations in North-west Italy were first assigned to *Rana ridibunda* Pallas and now to *R. kurtmuelleri* Gayda or *R. balcanica* Schneider and Sinsch (Sindaco et al. 2006). Finally, the bird *Aix galericulata* (Linnaeus) is not yet established (i.e. with self-sustaining populations), although a few couples have been recently found to breed in Piedmont (GPSO 2007).

Among the 64 invertebrates listed, 3 species are parasites (the Platyhelminthes *Gyrodactylus salaris*, the Nematoda *Anguillicola crassus*, and the Crustacea *Argulus japonicus*, all parasites of fish, i.e. salmonids, eels, and cyprinids/salmonids, respectively), whereas the Annelida *Cambarincola mesochoreus* and *Xironogiton victoriensis* are ectocommensals of non-indigenous crayfish, *P. clarkii* and *Pacifastacus leniusculus*, respectively. The remaining 59 invertebrates of our list are free-living species, mostly crustaceans (32 species) and molluscs (11 species); all of them are today established, except the Coleoptera *Sternolophus solieri*. The majority of the 48 vertebrates recorded here are fish (38 species). Nine fish species (labeled with an asterisk in Appendix 2) require a constant reintroduction by man to sustain their populations. Similarly, *Trachemys scripta* is considered not yet established in Italy, although some populations are know to reproduce in several sites (Di Cerbo and Di Tizio 2006).

The contribution of each division to the xenodiversity of Italian inland waters is shown in Fig. 1 and the fraction of NIS per taxon is given in Table 1. Both fish and arthropods are the most frequent non-indigenous taxa, but by far Mammalia (50% NIS) and bony fish (more than 46% NIS) communities seem to be the most affected, followed by Crustacea Ostracoda, Annelida Branchiobdellea, Crustacea

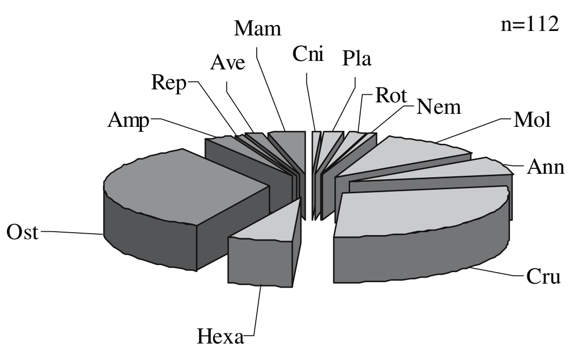

Fig. 1 Frequency (in %) of species of each phylum/division within the 112 non-indigenous animal species recorded in Italian inland waters. Ann = Annelida, Amp = Amphibia, Ave = Aves, Cni = Cnidaria, Cru = Crustacea, Hex = Hexapoda, Mol = Mollusca, Ost = Osteichthyes, Pla = Plathyhelmintes, Mam = Mammalia, Nem = Nematoda, Rep = Reptilia, Rot = Rotifera

Table 1 Number of non-indigenous (NIS) and indigenous (IS) species recorded in Italian inland waters and percentage of NIS per each phylum/division

Phylum/Division	NIS	IS	Total	% NIS
Cnidaria	1	439	440	0.23
Platyhelminthes/Monogenea	1	92	93	1.08
Platyhelminthes/Turbellaria	1	500	501	0.20
Nematoda/Secernentea	1	666	667	0.15
Rotifera/Monogononta	2	189	191	1.05
Mollusca/Gastropoda	7	122	129	5.43
Mollusca/Bivalvia	4	22	26	15.38
Annelida/Oligochaeta	4	196	200	2.00
Annelida/Hirudinea	2	24	26	7.69
Annelida/Branchiobdellea	2	4	6	33.33
Arthropoda/Crustacea/Anostraca	1	15	16	6.25
Arthropoda/Crustacea/Cladocera	12	101	113	10.62
Arthropoda/Crustacea/Ostracoda	9	16	25	36.00
Arthropoda/Crustacea/Amphipoda	2	92	94	2.13
Arthropoda/Crustacea/Copepoda	3	24	27	11.11
Arthropoda/Crustacea/Branchiura	1	3	4	25.00
Arthropoda/Crustacea/Decapoda	4	12	16	25.00
Arthropoda/Hexapoda/Ephemeroptera	1	94	95	1.05
Arthropoda/Hexapoda/Coleoptera	5	650	655	0.76
Arthropoda/Hexapoda/Diptera	1	311	312	0.32
Osteichthyes	38	44	82	46.34
Amphibia	3	31	34	8.82
Reptilia	1	4	5	20.00
Aves	2	69	71	2.82
Mammalia	4	4	8	50.00
Others	0	1821	1821	0.00
Total	112	5545	5657	1.98

The numbers of IS were obtained from Ruffo and Stoch (2005), Anonym. (2007), and pers. comm. by experts. Others include all the invertebrate divisions not shown in the list and 4 indigenous Cyclostomata

Branchiura, and Crustacea Decapoda. Invertebrates and vertebrates share a similar number of NIS ($G = 2.283$, $df = 1$, ns) but the fraction of xenodiversity is significantly higher in the latter (48/204, 23.53%) than in the former (64/5453, 1.17%; $G = 174.393$, $df = 1$, $P < 0.001$). Overall NIS contribute for 1.98% to the whole inland-water fauna (estimated to amount to over 5,600 species; Ruffo and Stoch 2005; Anonym. 2007; pers. comm. of several experts).

Asia, North America, and the rest of Europe are the prevalent donor continents for both invertebrates and vertebrates ($G = 10.533$, $df = 5$, ns; Fig. 2), but invertebrates originate from extra-European countries more often than vertebrates (81.71% vs. 65.52%, $G = 4.228$, $df = 1$, $P < 0.05$), particularly from Asia. A difference was also found for the times of NIS introduction or of their first record in the wild, the entrance into Italy of vertebrate species having apparently started long before that of invertebrates ($G = 25.999$, $df = 7$, $P < 0.001$) (Fig. 3). Interestingly, the rate of invertebrate introductions seems to increase since the 1970s (after 1970: 82.46%),

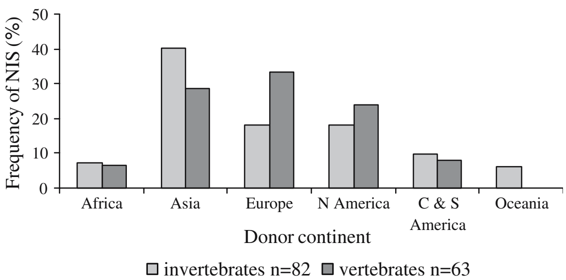

Fig. 2 Frequency distribution of the non-indigenous animal species (NIS) recorded in Italian inland waters per donor continent. Species whose native range includes two or more continents were tallied more than once

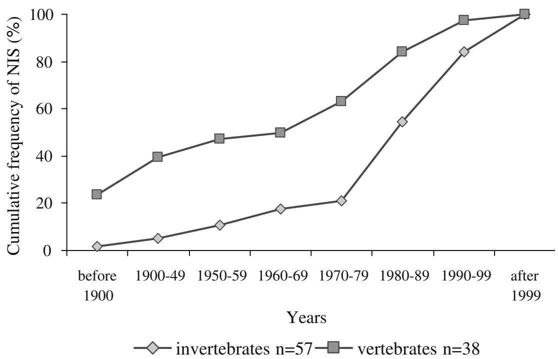

Fig. 3 Increase with time in the frequency of the non-indigenous animal species (NIS) recorded in Italian inland waters. Dates refer to the exact or approximate year of introduction into the wild or, when this datum is absent, to the year of the first record in the published literature. The year of the first introduction/record is missing for 7 invertebrates and 10 vertebrates of the list

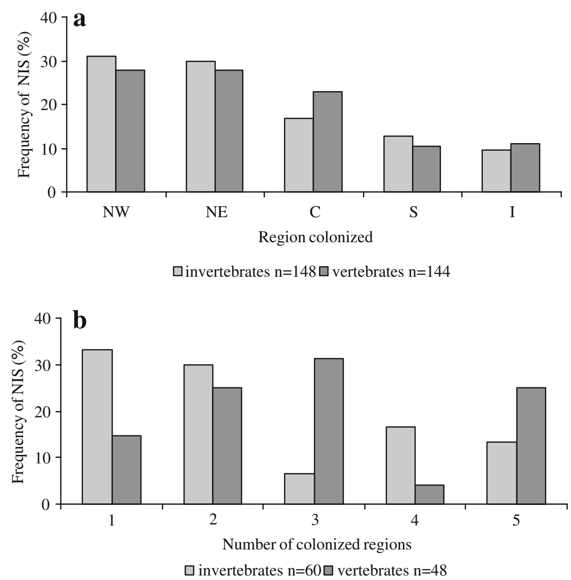

Fig. 4 Frequency distributions of inland-water non-indigenous animal species (NIS) (**a**) per Italian region (NW = North-west, NE = North-east, C = Center, S = South, and I = Islands) and (**b**) per number of regions they have colonized. Species that occur in two or more regions have been tallied more than once in (**a**). The distribution of 4 invertebrates is unknown

whereas vertebrate introductions appear to be relatively constant with time (after 1970: 50%; invertebrates vs. vertebrates compared before and after the 1970s: $G = 11.049$, $df = 1$, $P < 0.001$). Northern (NW: 29.45%, NE: 28.77%) and central Italy (19.86%) are significantly more affected by animal NIS than southern Italy (11.64%) and the islands (10.27%) ($G = 49.917$, $df = 4$, $P < 0.001$; Fig. 4a), without any significant difference between invertebrates and vertebrates ($G = 2.239$, $df = 4$, ns). However, non-indigenous vertebrates seem to be more widely diffused in Italy, as suggested by the larger number of Italian regions they have colonized ($G = 19.206$, $df = 4$, $P < 0.001$; Fig. 4b).

As obvious, vertebrates were introduced by intentional means significantly more often than invertebrates (excluding unknown cases, $G = 36.372$, $df = 1$, $P < 0.001$; Fig. 5a) as the result of the more frequent instances of releases of animals for stocking purposes (in the case of fish) or of abandonment by pet amateurs (in the case of reptiles and birds) (excluding unknown cases, $G = 87.084$, $df = 3$, $P < 0.001$) (Fig. 5b). However, both invertebrates and vertebrates used the same pathways of introduction (Fig. 5c; excluding unknown cases, $G = 8.282$, $df = 4$, ns), stock enhancement (47.92%) and culture (37.5%) largely prevailing over the other pathways (ornamental: 8.33%, biocontrol: 4.17%, shipping: 2.08%; excluding unknown cases, $G = 89.111$, $df = 4$, $P < 0.001$).

Discussion

Given the inevitable future increase of species introductions (e.g. Gherardi 2007a), this study provides only a snapshot of the number and distribution of animal NIS in Italian inland waters. It also offers suggestions about their prevalent modes of arrival, vectors, and pathways. According to our data, the current xenodiversity of Italian inland waters amounts to 112 species that contribute to about 2% to the Italian freshwater fauna. Northern and central regions are most affected by freshwater NIS and Asia, North America, and the rest of Europe are the main donor continents.

The total NIS we recorded is certainly an underestimate of the xenodiversity in Italian inland waters. First, notwithstanding the increased scientific interest for biological invasions in the last decade and the surge of researches focused on the identification of freshwater NIS (Gherardi 2007a), there is still a gap of knowledge about invertebrate taxa and some functional groups. For instance, we have recorded three parasitic and two ectocommensal invertebrates, which is a relatively low number if compared to the

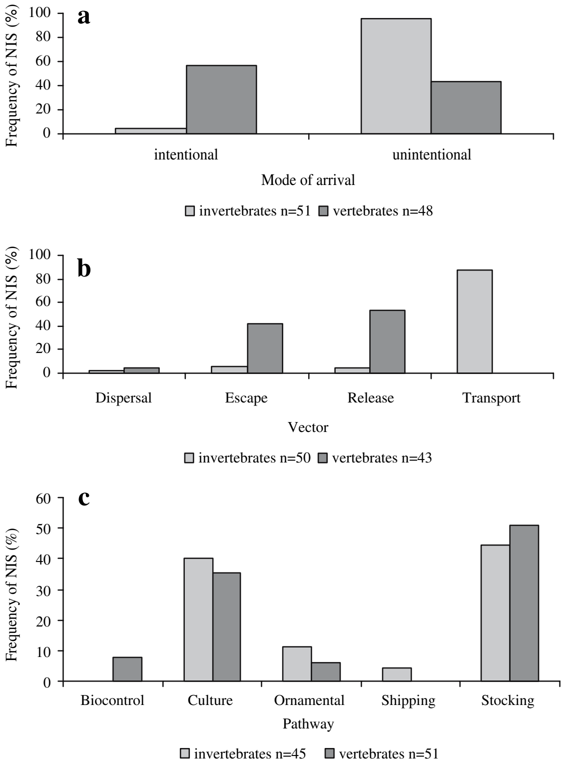

Fig. 5 Frequency distributions of inland-water non-indigenous animal species (NIS) per (**a**) mode of arrival, (**b**) vector, and (**c**) pathway used to enter Italian inland waters. Species that show two or more modes of arrival, vectors, or pathways have been tallied more than once. Data of 13, 15, and 23 invertebrates and of 4, 9, and 10 vertebrates are unknown for mode of arrival, vector, and pathway, respectively

list, although provisional, of eight parasites reported by García-Berthou et al. (2007) for the Iberian Peninsula. Second, we excluded from our list the species whose "cryptogenic" status (*sensu* Carlton 1996) has not been fully solved, such as *Lota lota* (Linnaeus), *Salvelinus alpinus* (Linnaeus) (Betti 2004; Piccinini et al. 2004), and *Tinca tinca* Linnaeus (Bianco 1998). On the contrary, our list includes the gastropod *Haitia acuta*: its origin from North America, and not from the continental Europe as previously suggested (e.g. Burch 1989; Smith 1989), has been confirmed by fossil records, morphological studies, and historical data (Taylor 2003; García-Berthou et al. 2007). Third, we have not analyzed the many events of translocations from one to another region or from the mainland to the islands (Scalera 2001), as well as those of fish between separated ichthyo-geographic districts (Zerunian 2002).

Although provisional, our list of NIS is relatively long if compared to the inventories recently compiled for other European countries, such as Austria (92 animal NIS; Füreder and Pöckl 2007), British Isles (about 60 NIS, plants included; Minchin and Eno 2002), Germany (82 NIS, fungi and plants included; Gollasch and Nehring 2006), and the Iberian Peninsula (73 animal NIS, species from estuaries and coastal lagoons included; García-Berthou et al. 2007). Only three were the species that seem to have entered Italy by the means of natural dispersal, i.e. *Daphnia parvula* that possibly moved in association with migrating waterfowl (but its transport with recreational boats cannot be excluded; Panov et al. 2004), *Ondatra zibeticus* that expanded its range from the neighboring Slovenia (Lapini and Scaravelli 1993), and *Cygnus olor* (but it has been also released for ornamental purposes; Andreotti et al. 2001). Conversely, the large majority of NIS arrived into Italy as a direct or indirect effect of human intervention.

Vertebrates in general and bony fish in particular seem to be the most affected taxon by species introductions. This is not surprising: comprising the most visible and attractive species, on the one hand, and because of the perceived ecological role they play in aquatic food webs and their economic importance, on the other, vertebrates have received the greatest scientific attention. Indeed, due to sport and commercial fishing, aquaculture practices, pet trade, and fur farming, vertebrates have been also subject for more than a century to recurrent and extensive introductions into Italy, most often intentional. The voluntary release of fish into the wild reflects a general phenomenon occurring across the entire Europe (Copp et al. 2005). However, this practice seems to be more diffused in Italy, where controls on legal and illegal stocking have been, at least in the past, generally ineffective or absent. As a consequence, non-indigenous fish in Italy are relatively more numerous than in the rest of Europe (Copp et al. 2005), representing the fourth cause of threat to indigenous fish (Zerunian 2002). As a side effect, fry production centers for sport-fish restocking have probably contributed to the introduction and spread of frogs. Among the other types of intentional introductions, Bertolino and Genovesi (2007) recently reported the release of more than 30,000 individuals of *Neovison vison* in the last 6 years by animal liberation activists and Scalera (2007a,b) showed that pet amateurs are responsible for the recurrent, voluntary release in the wild of *Trachemys scripta* in the last two decades.

Our list includes 64 invertebrate NIS, which exceed the total of 50 species recently reported by Zapparoli (2005). Their introduction is certainly a long-lasting phenomenon in Italy. The increased rate recorded here since the 1970s, also apparent in German fresh waters (Gollasch and Nehring 2006), might be a by-product of the augmented scientific interest in freshwater invertebrate communities but also the result of the success of more tolerant species in systems subject to an augmented degradation and pollution (Meier-Brook 2002). Accidental transport, in association with both fish (for aquaculture or stock enhancement) and crops, especially rice, has been the main vector of invertebrate introductions. Only the crayfish *Pacifastacus leniusculus* seems to have been intentionally released in the wild by fishermen (Capurro et al. 2007), whereas *Artemia franciscana*, first introduced as fish food, subsequently spread at a wide regional scale using waterfowl as vectors (Mura et al. 2006).

Obviously, a realistic assessment of the pathways followed to introduce species should be made on a case-by-case basis. For example, in Germany the most frequent pathway for freshwater introductions is the diffusion through artificial canals (31%) (Gollasch and Nehring 2006), which seems to be obviously less important in Italy (the Alps impede the construction of canals and navigation from the ports in the Mediterranean to inland waters is scarce or absent), whereas stock enhancement has a lower impact in Germany than in Italy (23% vs. 47.92%) and aquaculture or farming has none (0% vs. 37.5%). Shipping seems to be responsible for the arrival into Italy of only two species (*D. villosus* among Crustacea and *D. polymorpha* among Mollusca; 2.08%); on the contrary, it has caused 15% of the recorded freshwater introductions in Germany and 25% in the whole Europe (Gollasch 2007).

While some NIS seem to remain insignificant additions to the native biota, 17 and seven species of our list are included among the 100 worst invasive species of Europe (DAISIE consortium, “Delivering Alien Invasive Species Inventories for Europe”) and of the world (IUCN; Lowe et al. 2000), respectively. For some (but not all) species recorded the multilevel impact exerted on the recipient communities and ecosystems is known in Italy and elsewhere, even if seldom quantified (Gherardi 2007c), including (1) competitive superiority over indigenous species, possibly leading to local extinction or extirpation—e.g. *P. clarkii* (Gherardi 2007d, Gherardi and Acquistapace 2007); (2) hybridization with indigenous species with the consequent reduction of genetic diversity—e.g. *Barbus barbus* (S. Zerunian, pers. comm.); (3) disruption of the pristine interactions between species and of the existing food web links—e.g. *D. villosus* (e.g. Dick and Platvoet 2000; Casellato et al. 2007) (4) habitat modification and alteration of ecosystem functioning—e.g. the coypu *M. coypus* (Bertolino and Genovesi 2007, Panzacchi et al. 2007); (5) introduction of parasites and disease agents—e.g. *Anguillicola crassus* (Kirk 2003), *Aedes albopictus* (Craig 1993), and *Pseudorasbora parva* (Gozlan et al. 2005); and (6) damages to socio-economics, recreation, human health and well-being—e.g. *D. polymorpha* (e.g. Karatayev et al. 1997; Strayer et al. 1999; Lancioni and Gaino 2006). Conversely, we are still ignorant about the long-term ecological and evolutionary feedbacks between invasive species and the invaded communities and ecosystems (Strayer et al. 2006). This suggests that additional research is needed to provide valuable criteria for prioritizing interventions against well established invaders, evaluate alternative management approaches, and finally identify which new potential invader should be eventually targeted as “unwanted”.

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Appendices

Appendix 1 Non-indigenous invertebrate species recorded in Italian inland waters The asterisk means that there are no reports of established (i.e. self-substaining) populations

	Phylum/Division	Family	Species	Authority	Native range
1	Cnidaria	Olindiidae	*Craspedacusta sowerbyi*	Lankester, 1880	China
2	Platyhelminthes/Monogenea	Gyrodactylidae	*Gyrodactylus salaris*	Malmberg, 1957	Baltic
3	Platyhelminthes/Turbellaria	Dugesiidae	*Dugesia tigrina*	(Giard, 1850)	N America
4	Nematoda/Secernentea	Anguillicolae	*Anguillicola crassus*	Kuwahara, Niimi & Itagaki, 1974	E Asia
5	Rotifera/Monogononta	Bdelloidea	*Rhinoglena tokioensis*	Sudzuki, 1976	Japan
6	Rotifera/Monogononta	Notommatidae	*Filinia minuta*	(Smirnov, 1928)	Japan, E Siberia
7	Annelida/Oligochaeta	Ocnerodrilidae	*Eukerria saltensis*	(Beddard, 1895)	S America
8	Annelida/Oligochaeta	Ocnerodrilidae	*Ocnerodrilus occidentalis*	Eisen, 1878	Central Africa
9	Annelida/Oligochaeta	Tubificidae	*Branchiura sowerbyi*	Beddard, 1892	Australia, China, Indonesia, Japan
10	Annelida/Oligochaeta	Tubificidae	*Monopylephorus limosus*	(Hatai, 1898)	China, Japan
11	Annelida/Hirudinea	Erpobdellidae	*Barbronia weberi*	(Blanchard, 1897)	India, SE Asia
12	Annelida/Hirudinea	Piscicolidae	*Piscicola geometra*	(Linnaeus, 1758)	Central Europe
13	Annelida/Branchiobdellea	Branchiobdellidae	*Xironogiton victoriensis*	Gelder & Hall, 1990	N America
14	Annelida/Branchiobdellea	Cambarincolidae	*Cambarincola mesochoreus*	Hoffman, 1963	N America
15	Mollusca/Gastropoda	Ancylidae	*Ferrissia wautieri*	(Mirolli, 1960)	N America
16	Mollusca/Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum*	(J.E. Gray, 1843)	New Zealand
17	Mollusca/Gastropoda	Lymnaeidae	*Pseudosuccinea columella*	(Say, 1817)	N America
18	Mollusca/Gastropoda	Physidae	*Haitia acuta*	(Draparnaud, 1805)	N America
19	Mollusca/Gastropoda	Planorbidae	*Gyraulus chinensis*	(Dunker, 1848)	Asia
20	Mollusca/Gastropoda	Planorbidae	*Helisoma duryi*	(Wetherby, 1879)	N America
21	Mollusca/Gastropoda	Thiaridae	*Melanoides tuberculata*	(O.F. Müller, 1774)	S Asia, Africa
22	Mollusca/Bivalvia	Corbiculidae	*Corbicula fluminalis*	(O.F. Müller, 1774)	S Asia
23	Mollusca/Bivalvia	Corbiculidae	*Corbicula fluminea*	(O.F. Müller, 1774)	SE Asia
24	Mollusca/Bivalvia	Dreissenidae	*Dreissena polymorpha*	(Pallas, 1771)	Ponto-Caspian region
25	Mollusca/Bivalvia	Unionidae	*Anodonta woodiana*	(Lea, 1834)	E Asia
26	Arthropoda/Crustacea/Anostraca	Artemiidae	*Artemia franciscana*	(Kellog, 1906)	Central America, N America, S America
27	Arthropoda/Crustacea/Cladocera	Chydoridae	*Alona diaphana*	King, 1853	Europe, Asia
28	Arthropoda/Crustacea/Cladocera	Chydoridae	*Alona protzi*	Hartwig, 1900	E Europe, N Europe
29	Arthropoda/Crustacea/Cladocera	Chydoridae	*Alona rustica*	Scott, 1895	France, N Europe, Spain, UK
30	Arthropoda/Crustacea/Cladocera	Chydoridae	*Camptocercus uncinatus*	Smirnov, 1971	Central America, E Europe, NE Africa, Asia
31	Arthropoda/Crustacea/Cladocera	Daphniidae	*Ceriodaphnia rotunda*	G.O. Sars, 1862	N-central Europe
32	Arthropoda/Crustacea/Cladocera	Daphniidae	*Dapnhia ambigua*	Scourfield, 1947	N, S America

Appendix 1 continued

	Phylum/Division	Family	Species	Authority	Native range
33	Arthropoda/Crustacea/Cladocera	Daphniidae	*Daphnia parvula*	Fordyce, 1901	N America
34	Arthropoda/Crustacea/Cladocera	Daphniidae	*Simocephalus hejlongjiangensis*	Shi & Shi, 1994	China,Thailand
35	Arthropoda/Crustacea/Cladocera	Macrothricidae	*Wlassicsia pannonica*	Daday, 1904	E Europe, Kazakhistan
36	Arthropoda/Crustacea/Cladocera	Moinidae	*Moina affinis*	Birge, 1893	N America
37	Arthropoda/Crustacea/Cladocera	Moinidae	*Moina weismanni*	Ishikawa, 1896	Japan, SE Asia
38	Arthropoda/Crustacea/Cladocera	Sididae	*Latonopsis australis*	G.O. Sars, 1888	Australia
39	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Chlamydotheca incisa*	(Claus, 1892)	Central America, S America
40	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Chrissia* sp.	(G.O. Sars, 1896)	Africa, India, Malaysia
41	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Cypretta turgida*	(Sars, 1895)	Asia
42	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Dolerocypris sinensis*	Sars, 1903	Eurasia
43	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Hemicypris dentatomarginata*	(Baird, 1859)	India
44	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Isocypris beauchampi cicatricosa*	Fox, 1963	Africa
45	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Stenocypris major*	(Baird, 1859)	Ceylon, India
46	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Strandesia spinulosa*	Bronstein in Akatova, 1958	Africa, Asia
47	Arthropoda/Crustacea/Ostracoda	Cyprididae	*Tanycypris pellucida*	(Klie, 1932)	SE Asia
48	Arthropoda/Crustacea/Copepoda	Centropagidae	*Boeckella triarticulata*	(Thompson, 1883)	Australia, Mongolia, Russia, S America
49	Arthropoda/Crustacea/Copepoda	Cyclopidae	*Apocyclops panamensis*	(Marsh, 1913)	S America
50	Arthropoda/Crustacea/Copepoda	Diaptomidae	*Eudiaptomus gracilis*	(G.O. Sars, 1863)	Central Europe, N Europe
51	Arthropoda/Crustacea/Branchiura	Argulidae	*Argulus japonicus*	Thiele, 1900	Asia
52	Arthropoda/Crustacea/Amphipoda	Gammaridae	*Dikerogammarus villosus*	(Sowinsky, 1894)	Ponto-Caspian region
53	Arthropoda/Crustacea/Amphipoda	Gammaridae	*Gammarus roeseli*	Gervais, 1835	Balkans
54	Arthropoda/Crustacea/Decapoda	Astacidae	*Astacus leptodactylus*	Eschscholtz, 1823	Ponto-Caspian region
55	Arthropoda/Crustacea/Decapoda	Astacidae	*Pacifastacus leniusculus*	(Dana, 1852)	NW USA, SW Canada
56	Arthropoda/Crustacea/Decapoda	Cambaridae	*Orconectes limosus*	(Rafinesque, 1817)	N America
57	Arthropoda/Crustacea/Decapoda	Cambaridae	*Procambarus clarkii*	(Girard, 1852)	S-central USA, NE Mexico
58	Arthropoda/Hexapoda/Ephemeroptera	Siphlonuridae	*Ametropus fragilis*	Albarda, 1878	E Europe
59	Arthropoda/Hexapoda/Coleoptera	Curculionidae	*Stenopelmus rufinasus*	Gyllenhal, 1836	SW USA
60	Arthropoda/Hexapoda/Coleoptera	Hydrophilidae	*Sternolophus solieri**	Laporte, 1840	Asia, Australia
61	Arthropoda/Hexapoda/Coleoptera	Sphaeridiidae	*Cercyon (Paracycreon) laminatus*	Sharp, 1873	SE Asia
62	Arthropoda/Hexapoda/Coleoptera	Sphaeridiidae	*Cryptopleurum subtile*	Sharp, 1884	E Asia
63	Arthropoda/Hexapoda/Coleoptera	Sphaeridiidae	*Pelosoma lafertei*	Mulsant, 1844	S-central America
64	Arthropoda/Hexapoda/Diptera	Culicidae	*Aedes albopictus*	(Skuse, 1894)	SE Asia

Appendix 1 continued

	Date of introduction	Distribution in Italy	Mode of arrival	Vector	Pathway	References
1	1990s	NE, NW, C, Sardinia	Unintentional	Transport	Unknown	Didžiulis (2006)
2	Unknown	NE, NW, C, S, I	Unintentional	Transport	Stocking	Fioravanti (2005)
3	Unknown	NE, NW, C, S	Unintentional	Unknown	Unknown	Ruffo and Stoch (2005)
4	Unknown	NE, NW, C, S, Sicily	Unintentional	Transport	Stocking	Weidema (2000)
5	2000–2002	NW	Unintentional	Transport	Culture (with crops)/Stocking	Rossetti et al. (2003)
6	2000–2002	NW	Unintentional	Transport	Culture (with crops)/Stocking	Rossetti et al. (2003)
7	1996	S	Unknown	Unknown	Unknown	Ferreri (1996)
8	1980	I	Unintentional	Transport	Culture (with crops)	Omodeo (1984); Omodeo et al. (2005)
9	1954	NE, NW, C, S	Unintentional	Transport	Ornamental	Casellato (1984); E. Rota, pers. comm.
10	1980s	NW	Unintentional	Transport	Unknown	Erséus and Paoletti (1986)
11	2005	NW	Unknown	Unknown	Unknown	M. Bodon, pers. comm.
12	1930	NE, NW	Unintentional	Transport	Stocking	Minelli (2005)
13	1999	NE, NW	Unintentional	Transport	Stocking	Morolli and Quaglio (2002); Nobile et al. (2002)
14	1989	NE, NW, C, I	Unintentional	Transport	Stocking	Gelder et al. (1994); Ruffo and Stoch (2005)
15	1959	NE, NW, C, S, Sardinia	Unintentional	Unknown	Unknown	Cianfanelli et al. (2007)
16	1961	NE, NW, C, S, Sicily	Unintentional	Transport	Stocking	Cianfanelli et al. (2007)
17	2004	NW	Unintentional	Transport	Ornamental	Cianfanelli et al. (2007)
18	1866	NE, NW, C, S, I	Unintentional	Transport	Ornamental/Stocking	Cianfanelli et al. (2007)
19	1983	NE, NW, C, S	Unintentional	Transport	Culture	Cianfanelli et al. (2007)
20	1988	NW, C, S, Sicily	Unintentional	Transport	Ornamental	Cianfanelli et al. (2007)
21	1984	C	Unintentional	Escape	Ornamental	Cianfanelli et al. (2007)
22	2004	NE	Unintentional	Transport	Unknown	Cianfanelli et al. (2007)
23	1998	NE, NW	Unintentional	Transport	Stocking	Cianfanelli et al. (2007)
24	1970	NE, NW, C, S	Unintentional	Transport	Shipping	Cianfanelli et al. (2007)
25	1996	NE, NW, C, S	Unintentional	Transport	Stocking	Cianfanelli et al. (2007); De Vico et al. (2007)
26	2004	S	Intentional	Release	Stocking	Mura et al. (2006)
27	1962	NE, NW	Unknown	Unknown	Unknown	Anonym. (2007)
28	2001	NE	Unknown	Unknown	Unknown	Margaritora (2005)
29	1995	NW	Unknown	Unknown	Unknown	Margaritora (2005)
30	1999	C	Unknown	Unknown	Unknown	Margaritora (2005)
31	1992	NE	Unknown	Unknown	Unknown	Margaritora (2005)
32	1969	NE, NW, C, S, Sicily	Unknown	Unknown	Unknown	Anonym. (2007)

Appendix 1 continued

	Date of introduction	Distribution in Italy	Mode of arrival	Vector	Pathway	References
33	2002	Unknown	Unintentional	Dispersal/Transport	Unknown	Panov et al. (2004); Margaritora (2005)
34	1996	NW	Unintentional	Transport	Culture (with crops)	Margaritora (2005)
35	1995	NW, C	Unintentional	Transport	Culture (with crops)	Margaritora (2005)
36	1960s	NE, NW, C	Unintentional	Transport	Culture (with crops)	Margaritora (2005)
37	1986	NE	Unintentional	Transport	Culture (with crops)	Margaritora (2005)
38	1986	NE	Unintentional	Transport	Culture (with crops)	Margaritora (2005)
39	1980s	NE, NW	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003); Rossetti et al. (2006); Pieri et al. (2007)
40	1990s	Unknown	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
41	1980s	NE, NW	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
42	1980s	NE, NW	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
43	1990s	Unknown	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
44	1980s	NE, NW	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
45	1980s	NE, NW	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
46	1980s	NE, NW	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
47	1980s	NE, NW	Unintentional	Transport	Culture (with crops)	Rossi et al. (2003)
48	1980s	NE, S	Unintentional	Transport	Stocking	Ferrari and Rossetti (2006); Rossetti, pers. comm.
49	1997	Unknown	Unknown	Unknown	Unknown	Baldaccini et al. (1997)
50	1980s	NE, NW	Unintentional	Transport	Unknown	Riccardi and Giussani (2007); Riccardi and Rossetti (2007)
51	Unknown	NE, NW, S	Unintentional	Transport	Stocking	Anonym. (2007)
52	2003	NE, NW	Unintentional	Transport	Shipping/Stocking	Casellato et al. (2006, 2007)
53	1986	NW	Unintentional	Transport	Stocking	Ruffo and Stoch (2005)
54	1970s	C	Unintentional	Escape	Stocking	M. Scalici, pers. comm.
55	1997	NE, NW	Intentional	Release	Stocking	Machino (1997); Capurro et al. (2007)
56	1992	NE, NW, C	Unknown	Unknown	Unknown	Delmastro (1992)
57	1989	NE, NW, C, I	Unintentional	Escape	Stocking	Gherardi (2006b)
58	1993	NE	Unintentional	Transport	Stocking	Turin et al. (1997); Belfiore (2005)
59	Unknown	NE, NW, C, S	Unknown	Unknown	Unknown	Anonym. (2007)
60	Unknown	NE, NW	Unintentional	Transport	Unknown	Ruffo and Stoch (2005); Anonym. (2007)
61	1957	NE, NW, C, S, Sardinia	Unknown	Unknown	Unknown	Ruffo and Stoch (2005); Anonym. (2007)
62	Unknown	NE, NW, C, S, Sardinia	Unknown	Unknown	Unknown	Ruffo and Stoch (2005); Anonym. (2007)
63	1929	NE, Sardinia	Unintentional	Transport	Unknown	Ruffo and Stoch (2005); Anonym. (2007)
64	1990	NE, NW, C	Unintentional	Transport	Unknown	Romi (2001)

Appendix 2 Vertebrate non-indigenous species recorded in Italian inland waters. The asterisk means that there are no reports of established (i.e. self-substaining) populations

	Class	Family	Species	Authority	Native range
1	Osteichthyes	Acipenseridae	*Acipenser transmontanus**	Richardson, 1836	N America
2	Osteichthyes	Anguillidae	*Anguilla rostrata**	(Lesueur, 1817)	Central America, N America
3	Osteichthyes	Atherinidae	*Odontesthes bonariensis*	(Valenciennes, 1835)	S America
4	Osteichthyes	Centrarchidae	*Lepomis gibbosus*	(Linnaeus, 1758)	N America
5	Osteichthyes	Centrarchidae	*Micropterus salmoides*	Lacépède, 1802	N America
6	Osteichthyes	Cichlidae	*Oreochromis niloticus*	Greenwood, 1960	Africa
7	Osteichthyes	Claridae	*Clarias gariepinus**	Burchell, 1822	Africa, Jordan, Israel, Lebanon, Syria, Turkey
8	Osteichthyes	Cobitidae	*Misgurnus anguillicaudatus*	(Cantor, 1842)	NE Asia
9	Osteichthyes	Cyprinidae	*Abramis brama*	(Linnaeus, 1758)	Europe
10	Osteichthyes	Cyprinidae	*Aspius aspius*	(Linnaeus, 1758)	Europe
11	Osteichthyes	Cyprinidae	*Barbus barbus*	(Linnaeus, 1758)	Europe
12	Osteichthyes	Cyprinidae	*Barbus graellsii*	Steindachner, 1866	N Spain
13	Osteichthyes	Cyprinidae	*Blicca bjoerkna*	(Linnaeus, 1758)	Europe
14	Osteichthyes	Cyprinidae	*Carassius auratus*	(Linnaeus, 1758)	Central Asia, China, Japan
15	Osteichthyes	Cyprinidae	*Carassius carassius*	(Linnaeus, 1758)	Europe, N-central Asia
16	Osteichthyes	Cyprinidae	*Chondrostoma nasus*	(Linnaeus, 1758)	Danube basin, Rhine basin
17	Osteichthyes	Cyprinidae	*Ctenopharyngodon idellus**	(Valenciennes, 1844)	Asia, E Europe
18	Osteichthyes	Cyprinidae	*Cyprinus carpio*	(Linnaeus, 1758)	China, E Europe, India, SE Asia, Siberia
19	Osteichthyes	Cyprinidae	*Hypophthalmichthys molitrix**	(Valenciennes, 1844)	China, Siberia
20	Osteichthyes	Cyprinidae	*Hypophthalmichthys nobilis**	(Richardson, 1836)	China
21	Osteichthyes	Cyprinidae	*Pachychilon pictum*	(Heckel & Kner, 1858)	Albania
22	Osteichthyes	Cyprinidae	*Pseudorasbora parva*	(Schlegel, 1842)	E Asia
23	Osteichthyes	Cyprinidae	*Rhodeus sericeus*	(Pallas, 1776)	Asia, Europe
24	Osteichthyes	Cyprinidae	*Rutilus rutilus*	(Linnaeus, 1758)	Europe
25	Osteichthyes	Ictaluridae	*Ameiurus melas*	(Rafinesque, 1820)	N America
26	Osteichthyes	Ictaluridae	*Ameiurus nebulosus**	(Lesueur, 1819)	N America
27	Osteichthyes	Ictaluridae	*Ictalurus punctatus*	(Rafinesque, 1818)	N America
28	Osteichthyes	Percidae	*Gymnocephalus cernuus*	(Linnaeus, 1758)	Europe
29	Osteichthyes	Percidae	*Sander lucioperca*	(Linnaeus, 1758)	E-central Europe, W Asia
30	Osteichthyes	Poeciliidae	*Gambusia holbrooki*	Girard, 1859	USA

Appendix 2 continued

	Class	Family	Species	Authority	Native range
31	Osteichthyes	Salmonidae	*Coregonus lavaretus*	(Linnaeus, 1758)	Europe
32	Osteichthyes	Salmonidae	*Coregonus oxyrhynchus*	(Linnaeus, 1758)	Europe
33	Osteichthyes	Salmonidae	*Oncorhynchus kisutch**	(Walbaum, 1792)	Canada, Japan, Mexico, Russia
34	Osteichthyes	Salmonidae	*Oncorhynchus mykiss**	(Walbaum, 1792)	E Asia, N America
35	Osteichthyes	Salmonidae	*Salmo trutta (Atlantic lin.)*	Linnaeus, 1758	Asia, Europe
36	Osteichthyes	Salmonidae	*Salvelinus fontinalis*	(Mitchill, 1814)	NE N America
37	Osteichthyes	Salmonidae	*Thymallus thymallus (Danube lin.)*	(Linnaeus, 1758)	Danube basin
38	Osteichthyes	Siluridae	*Silurus glanis*	Linnaeus, 1758	Asia, Europe
39	Amphibia	Pipidae	*Xenopus laevis*	(Daudin, 1802)	Angola, Nigeria, South Africa, Sudan
40	Amphibia	Ranidae	*Rana catesbeiana*	Shaw, 1802	NE N America
41	Amphibia	Ranidae	*Rana kurtmuelleri*	Gayda, 1940	Albania, Greece, Serbia
42	Reptilia	Emydidae	*Trachemys scripta*	(Schoepff, 1792)	Columbia, Mexico, USA, Venezuela
43	Aves	Threskiornithidae	*Threskiornis aethiopicus*	(Latham, 1790)	Iraq, Sub-Saharan Africa
44	Aves	Anatidae	*Cygnus olor*	(Gmelin, 1789)	Europe, Asia
45	Mammalia	Muridae	*Ondatra zibeticus*	(Linnaeus, 1766)	N America
46	Mammalia	Muridae	*Rattus norvegicus*	(Berkenhout, 1769)	China, Siberia
47	Mammalia	Mustelidae	*Neovison vison*	(Schreber, 1777)	N America
48	Mammalia	Myocastoridae	*Myocastor coypus*	(Molina, 1782)	S America

	Date of introduction	Distribution in Italy	Mode of arrival	Vector	Pathway	References
1	1987	NE, NW	Intentional	Unknown	Culture	Froese and Pauly (2007); Nocita and Zerunian (2007)
2	Unknown	NE, NW	Intentional	Unknown	Culture	Froese and Pauly (2007); Nocita and Zerunian (2007)
3	1974	C	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
4	19th cent	NE, NW, C, S, I	Unknown	Unknown	Unknown	Froese and Pauly (2007); Nocita and Zerunian (2007)
5	19th cent	NE, NW, C, S, I	Intentional	Release	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)

Appendix 2 continued

	Date of introduction	Distribution in Italy	Mode of arrival	Vector	Pathway	References
6	Unknown	NE	Unknown	Unknown	Unknown	Froese and Pauly (2007); Nocita and Zerunian (2007)
7	Unknown	NW, C	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
8	Unknown	C	Unintentional	Escape	Unknown	Froese and Pauly (2007); Nocita and Zerunian (2007)
9	1985	NE, NW, C	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
10	Unknown	NE, NW	Unknown	Unknown	Unknown	Froese and Pauly (2007); Nocita and Zerunian (2007)
11	1994–1995	NE, NW, C	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
12	Unknown	C	Unintentional	Escape	Unknown	Froese and Pauly (2007); Nocita and Zerunian(2007)
13	1993	NE, NW, C	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
14	18th cent	NE, NW, C, S, I	Intentional	Unknown	Culture	Froese and Pauly (2007); Nocita and Zerunian (2007)
15	19th cent	NE, NW, C	Intentional	Unknown	Culture	Froese and Pauly (2007); Nocita and Zerunian (2007)
16	1991	NE, NW	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
17	1975	NE, NW, C	Intentional	Release	Biocontrol/Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
18	Unknown	NE, NW, C, S, I	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
19	Unknown	NE, NW, C	Intentional	Release	Biocontrol/Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
20	1975	NE, NW, C	Intentional	Release	Biocontrol/Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
21	1989	NE, NW	Unintentional	Escape	Unknown	Froese and Pauly (2007); Nocita and Zerunian (2007)
22	1990	NE, NW, I	Intentional	Release	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
23	1980s	NE, NW	Unintentional	Escape	Unknown	Froese and Pauly (2007); Nocita and Zerunian (2007)

Appendix 2 continued

	Date of introduction	Distribution in Italy	Mode of arrival	Vector	Pathway	References
24	1989	NE, NW, C	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
25	19th cent	NE, NW, C, S, I	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
26	1906	NE, NW, C, S, I	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
27	1970s	NE, NW, C	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
28	1985	NE, NW, C	Unintentional	Escape	Unknown	Froese and Pauly (2007); Nocita and Zerunian (2007)
29	1900	NE, NW, C	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
30	1922	NE, NW, C, S, I	Intentional	Release	Biocontrol	Froese and Pauly (2007); Nocita and Zerunian (2007)
31	1880	NE, NW, C, S	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
32	1950s	NW, C	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
33	1960s	NE, NW	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
34	1895	NE, NW, C, S, I	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
35	Unknown	NE, NW, C, S, I	Intentional	Release	Culture/Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
36	1891	NE, NW	Intentional	Release	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
37	Unknown	NE, NW	Intentional	Release	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
38	1950–1974	NE, NW, C	Unintentional	Escape	Stocking	Froese and Pauly (2007); Nocita and Zerunian (2007)
39	2004	Sicily	Unknown	Unknown	Unknown	Sindaco et al. (2006)
40	1932	NE, NW, C?, S?	Intentional	Release	Culture	Scalera (2001, 2003); Sindaco et al. (2006)
41	1941	NW	Intentional	Release	Stocking	Scalera (2001, 2003); Sindaco et al. (2006)
42	1977	NE, NW, C, S, I	Intentional	Release	Ornamental	Sindaco et al. (2006)

Appendix 2 continued

	Date of introduction	Distribution in Italy	Mode of arrival	Vector	Pathway	References
43	1989	NE, NW	Intentional/Unintentional	Escape/Release	Ornamental	Andreotti et al. (2001); Scalera (2001)
44	1950–1960	C, S,Sardinia	Intentional/Unintentional	Dispersal/Release	Ornamental	Andreotti et al. (2001)
45	1990s	NE	Unintentional	Dispersal	Not applicable	Lapini and Scaravelli (1993)
46	16–17th cent	NE, NW, C, S, I	Unintentional	Unknown	Unknown	Andreotti et al. (2001); Ruffo and Stoch (2005)
47	1980s	NE, C, Sardinia	Intentional/Unintentional	Escape/Release	Culture	Bertolino and Genovesi (2007)
48	1930s	NE, NW, C, S, I	Intentional/Unintentional	Escape/Release	Culture	Bertolino and Genovesi (2007)

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