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Zapparoli, Marzio

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The allochthonous component in the fauna of peninsular Italy

MARZIO ZAPPAROLI

*Dipartimento di Protezione delle Piante, Università degli Studi della Tuscia,
Via San C. De Lellis s.n.c., 01100 Viterbo (Italy);
e-mail: zapparol@unitus.it*

Key words: Italy, introduced species, biological invasions

SUMMARY

A broad picture of the animal species, both terrestrial and inland water, that have recently been introduced in the Apennine region of Italy (from Tuscany to Calabria) is presented in this paper. Information was gathered from a) the latest studies on the consistency and distribution of the Italian fauna (e.g., "Checklist delle specie" and "CKmap" projects), b) syntheses on particular taxonomic groups and/or fields of research, and c) other information from scientific literature or from taxonomists. Extinct allochthonous species, species whose status of acclimatization/naturalization is unknown, and parautochthonous species (introduced before 1500 A.D.), were excluded from this analysis. 397 allochthonous species have been documented as introduced in this area, of which 320 (80.6%) have naturalized (represented by self-sustaining populations) and 77 (19.4%) have acclimatized (with populations in the wild, but not yet self-sustaining). The naturalized species constitute 1.2% of the fauna in the study area (26,200 total species). The majority of introduced species are Arthropoda, in particular Insecta (68% of the naturalized species, especially Homoptera Sternorrhyncha and Coleoptera), followed by Vertebrata (16% of the naturalized species, especially Osteichthyes). Annelida Oligochaeta, Mollusca Gastropoda and Bivalvia, Platyhelminthes and Nematoda are also present, but are much less numerous. According to the presence/absence regional data of 189 introduced species (both acclimatized and naturalized), Lazio, Tuscany and Campania are the surveyed administrative regions in which the highest number of species have been recorded. This result could be due to a greater effort of research having been realized in these areas or to the presence of factors that "predispose" the entry of allochthonous species, such as the high number of city centers, economic activities, and anthropic disturbance. With regard to the causes of introduction, the unintentionally introduced species represent 75% (304 species), while the intentional introductions represent only 25% (93 species) of the total; in both categories the naturalized species constitute 75-80%. Intentional introductions were carried out for biological control (34%), professional and sport fishing (27%), collection/ornamental (18%), hunting/alimentary (12%), industrial (fur and other) (4%) and scientific (3%) purposes. The unintentional introductions occurred largely through the importation of plants and/or vegetable products (58%), human movements (17%), importation of stored products (11.5%), fish spawning/aquaculture (5.5%), and importation of infected animals (2%) or other (4%). According to the zoogeographic origin of 298 introduced species, 44% are of Palaearctic (16% E-Palaearctic, 28% W-Palaearctic), 21% Neoarctic, 11% Afrotropical, 10% Neotropical, 9% Oriental, 6% Australoasiatic origin. A preliminary assessment based on the presence and distribution in selected macrohabitats of potentially or effectively invasive (impacting on biodiversity) species suggest that natural inland water habitats are at greater risk of invasion in comparison with natural/semi-natural terrestrial ones. However differing amounts of knowledge are available for the two main type of habitats, greater for the inland water, smaller for the terrestrial ones. In the latter, the effects produced by allochthonous mammals and birds are especially known, meanwhile information about the impact of introduced invertebrates is highly lacking, in particular of insects, which while represented in great numbers of species are at present largely confined to artificial habitats (urban areas and/or agroecosystems).

INTRODUCTION

The introduction of allochthonous species is a subject which has long attracted the attention of scientists and the literature on this topic is now quite rich (Elton, 1958; Simberloff, 2004). The spread of non native species is a remote phenomenon and it has increased over time, chiefly in the last few decades. Especially the introduction of invasive alien species is today considered, on a local and global scale, one of the main causes of loss of biodiversity at all levels (e.g., Kowarik, 2003; Mack et al., 2000; McKinney and Lockwood, 1999; Mooney and Hobbs, 2000; Schmitz and Simberloff, 1997; Simberloff and Von Holle, 1999; Van Driesche and Van Driesche, 2000; Veitch and Clout, 2002). Biological invasions are also facilitated by other forms of environmental alteration that are now more and more widespread and evident, such as the habitat fragmentation, the urbanization, and the climatic change (Sala et al., 2000), and may also have substantial economic consequences (Perrings et al., 2000; Pimentel, 2002).

This phenomenon is quite significant also in Italy, both on a local and national level. Concerning birds, for instance, Andreotti et al. (2001) listed 110 allochthonous species as present in the whole country, where 484 autochthonous species are known (Brichetti and Massa, 1998). Meanwhile, 52 allochthonous species have been reported in the Lazio (Central Italy), against 374 known autochthonous species (Brunelli and Fraticelli, 2004). Although only a small portion of the allochthonous bird species recorded (nearly 13%) have formed more or less stable naturalized or acclimatized populations, the speed with which some of them are colonizing natural key habitats, like wetlands, is a source of great concern for the conservation of the native biocenosis (Andreotti et al., 2001).

The number of legislative and technical tools with which several countries are being equipped in order to contain and prevent the introduction of new organisms is also increasing rapidly (e.g., IUCN, 2000; McNeely et al., 2001; Perrings et al., 2005; Simberloff et al., 2005; Wittenberg and Cock, 2001). In Europe, one can mention the “European Strategy on the Invasive Alien Species”, elaborated by the Council of Europe, which should allow the guiding principles approved by the Convention on the Biodiversity to be applied (Genovesi and Shine, 2004), and the DAISIE project (Delivering Alien Invasive Species Inventories for Europe; <http://www.europe-aliens.org>) directed to the organization and implementation of a free internet database that, after one year of its set up, should bring together nearly 1500 experts from 89 countries (Shirley and Kark, 2006).

Italy has not only adhered to the international conventions and directives (e.g., Bern, Bonn, Ramsar, Rio de Janeiro, Washington Conventions; Barcelona Protocol; Wild Birds, Habitat, EC 2000/29/EC Directives, CITES), but has

also taken further steps, namely the emanation of national and local laws, the application of the above mentioned “European Strategy on the Invasive Alien Species”, and, more recently, the production of “Guidelines for the translocation of wildlife species” (AA.VV., in press; Bertolino and Genovesi, 2005; Genovesi and Shine, 2004; Spagnesi and Zambotti, 2001).

Aim of the present work is to offer a synthesized picture of terrestrial and inland water animal species that have been recently introduced to the Italian peninsula, also providing estimates and considerations on the consistency and complexity of this component of the Italian fauna in a significant part of the national territory.

STUDY AREA

In this study a territorial subdivision of the country which is necessarily schematic, but has already been productively used in recent faunistic analysis carried out on a national level, has been chosen to adopt. It has been therefore investigated the geographical sub-area indicated as “S” (= Central and Southern Italy) in the recent “Checklist of the species of the Italian fauna” (Minelli et al., 1993-1995) and the subsequent updating, the most authoritative and up-to-date list of animal species in Italy, a basis for every project dealing with Italian fauna. This sub-area includes the administrative regions of Tuscany, Marches, Umbria, Lazio, Abruzzo, Molise, Campania, Apulia, Basilicata and Calabria; it extends for approximately 131,632 km², encompassing almost 44% of the national territory.

METHODS

Published data on allochthonous species that have acclimatized or naturalized in the study area since 1500 A.D. were examined. The extinct allochthonous species, and those whose status of acclimatization/naturalization is unknown (about one hundred species) were excluded. Species introduced before 1500 A.D., parautochthones or archeozoa according to AA.VV. (in press) and Geiter (1999) respectively (at least 130 species) were also not included because of their origins not verified with reasonable certainty (Robinson, 1996), and/or they special historical and social-cultural value (e.g., Amori and Lapini, 1997; Andreotti et al., 2001; Arrébola Burgos and Álvarez Halcón, 2001; Perco and Lovari, 2002; Scalerà, 2001).

Sources of the data

Data are from the following five groups of documentary sources:

- 1) the “Checklist of the species of the Italian fauna” (Minelli et al., 1993-1995) and the subsequent updating papers periodically published on the

Bollettino della Società italiana di Entomologia starting from volume 131 (Baccetti et al., 1999); in particular, the notes accompanying the listed species were consulted;

2) the “Project CKmap” (Ruffo and Stoch, 2005), a project dealing with the computerization of the distributional data of more than 10.000 terrestrial and freshwater invertebrate and vertebrate species in Italy;

3) recently published synthesis on specific taxonomic groups and research fields, i.e. freshwater Mollusca (Lori et al., 2005), insects of stored products (Nicoli Aldini, 2003) and of phytosanitary interest (Pellizzari and Dalla Montà, 1997), as well as vertebrates (Amori and Lapini, 1997; Amori et al., 1999; Andreotti et al., 2001; Bianco and Ketmaier, 2001; Calvario et al., 2004; Gandolfi et al., 1991; Scalera, 2001; Sindaco et al., 2006; Zerunian, 2002, 2004);

4) approximately 600 specialistic papers published in major technical/scientific Italian or foreign journals;

5) personal communications of specialists of selected taxonomic groups.

The obtained information (updated to June 2006) has been arranged in a database that includes numerous entries, such as the Italian and general geographic distribution, area of origin, habitat, time, causes and aims of introduction, data on invasiveness as well as bibliographic references.

Definitions

Definitions were adopted from the Convention on the Biological Diversity signed in 1992 in Rio de Janeiro at the Conference of the United Nations on “Environment and Development” (COP, 2002); Italy ratified this Convention with the law n. 124 on February 14, 1994. Other sources, such as IUCN (2000), Genovesi and Shine (2004), and AA.VV. (in press) were also considered. For a useful thorough analysis of the theoretical aspects related to the used terminology, see Richardson et al. (2000). The following definitions of terms were followed herein:

- autochthonous species: a species naturally present in a given geographic area in which it originated or has reached without direct/indirect human participation (intentional/unintentional);
- allochthonous species (alien, exotic, non autochthonous, non native species): a species that do not belong to the original fauna of a given geographic area, but is there due to direct/indirect human participation (intentional or unintentional); the definition includes any part of the organism (gametes, eggs, propagules) able to survive and subsequently reproduce;
- acclimatized species: a recently introduced allochthonous species that, although able to reproduce in the short time, still have not reached levels of consistency and distribution to assure its self-sustaining for a long period of time;

- naturalized species: an allochthonous species represented by one or more populations that have successfully been established for a long period of time and are now able to self-sustaining indefinitely;
- invasive species: a naturalized species whose introduction or whose expansion represents a threat for the biological diversity.

In the Italian zoological literature one can also meet with other terms, such as “adventitious” and “intercepted”, not always clearly defined and sometimes referred to particular cases (e.g., “indoor” habitats). According to Nicoli Aldini (2003), an adventitious species is an allochthonous species reproducing (or completing its life cycle) in closed anthropic habitats (e.g., buildings, stores), perhaps reproducing also in the wild; an intercepted species is an allochthonous species singleton or occasionally recorded in the new area and whose reproduction (or complete life cycle) has never been reported there. In the present analysis the species defined by the former term are considered as acclimatized, whereas those defined by the second are excluded.

RESULTS

Consistency of the allochthonous component in the fauna of peninsular Italy

Examination of the data revealed that have been 397 allochthonous species inhabit the terrestrial and inland water habitats of the area under investigation. Among those species, 77 are acclimatized (19.4%) and 320 are naturalized (80.6%). These estimates account for more than half (52.9%) of the 750 allochthonous animal species (acclimatized or naturalized) recorded in terrestrial and inland water habitats of the whole Italy (Zapparoli, unpublished data). These values however provide a limited view of the phenomena underway in the studied area, as they does not include near one hundred species whose status of naturalization/acclimatization has not yet been stated.

If we consider the number of species reported in the “subarea S” of the “Checklist of the species of the Italian fauna” (Minelli et al., 1993-1995), the naturalized species would constitute a portion of the peninsular Italy fauna equal to 1.2% of the total species. This estimate was based on the assumption that there are approximately 26,200 species (26,161 according to Minelli et al., 2005, and at least forty allochthonous species have been subsequently reported). In the other sub-areas of the Check-list project the naturalized species component comprises similar portions (Zapparoli, unpublished data), ranging between 0.9% (northern Italy, 322 species) and 1.4% (Sicily, 196 species). Meanwhile near 1.6% of the species in Italy nationwide can be considered naturalized (518 species) (Tab. I).

Tab. I - Approximate number of species and percentage of the allochthonous component in the terrestrial and freshwater fauna in Italy (only naturalized species); * = source Minelli et al. (2005), Stoch (2005), ** = approx.

Geographical sectors	Number of species*	Number of allochthonous species (naturalized)	% of allochthonous species (naturalized)
Northern Italy	35,581	322	0.9
Central and Southern Italy	26,200	320	1.2
Sicily	14,302	196	1.4
Sardinia	10,915	139	1.3
Italy	47,000**	518	1.1

These values are similar to the near 2% of cosmopolitan or subcosmopolitan species, whose spread is due mostly to anthropic activities and that characterize, from a zoogeographic point of view, the Italian terrestrial and freshwater fauna (Stoch and Vigna Taglianti, 2005) although, as it will be shown below, such a model has some exceptions. These percentage values are substantially lower than what is currently found on a national level for allochthonous vascular flora, which is equal to 11% of the total species (751 of 6711 species; Blasi et al., 2005). The percentage of animal naturalized species in Italy, both at a local and national level, is very similar to that found in other European countries, in particular in central Europe, for which analogous estimates are available. For instance, the Czech Republic also is represented by near 34,000 species of which near 600 (1.8% of the total, also including paraautochthonous species) are allochthonous (Šefrová and Laštůvka, 2005). Likewise in Germany in the year 2000, of 44,250 known species, 1,322 were allochthonous, and 262 of those (near 0.6% of the total species) were classified as naturalized (Geiter et al., 2002).

The majority of the species that were introduced in the study area are represented by vertebrates and arthropods, especially insects (13 orders out of 32 present in Italy). Together allochthonous species of vertebrates (16%) and arthropods (68%) represent greater than 80% of the total number of recognized naturalized species in the study area (Fig. 1). For both taxonomic groups, there is an abundance of well documented data. There is a substantial body of literature concerning also some other phyla or classes, like Annelida Oligochaeta and Mollusca Gastropoda and Bivalvia. However, Platyhelminthes and Nematoda species may be underestimated, even though the available information for these groups is greatly increasing (e.g., Ambrogini et al., 2003; Galliums et al., 2003, 2005; Marinari Palmisano, 1980; Paggi et al., 1982).

Among insects, the order/suborder mainly relevant to this phenomenon are Homoptera Sternorrhyncha and Coleoptera (Fig. 2). In this class the allochthonous species clearly do not reflect the specific diversity of each

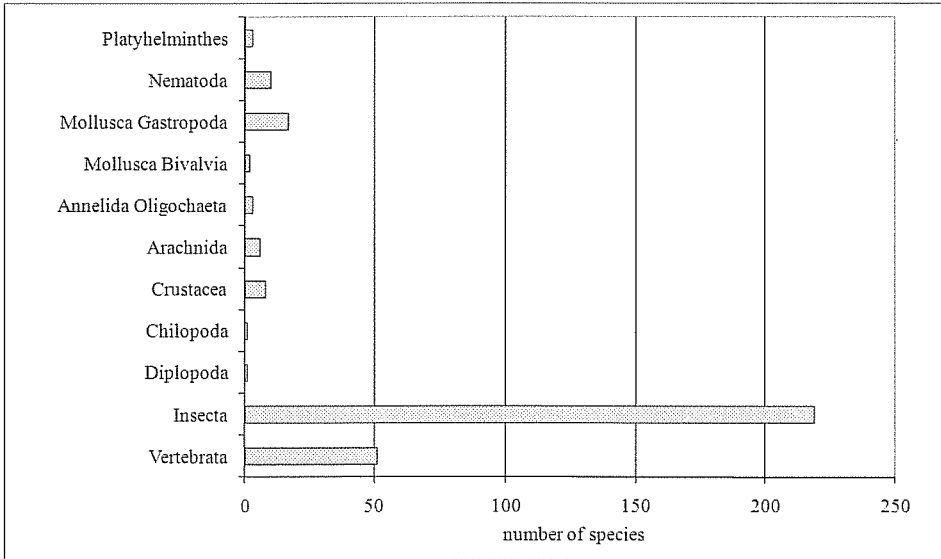


Fig. 1 - Number of animal species naturalized in peninsular Italy according to phyla, subphyla or classes (n = 320).

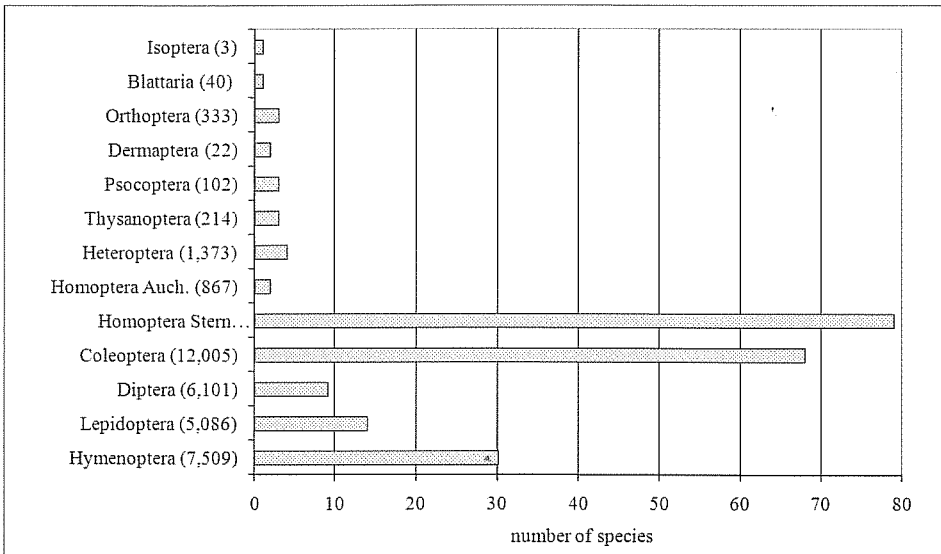


Fig. 2 - Number of insect species naturalized in peninsular Italy according to order or suborder (n = 219); number of species in Italy according to Minelli and Stoch (2005) in parentheses.

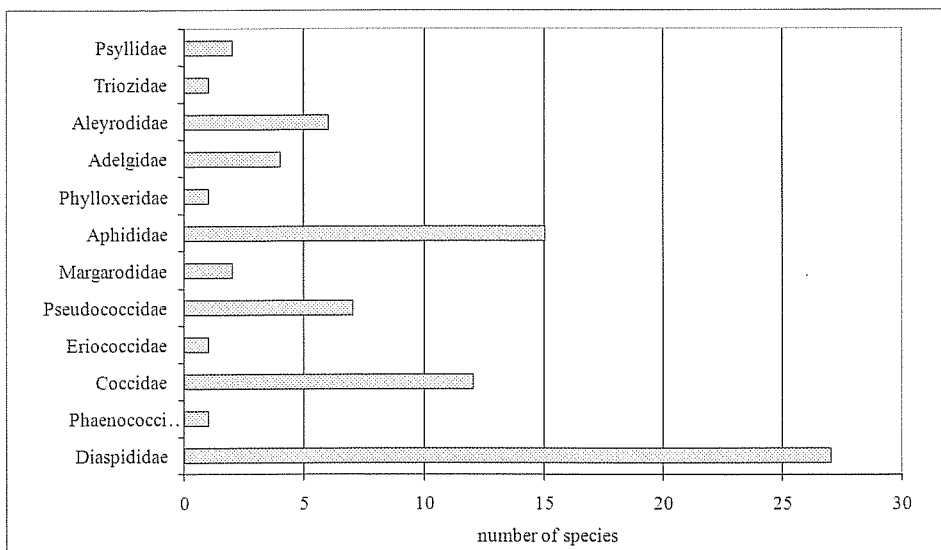


Fig. 3 - Number of Homoptera Sternorrhyncha species naturalized in peninsular Italy according to families (n = 79).

taxonomic groups that compose it, as in the groups represented by a relatively small number of species, like Homoptera Sternorrhyncha (Fig. 3), the number of allochthonous species is much higher than in other groups with a similar or higher number of species. Although the invasiveness of a species generally depends upon the characteristics of the habitat (Drake et al., 1989), polyphagous habits and parthenogenesis, characteristics very widespread among these phytophagous insects (Arzone and Vidano, 1990), are factors that certainly favour their dispersal through the commerce of plants (Ehrlich, 1986; Pellizzari and Dalla Montà, 1997). The results of a recent zoogeographic analysis of the Italian scale insect fauna (Longo et al., 1999) are highly significant in this regard. Based on this analysis, the cosmopolitan species and “cultural immigrants” (that is, those species unintentionally introduced into Italy via cultivated and ornamental plants) constitute more than 30% of the Italian scale insects fauna (111 of 365 species belonging to 12 of the 24 families). Therefore, many more than the above mentioned 2% that generally characterize the terrestrial and freshwater fauna of Italy (Stoch and Vigna Taglianti, 2005). Approximately one fifth (25 of 142) of the Coleoptera families represented in Italy includes naturalized species (Fig. 4). The majority of those species are represented by Staphylinidae, Nitidulidae, Bruchidae and Coccinellidae; they were introduced by several ways, both unintentional and intentional (Audisio, 1993; Audisio and De Biase, 2005; Audisio et al., 1995; Ciceroni et al., 1995; Migliaccio and Zampetti, 1989; Nicoli Aldini, 2003). It is possible that the allochthonous component has been underestimated in some groups of insects, such as Diptera, which knowledge in

Italy is rapidly increasing (Mason, 2005; Mei et al., 2005; Oosterbroek, 2005; Rivosecchi and Mancini, 2005a, 2005b; Sommaggio, 2005).

Concerning terrestrial Vertebrata, there are at least 18 species that have been introduced and naturalized in peninsular Italy (Fig. 5), meanwhile 34 naturalized species of allochthonous Osteichthyes are present in public waters.

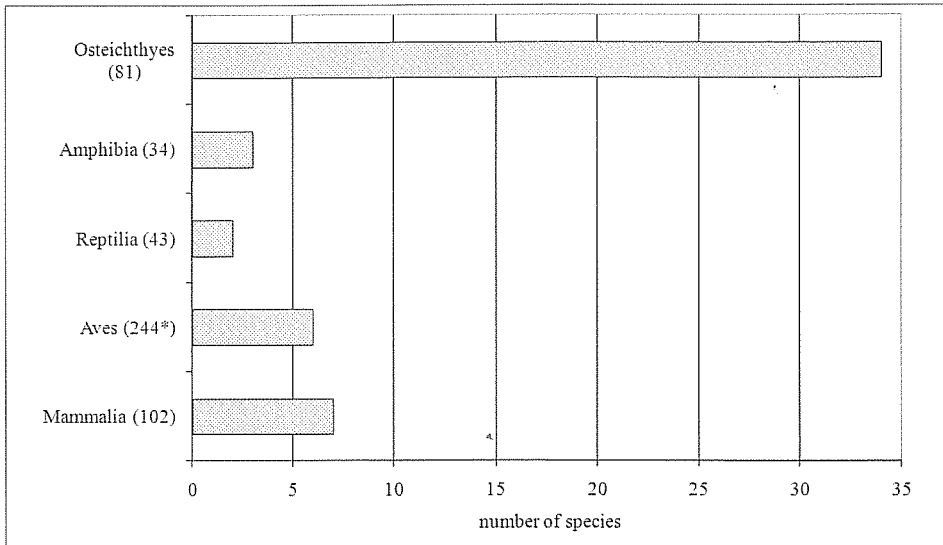
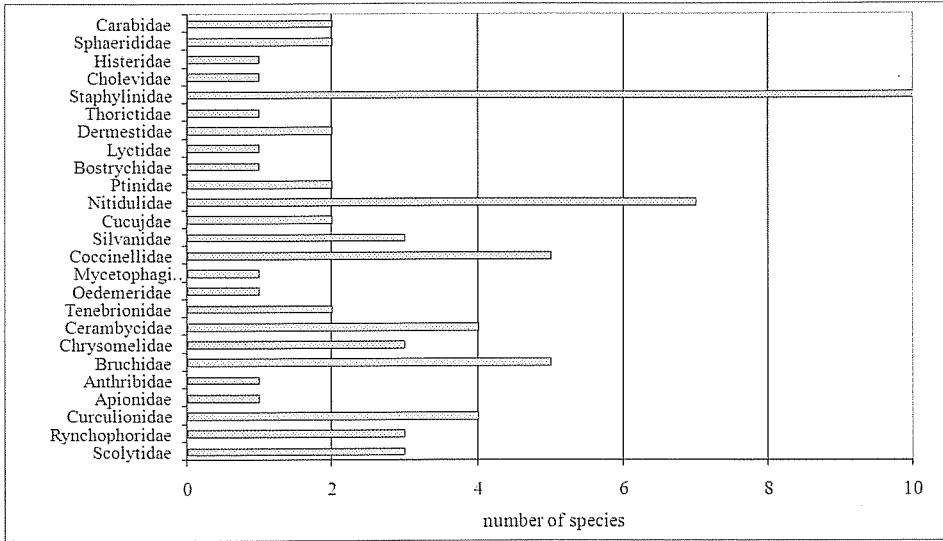


Fig. 5. Number of the terrestrial and inland water vertebrate species naturalized in peninsular Italy according to classes (n = 51); number of species in Italy in parentheses (see text for the sources); * = only breeding species.

Regional presence

On the basis of the regional distribution of 189 of the 397 acclimatized or naturalized species in the study area (48% of the total), Lazio, Tuscany and Campania are the administrative regions where the greater numbers of allochthonous species (invertebrates and vertebrates) have been reported (Fig. 6). If the data concerning Vertebrata are shared out by class (Fig. 7), it is clear that Osteichthyes make the greatest contribution in Umbria and Lazio. This is probably related to the greater ecological and economic vocations of these regions, where there are wide lake and river basins in which there are professional and sport fishing activities and a large amount of fishing production (Tab. II). Records on Amphibia mostly comes from Tuscany, whereas there are no documented records of acclimatized or naturalized Amphibia from Marches, Umbria, Abruzzo, Molise, Apulia and Basilicata. The highest number of allochthonous species of Reptilia is from Abruzzo, while, apparently, there are not any naturalized or acclimatized species in Umbria or Lazio. The allochthonous bird fauna is especially rich in Tuscany and Lazio, but that could be due to a greater effort of research in these areas (e.g., Andreotti et al., 2001; Biondi et al., 2005; Pitzalis et al., 2005). Allochthonous mammals are present in all the regions with Tuscany and Lazio being again the regions with the greatest numbers of species. No allochthonous mammal species are known to be present in Basilicata, which is probably an underestimated area.

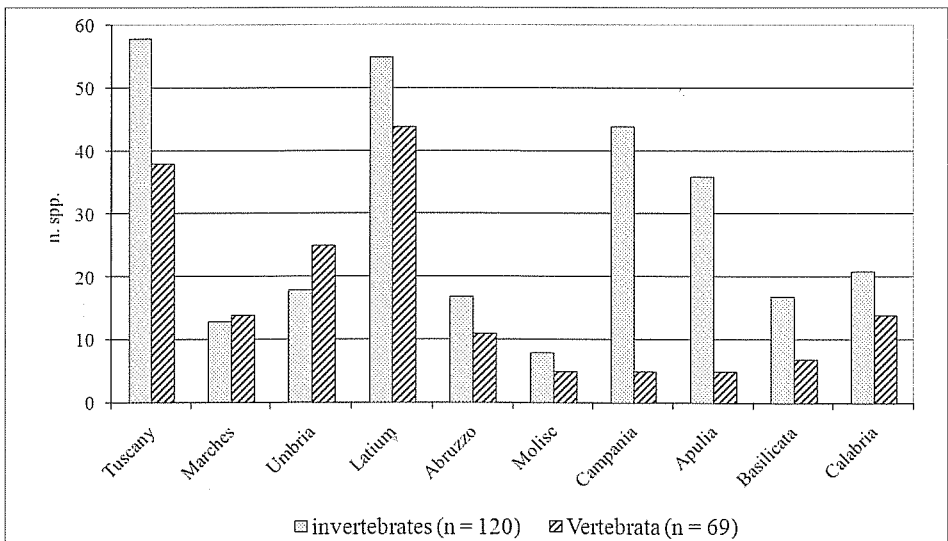


Fig. 6 - Number of invertebrate and vertebrate species acclimatized and naturalized in peninsular Italy according to administrative regions (n = 189; 48% of the sample).

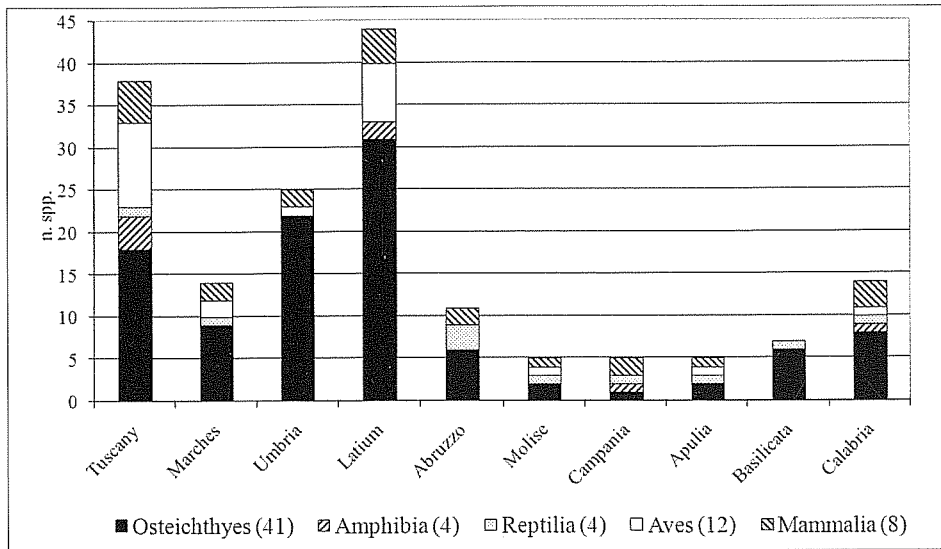


Fig. 7 - Number of vertebrate species acclimatized and naturalized in peninsular Italy according to classes and administrative regions (n = 69; 96% of the sample); number of species in parentheses.

Tab. II. Demographic and economic parameters values recorded in Italy and in the peninsular regions in recent years (source ISTAT, 2006); A.F.V. = Aziende Faunistiche Venatorie, literally "Faunistic hunting companies" (private hunting reserves).

Region	area 2004 (km ²)	municipal districts 2004 (number)	population 2004 (people)	population density 2004 (inhabitants/km ²)	farms 2003 (number)	A.F.V. 2003 (number)	fishing production in lakes and artificial basins 2003 (quintals)	volume of import 2003 (millions of euros)	foreign arrivals 2004 (number)
Marche	9,694	246	1,518,780	157	55,681	55	110	3,907	334,264
Tuscany	22,993	287	3,598,269	156	89,780	295	356	15,141	4,802,120
Umbria	8,456	92	858,938	101	43,484	77	12,136	1,909	544,309
Lazio	17,236	378	5,269,972	306	130,547	93	5,356	22,030	5,706,233
Abruzzo	10,763	305	1,299,272	121	62,280	9	107	3,769	175,042
Molise	4,438	136	321,953	72	27,314	2	-	301	15,785
Campania	13,590	551	5,788,986	426	172,206	13	16	7,906	1,742,351
Apulia	19,358	258	4,068,167	210	283,894	19	570	4,891	334,955
Basilicata	9,995	131	596,546	60	74,514	4	407	458	48,970
Calabria	15,080	409	2,009,268	133	162,997	8	28	550	179,513
Italy	301,336	8,101	58,462,375	194	1,963,817	1,659	43,790	262,998	36,715,739

These results could be related to various independent causes. On the one hand, they could highlight the research efforts to date done (Stoch, 2005). On the other hand, they are likely to be linked to the extension of the single regional areas, or to “predisposing” factors that would help the introduction of allochthonous species, such as the number of city centers, ports and airports, the density of the human populations, the amounts and the types of local economic activities, including agricultural and hunting activities. Indeed the degree of anthropic disturbance of the territory in general could be an important feature affecting species invasion (Tab. II). The fact that the regions Tuscany, Lazio and Campania have the highest reported numbers of allochthonous species of the vascular flora (Conti et al., 2005) is consistent with this possibility.

Causes of introduction

The number of unintentionally introduced species is greater than the number of intentionally introduced species (304 versus 93, equal to 75% of the cases). In both categories however, the naturalized species constitute a rather high percentage, 75-80%, of the total (Fig. 8). Quite apart from the outcome that an introduction have had (acclimatation or naturalization) the vast majority of allochthonous species unintentionally introduced, 87-98%, were terrestrial

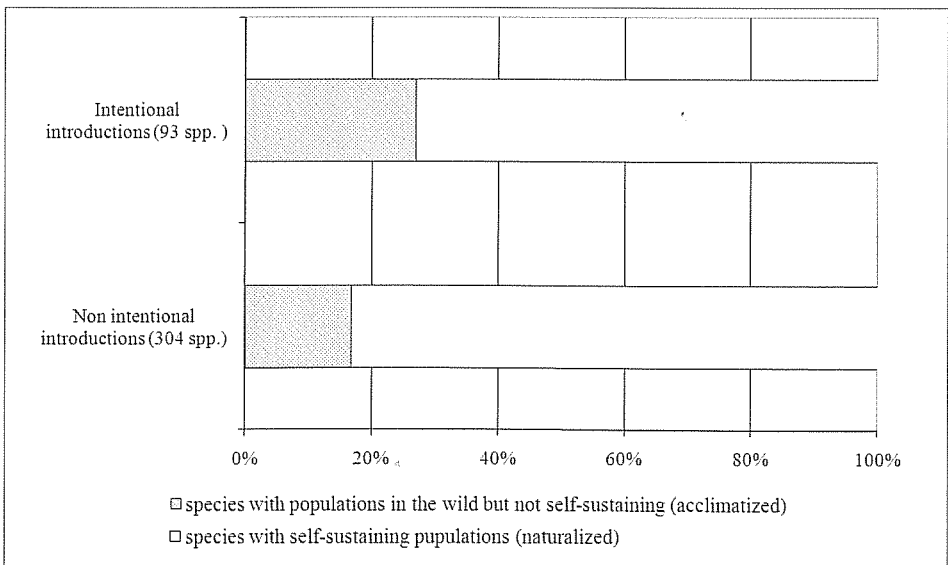


Fig. 8 - Percentage distribution of the animal species acclimatized and naturalized in peninsular Italy according to the type of introduction, intentional or unintentional (number of species in parentheses; n = 397; 100% of the sample).

(Fig. 9). In contrast, among intentionally introduced species, there are far fewer terrestrial species and a greater portion, almost 50%, of aquatic species, especially Osteichthyes (Fig. 10).

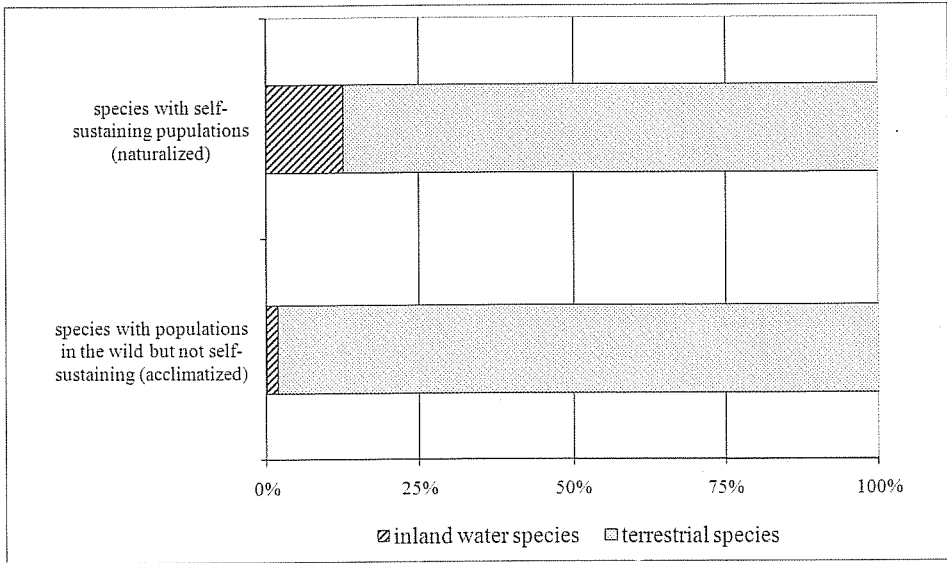


Fig. 9 - Unintentional introductions: percentage distribution of the animal species acclimatized and naturalized in peninsular Italy according to the adult habitat (n = 304).

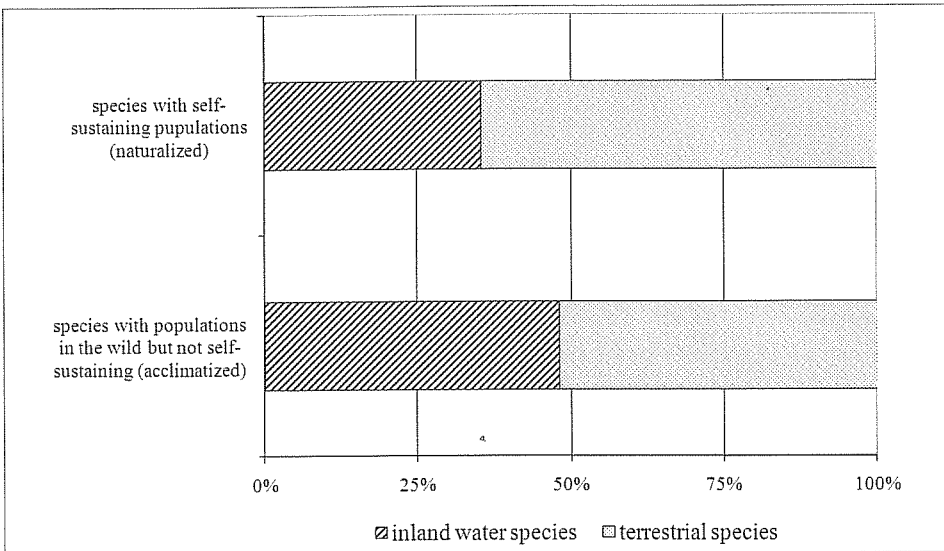


Fig. 10 - Intentional introductions: percentage distribution of the animal species acclimatized and naturalized in peninsular Italy according to the adult habitat (n = 93).

The majority of the intentional introductions into peninsular Italy occurred in relation to two activities: biological control (34%), and professional and sport fishing (27%) (Fig. 11). Neuroptera, Coleoptera Coccinellidae, Hymenoptera

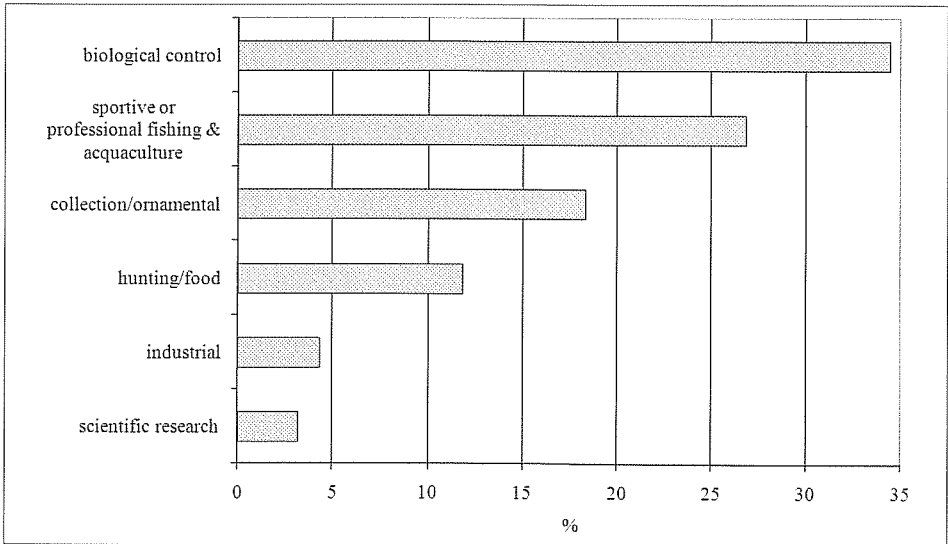


Fig. 11 - Aims of intentional introductions: percentage distribution of the species acclimatized and naturalized in peninsular Italy according to main categories (n = 93; 23% of the sample).

Chalcidoidea among insects have been introduced for biological control purposes (Viggiani, 1980): this is not surprising as there are at least ten Universities with Faculties of Agronomic Sciences in peninsular Italy that have done or are doing this type of experimentation, especially on insects, and this does not include other research centers and bio-farms (AA.VV., 1980; Bin and Bruni, 1997; Bin and Pennacchio, 2005). Two fishes species have been introduced for the same aim (Zerunian, 2002). Species imported for aquaculture and professional and/or sport fishing are mainly Osteichthyes, but also Crustacea Decapoda are involved. The process of transformation of the fish communities in public waters in Italy as a result of uncontrolled fish introductions and spawning is well known. Aside from some cases that occurred long ago, this phenomenon largely began in the late 1800s (1893-1895) and it has increased in recent years (Bianco, 1993; Zerunian, 2002). Among Crustacea Decapoda, the most significant species that has been imported is *Procambarus clarkii* (Girard, 1852) (Cambaridae) (Petrini and Venturano, 2002).

For collection/ornamental (pet species), alimentary or industrial purposes, terrestrial vertebrates have been mostly introduced (Andreotti et al., 2001; Scalera, 2001). Among the few species introduced for scientific purposes (or

supposed so) have been here included three endemic Apennine species, namely *Bathysciola derosasi* (Jeannel, 1914) (Coleoptera Cholevidae), naturalized in a cave near Rome (Lazio) in the 1950s (Patrizi, 1956), and the cave salamanders, *Speleomantes ambrosii* (Lanza, 1955) and *S. italicus* (Dunn, 1923) (Amphibia, Plethodontidae), naturalized in a cave near Siena (Tuscany) since 1983 (Sindaco et al., 2006). Concerning the introduction of species in cave habitats, there have also been some other isolated cases from elsewhere in Italy and Europe (e.g., Bernardini et al., 1996 and the reported bibliography; Lana, 2001). This kind of transfer however deserves to be further studied, because in other parts of the world, such as the United States, the phenomenon seems to have relatively consistent dimensions, despite little documentation (Reeves, 1999; White and Kingsley, 1999).

In peninsular Italy, unintentional introductions (Fig. 12) have occurred primarily through the following four mechanisms: a) the import of plants and/or vegetable products (including timber) (near 58% of the species), this phenomenon mainly involves phytophagous or phytosaprobic insects but it can also involve other invertebrates, such as Nematoda (e.g., *Bursaphelenchus* spp.) of which various cases in Italy are known (Ambrogini et al., 2003); b) human movements (17%), which especially affects terrestrial invertebrates; c) the import of stored products (11.5%), which often carries spermophagous or detritivores insects (Nicoli Aldini, 2003); d) the fish spawning and/or aquaculture (5.5%), this mechanism has resulted in the involuntary introduction not only of fishes but also of other aquatic organisms like Crustacea and Mollusca and, elsewhere

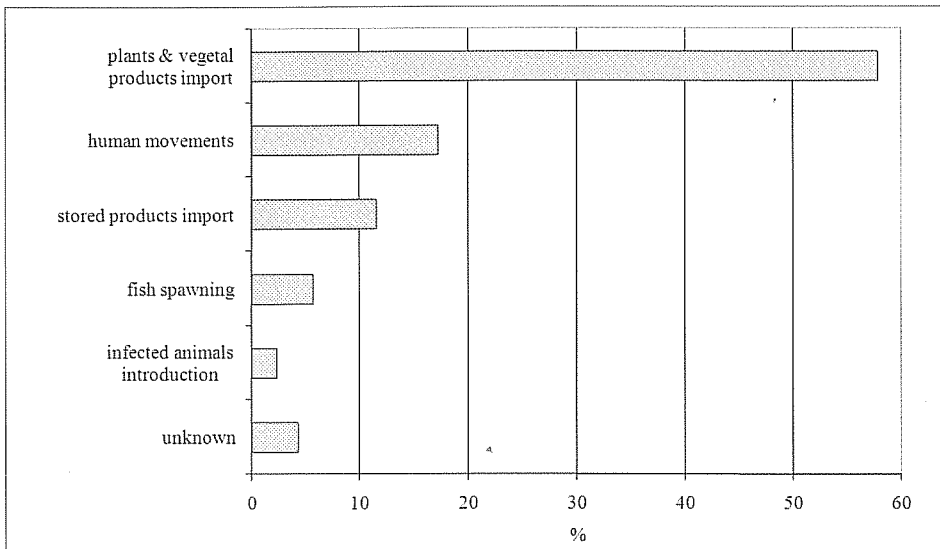


Fig. 11 - Aims of intentional introductions: percentage distribution of the species acclimatized and naturalized in peninsular Italy according to main categories (n = 93; 23% of the sample).

in Italy, also Hirudinea and Insecta Ephemeroptera (e.g., Belfiore, 2005; Casellato et al., 2006; Gelder et al., 1994; Turin et al., 1997).

Zoogeographic region of origin

According to the zoogeographic origin of 298 of the 397 allochthonous species recorded in the study area (75% of the total), the most important portion of the acclimatized and naturalized species, 44%, are of Palearctic, in particular Western Palearctic (28%), origin. The remaining species are of Neartic (21%), Afrotropical (11%), Neotropical (10%), Oriental (9%), and Australasiatic (6%) origin (Fig. 13).

These results, though preliminary, would be on the whole related to the volume and the intensity of trade with countries within each zoogeographic region (supposing the present traffics mostly nonstop). However, they also would be linked to the degree of similarity between the bioclimatic features of the areas and habitats included in the allochthonous species' natural and secondary range, as well as the ability of each non native species to adapt and compete in hosting biocenosis.

In relation to this latter aspects, it would be therefore of interest to assess the proportion of allochthonous animal species in the temperate-continental and Mediterranean climate regions of Italy, with regard to their zoogeographic origin and as a results of their ability to adapt to the local condition.

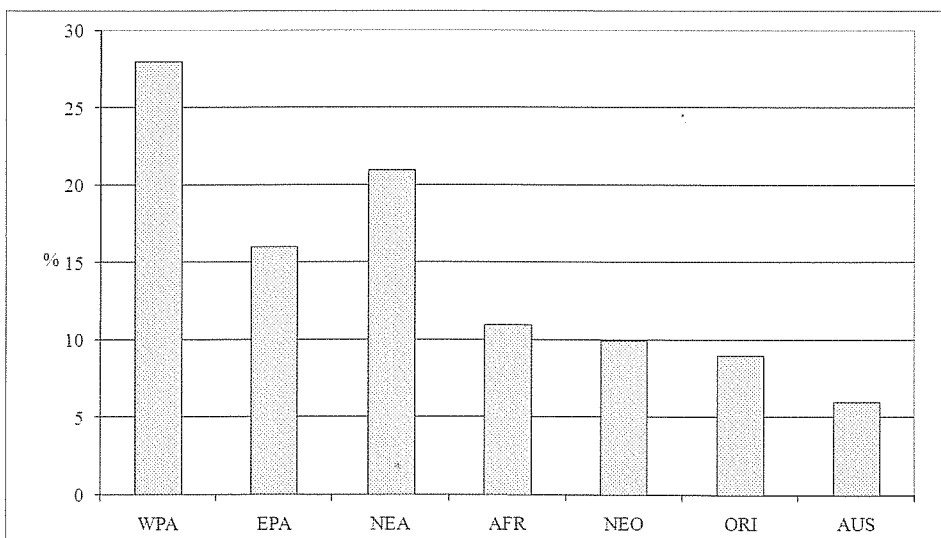


Fig. 13 - Percentage distribution of the animal species acclimatized and naturalized in peninsular Italy according to their zoogeographic region of origin (n = 298; 75% of the sample); abbreviations: W-Palearctic (WPA), E-Palearctic (EPA), Neartic (NEA), Afrotropical (AFR), Neotropical (NEO), Oriental (ORI), Australasiatic (AUS).

Invasive species

The data collected on the naturalized species revealed that the majority of the cases of introduction in peninsular Italy is represented by terrestrial species (83.1% of the total; 266 species); meanwhile, the number of inland water species is relatively few (16.9% of the total; 54 species). Besides the particular cases of cavernicolous species (see above), these data alone are insufficient and could be misleading for application to biodiversity conservation. For that purpose it will be important to examine the particular habitats colonized by the non native species. Accordingly, some main typologies of habitat have been recognized, to which the naturalized species (adult stage) can be associated with, both for the terrestrial and inland water habitats. Within these two main ecosystems the artificial (cities, agricultural and industrial areas, ports, airports, greenhouses, flower farms, reforestations, artificial lakes, channels and rice-fields) and the natural or semi-natural habitats are kept distinct. Also, it should be noted that a species can be present in more than one environmental category.

As assessment of the consistency (percentage) of the invasive allochthonous species (those naturalized species whose introduction or whose expansion represents a threat for the biological diversity, according to the Convention on the Biological Diversity) for each environmental typology has been attempted. However it has not been easy to do this sort of evaluation. The available data are insufficient and the few studies done in Italy and elsewhere in Europe have focused only vertebrates, as evidenced by the eradication programs adopted thus far (Genovesi, 2005). Knowledge about invertebrates is quite limited, and only freshwater Crustacea Decapoda (Barbaresi and Gherardi, 2000; Gherardi and Holdich, 1999; Scalici and Gibertini, 2002) and Mollusca (Lorj et al., 2005), has been investigated from this point of view.

Species has been classified into the following three generic categories of “invasive ability”:

- invasive species: naturalized species for which an active or potential negative interference with the natural biocenosis has been identified; 88 species (44 terrestrial and 44 of inland water) are part of this group;
- species presumed to be not invasive: naturalized species for which in present scientific literature it is asserted or inferred a) an absence of negative interference with natural/semi-natural biocenosis, b) the condition of specific host (monophagous) of an introduced plant species, or c) a presence limited or quite limited to artificial habitats (urban areas, agroecosystems); these especially include species that are of hygienic-sanitary interest, phytosanitary interest or food industry pests, and are generally localized;
- species of unknown status: naturalized species for which there are no data in the scientific literature about their effective or potential invasiveness.

The results of this analysis are shown in Figs 14 and 15. According to the repartition of the naturalized species into the fixed environmental typologies, there is a notable difference between artificial and natural/semi-natural habitats,

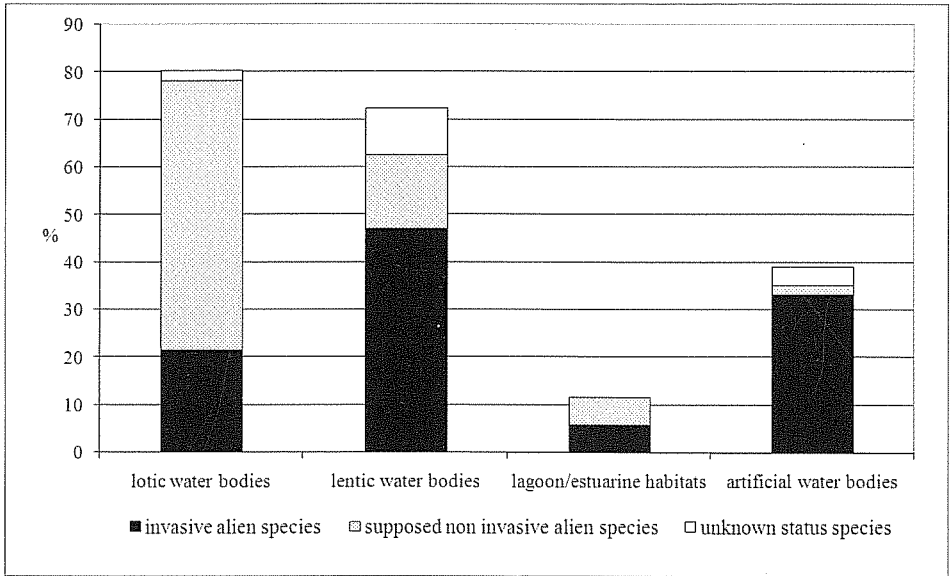


Fig. 14 - Percentage distribution of the animal species naturalized in inland water habitats of peninsular Italy according to categories of "invasive ability" (see text for the definitions) and main environmental typologies (n = 51).

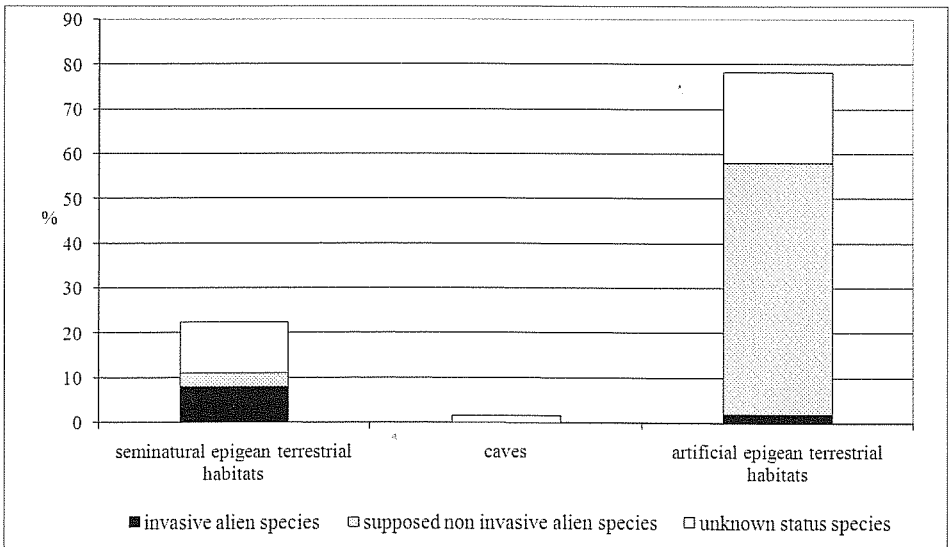


Fig. 15 - Percentage distribution of the animal species naturalized in terrestrial habitats of peninsular Italy according to categories of "invasive ability" (see text for the definitions) and main environmental typologies (n = 262).

both in the terrestrial and inland water ecosystems. In the terrestrial ecosystems, artificial habitats host the majority of the allochthonous species. In contrast, in inland water habitats the majority of the naturalized species are associated with natural habitats. Moreover, if the analysis based on the division in categories of “invasive ability” leads to conclusions that confirm that the natural inland water communities are at greater risk of invasion than terrestrial communities, then this realization highlights the differing levels of knowledge that have been achieved for terrestrial versus inland water habitats with regard to the impact of allochthonous species on natural communities, greater for the inland water habitats lower for the terrestrial ones.

It is clear that the effects produced by allochthonous mammals and birds, the taxonomic groups that are best represented in the scientific literature among the vertebrates, especially in natural/semi-natural ecosystems are relatively well documented (Fig. 16). In contrast, the knowledge on introduced invertebrates

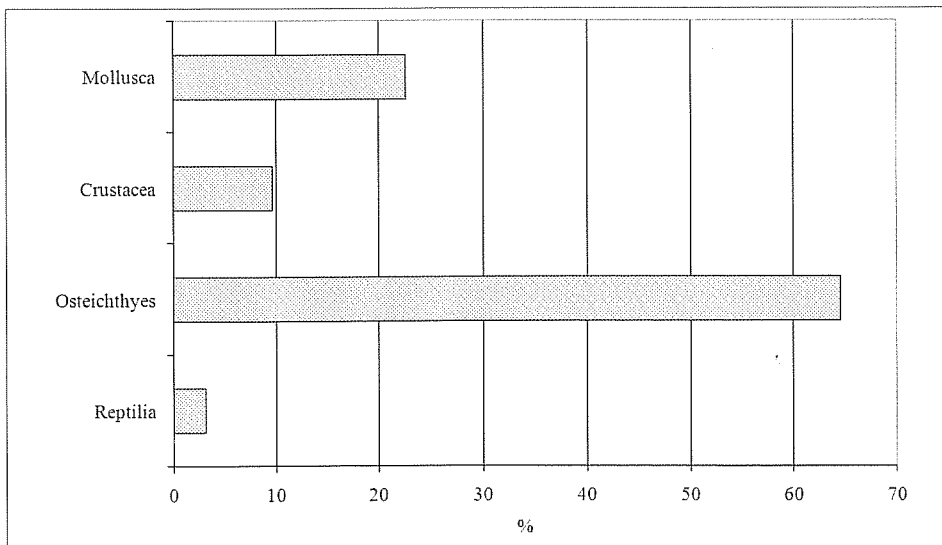


Fig. 16 - Percentage distribution of invasive species in inland water habitats of peninsular Italy according to phyla, subphyla, classes (n = 31).

is still incomplete, especially for arthropods (Fig. 17). Although they are mostly confined to artificial habitats, it is not known whether or to what extent they will spread from artificial to natural/semi-natural habitats (Richardson et al., 2000). Moreover while their interferences with anthropic activities are well documented, little is known about their active and/or potential impact upon biodiversity in natural/semi-natural habitats.

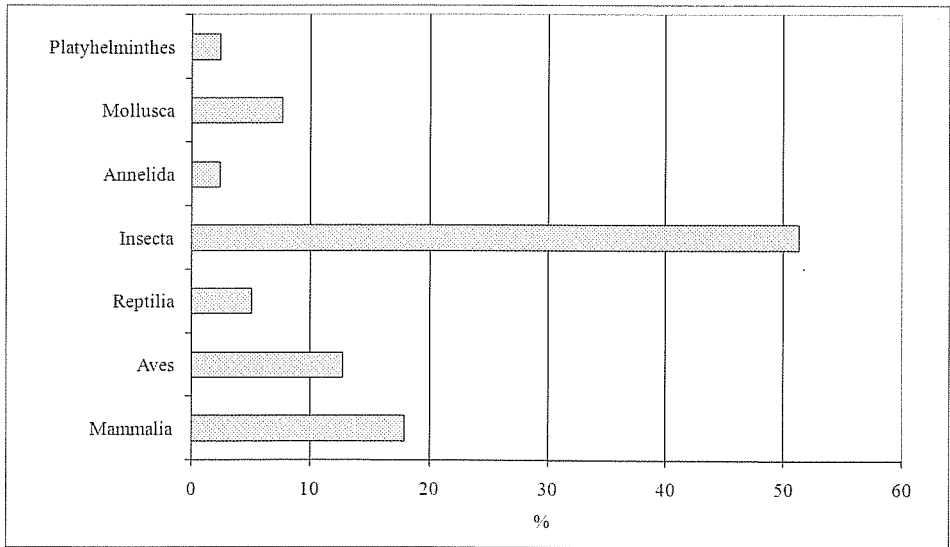


Fig. 17 - Percentage distribution of invasive species in terrestrial habitats of peninsular Italy according to phyla, subphyla, classes (n = 39).

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