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Comparison of the invasive alien flora in continental islands: Sardinia (Italy) and Balearic Islands (Spain)

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Abstract This article provides a comparison of the invasive vascular flora of Sardinia and that of the Balearic Islands. The study has recorded 53 invasive *taxa* in Sardinia (12% of the alien flora) while 48 (14%) in the Balearic Islands, 19 of them common for both territories. The invasive flora of Sardinia is included in 18 families; *Asteraceae* is the richest in *taxa*, followed by *Amaranthaceae*, while in the Balearic Islands in 19 families, with a predominance of *Poaceae* and *Asteraceae*. The comparison of the biological spectrum reveals that in Sardinia therophytes and phanerophytes are the most represented, as well as therophytes and hemicryptophytes are in the Balearic Islands. Neophytes are clearly dominant comparing to archaeophytes. A study of the geographical origin shows supremacy of the American element. The majority of invasive *taxa* is a result of intentional human introductions, mainly for ornamental use. The most occupied habitats in both territories are the semi-natural, agricultural and synanthropic for both territories, followed

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by natural habitats as coastal ones in Sardinia and wetlands in the Balearic Islands. An important part of the work deals with the environmental, economic and human-health impact.

Keywords Continental Islands · Impact · Invasive species · Mediterranean · Pathways · Prevention

1 Introduction

Invasive alien species are known as the most important cause of current biodiversity loss after habitat destruction and fragmentation (IUCN 2000; Mack et al. 2000); they may cause significant damage to natural ecosystems not only from an environmental point of view, but also from an economic and health one (DAISIE 2009; Mooney and Hobbs 2000; Pimentel et al. 2001; Wittenberg and Cock 2001). Certain regions are more affected than others or, in certain regions, invasive species could turn out to be more abundant in certain habitats (Pino et al. 2008). Therefore, there are some differences in the habitats or regions that invasive species tend to prefer, but also in the intrinsic traits of the species which determine their invasiveness and impact (Lockwood et al. 2005, 2006; Lonsdale 1999; Pyšek and Richardson 2007; Richardson and Pyšek 2006).

With respect to mainland areas, insular systems, both continental (Dal Cin D'Agata et al. 2009; Hulme et al. 2008b; Jeanmonod and Gamisans 2007; Moragues and Rita 2005; Vilà et al. 2006) and oceanic (Cox 1999; Crawley et al. 1996; Daehler et al. 2004; Kueffer et al. 2010; Sherley 2000; Silva et al. 2008), are considered the most vulnerable to biological invasions, due to the development of activities connected to tourism in the past decades (especially on coastal areas), their dependence on external trade, the high rate of urban development and the relative widespread and dense communication network. All these events have enhanced the increase of propagule pressure and habitat fragmentation, thus lowering the competitive capacity of autochthonous species (Hulme et al. 2008b).

During the past 5 years, a great deal of studies focused on invasive species affecting insular areas in the Mediterranean have been held at the international scale (e.g., Bacchetta et al. 2010; Brundu et al. 2004; Hulme et al. 2008b; Lloret et al. 2004; Vilà et al. 2004, 2006), and a great number of them underline the importance of comparing the invasive floras from areas with similar climatic features, attending to the temperature, distribution, and average rainfall along the year (Di Castri 1991; Le Houérou 1991; Lonsdale 1999; Pauchard et al. 2004).

For Mediterranean continental islands, Lloret et al. (2005) reveal a series of characteristics of those species with a greater invasive capacity, assessing data from Corsica, Crete, Majorca, Malta, and Sardinia. More recently, Podda et al. (2010) analyze the vascular exotic flora of Sardinia and the Balearic Islands, making a comparison with the total floras of both insular systems, studying in particular biogeographical relationships.

The comparison of invasive floras among similar territories is important in order to form a principal contribution to developing a wide management strategy of alien species (Wittenberg and Cock 2001). Dispersed and disconnected knowledge cannot easily be assembled to deliver the information and knowledge required to address biological invasions' policy. Improving information exchange can build regional capacity to identify and manage invasive alien species threats (Lambdon et al. 2008). The best international toolkit for prevention and management practices recommends minimizing risks of new introductions and rapid detection of low infestations in order to contain and not allow the weeds to spread to new sites that are presently clean (CBD 2002; European Commission 2006; Genovesi and Shine 2004; Planta Europa 2008). And this prevention tool needs a regional network of invasive alien species information based on an exchange of databases and lessons learned from experiences of other territories and the strengthening of abilities to address these threats.

Pest risk analysis (PRA) standards have been developed at the International Plant Protection Convention (IPPC 2007) and by the European and Mediterranean Plant Protection Organization (EPPO 2010) to allow assessment of the phytosanitary risks presented by invasive alien plants, and the development of appropriate measures to prevent their introduction and spread. Although the EPPO provides guidance for best practices (including a positive list of biocontrol agents without known negative side effects), member countries do not always follow these recommendations, and few species have been subjected to PRA (Brunel et al. 2009). The Plant Health Directive (European Community 2000) contains measures to be taken in order to prevent the introduction and spread of serious pests and diseases of plants or that plant produce. One of the most important measures in this Directive is the listing of harmful organisms whose introduction into the Community must be prohibited, but this regulatory framework does not include invasive alien plants (Schrader 2005).

With this study, we intend to make a comparative analysis between the invasive floras of Sardinian and the Balearic Islands. Introduction pathways of *taxa* are determined, and the most sensitive habitats to biological invasions are identified. One of the objectives was to analyze the impacts of these species on the environment, the economic activity, and on human health. The final goal of this study was to propose exhaustive data to elaborate in the immediate future priority-lists and management projects aimed at mitigation strategies for the control of the biological invasions and the establishment of a monitoring and prevention network in an interinsular framework.

2 Materials and methods

In order to perform the comparison analysis of the invasive floras of the two study areas, the floristic data presented in the check-lists of the alien floras of Sardinia (Bacchetta et al. 2009) and Balearic Islands (Moragues and Rita 2005; Vilà and Muñoz 1999) were used, implemented by a 5-year study that included field investigation and the review of herbarium and bibliographic material. In particular, the DAISIE database (2010) and Podda et al. (2010) were used as most updated bibliographic references.

Invasive *taxa* were determined and ordered on the basis of the criteria proposed by Richardson et al. (2000), elaborated by Pyšek et al. (2004), and reviewed according to Richardson and Pyšek (2006).

Archaeophyte and neophyte *taxa* were differentiated depending on their introduction before or after 1492/1500, respectively.

Life-forms were determined according to the classification of Raunkiaer (1934), using the abbreviations of Pignatti (1982).

Species origin is based on the geographical area or the biogeographical region, and follows the same criteria used by Moragues and Rita (2005) and Bacchetta et al. (2009).

Taxa were also classified according to their intentional or not intentional introduction by man, and following the definitions proposed by the Convention on Biological Diversity (CBD) (Miller et al. 2006). In respect to the introduction pathways of the *taxa*, the categories proposed by Sanz Elorza et al. (2004) and Hulme et al. (2008b) were followed.

In order to analyze the sensitivity of habitats, the standards proposed by Vilà and Muñoz (1999) and Bacchetta et al. (2009) were adopted. Habitat typologies were recorded according to the habitats that most frequently the species occupy, following 7 categories: (1) agricultural; (2) synanthropic; (3) coastal; (4) matorral; (5) woodland; (6) riparian; (7) wetland.

Moreover, the impact of each invasive *taxon* was investigated according to Celesti-Grapow et al. (2010) but readapting it with the identification of three broad categories: (1) Environmental (competition and hybridization; changes in the structure and function of the habitats; abiotic changes); (2) Economic (agricultural weeds; threatening livestock; damaging human constructions, infrastructures, monuments and archaeological remains); (3) Human health (toxic; poisonous; allergenic and armed species).

The assignment of impact classes to each *taxon* was made in regional scale and based on field data.

In order to study differences among the invasive floras of Sardinia and the Balearic Islands the non-parametric *U* test Mann–Whitney was applied using version 15 (Minitab Inc.) of MINITAB©.

3 Results

The invasive component represents 12% (53 *taxa*) of alien flora of Sardinia and the 14% (48) of the Balearic Islands (Podda et al., 2010), while it only represents the 4% for Sardinia and 6% for Balearic Islands, when considering the 19 invasive *taxa* common to both territories (Fig. 1). Attending to the other invasive species, 13 are exclusive of Sardinia and 8 of the Balearic Islands, the same number of *taxa* (17) are invasive and naturalized in both studied areas, and also the same number (4) are shared as invasive and casual (Fig. 1). Attending the status, the Mann–Whitney test showed no significant differences between the medians of the samples considered (U = 4, $p = 0.8852$). In particular, the invasive alien flora of Sardinia includes 18 families; *Asteraceae* is the richest one (10 *taxa*), followed by *Amaranthaceae* (8), *Poaceae* (6), and *Solanaceae* (6). For the Balearic Islands the invasive alien flora includes 19 families, among which the most represented are *Poaceae* (9), *Asteraceae* (8), and *Aizoaceae* (7) (Fig. 2). The Mann–Whitney test showed no significant differences between the medians of the different families of the samples considered (U = 12, $p = 0.9307$).

The proportion of invasive neophytes is 11% (SA) and 13% (BL). The other neophytes (naturalized and casual) represent a 50% (SA) and 48% (BL). Attending to archaeophytes, only a low proportion are invasive (1%) while the percentage of naturalized and casual is higher (38%), the same in Sardinia and Balearic Islands (Fig. 3). The Mann–Whitney test confirmed no significant differences between the medians of the samples considered (U = 4, $p = 0.8852$).

The comparison of the biological spectrum of invasive *taxa* from the two territories (Fig. 4) reveals that therophytes are the most represented (41% SA, 33% BL), followed by phanerophytes (24% SA, 17% BL), hemicryptophytes (11% SA, 21% BL), chamaephytes (11% SA, 10% BL), geophytes (7% SA, 17% BL), and hydrophytes (6% SA, 2% BL). The Mann–Whitney test showed no significant differences between the medians of the samples considered (U = 6, $p = 0.9360$).

A data analysis according to the geographical origin of the invasive *taxa* (Fig. 5) shows a dominance of the American element (61% SA, 57% BL), followed by the South African (19% SA, 23% BL) and the Asiatic (6% SA, 8% BL) ones. The Mann–Whitney test

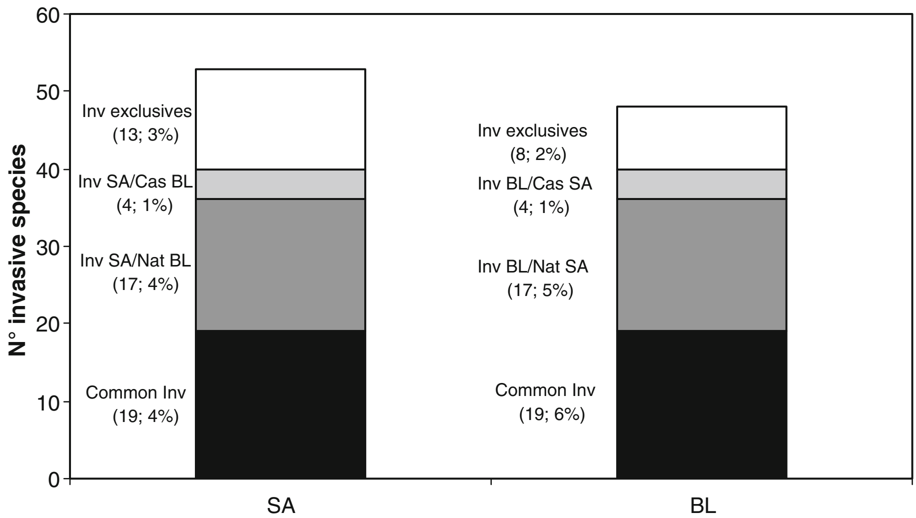

Fig. 1 Comparison of each type of invasive in Sardinia and Balearic Islands. Percentages consider the total exotic flora

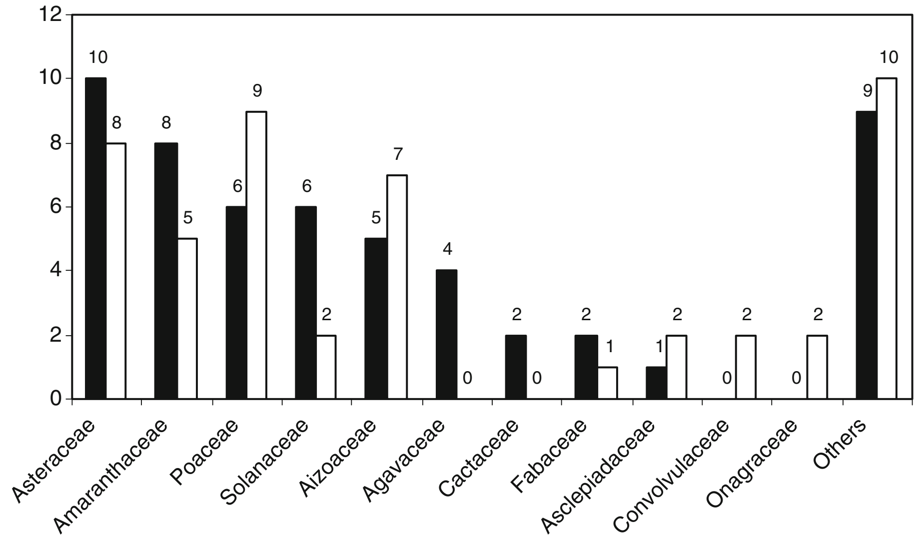

Fig. 2 Comparison of the number of species per family in Sardinia (*black*) and the Balearic Islands (*white*)

confirmed no significant differences between the medians of the samples considered (U = 6, $p = 0.8102$).

The analysis of introduction pathways of invasive *taxa* (Fig. 6) shows that in both territories the majority of them were introduced by men intentionally (53% SA, 65% BL). Ornamental use is the direct cause of a great part of these introductions (41% SA, 55% BL), followed by the unintentional contamination of seeds (seed contaminant) (36% SA, 25% BL) and by casual introductions (hitchikers) (11% SA, 10% BL). Species

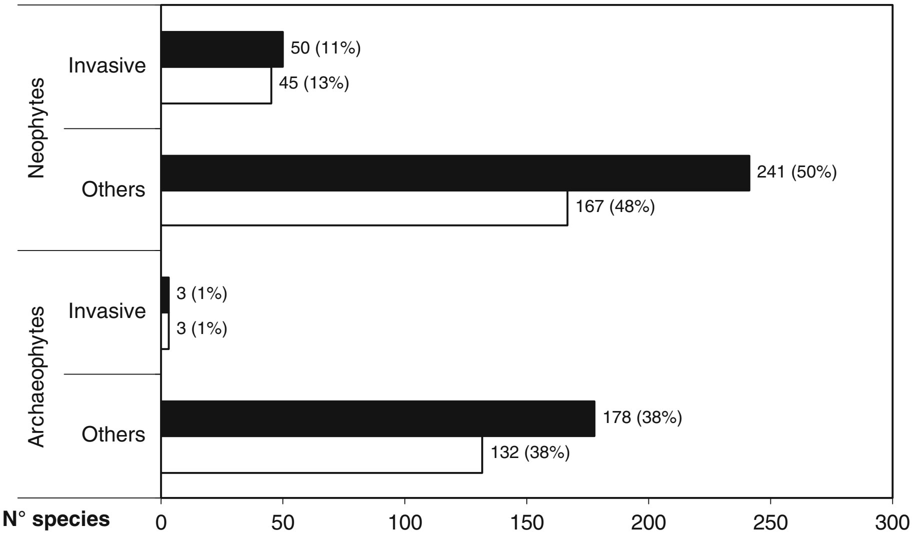

Fig. 3 Numerical and percentage comparison of invasive species and other alien species (naturalized and casual), distinguishing archaeophytes and neophytes from the total alien flora in Sardinia (*black*) and the Balearic Islands (*white*)

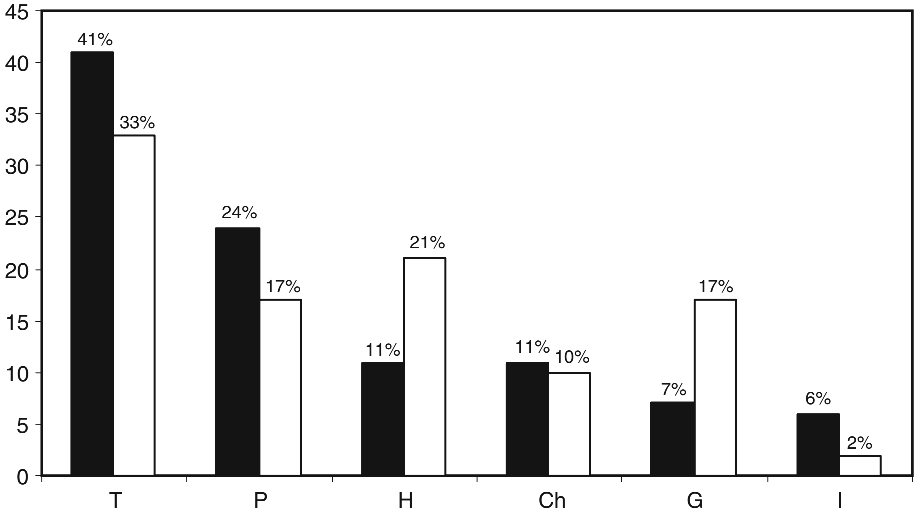

Fig. 4 Comparison between the life-forms of invasive alien flora in Sardinia (*black*) and Balearic Islands (*white*). *Note*: T: therophytes, P: phanerophytes, H: hemicryptophytes, Ch: chamaephytes, G: geophytes, I: hydrophytes

intentionally introduced by agriculture (8% SA, 10% BL) and by forestry (4% SA, 0% BL) show lower percentages. The Mann–Whitney test confirmed no significant differences between the medians of the samples considered (U = 5, $p = 1.0000$).

For both territories (Fig. 7), synanthropic (26% SA, 21% BL) and agricultural areas (26% SA, 33% BL) turn out to be the most sensitive habitats to colonizations, followed by

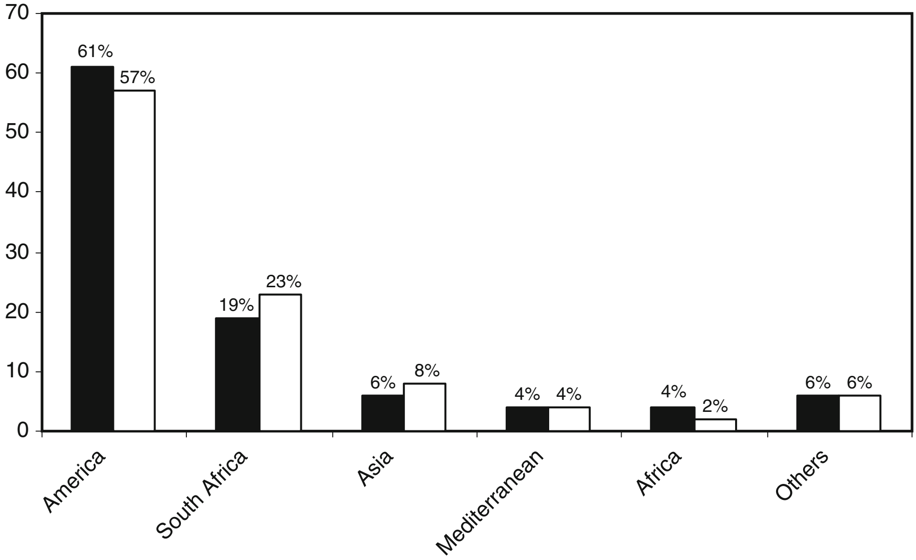

Fig. 5 Comparison of invasive species according to their geographic origin in Sardinia (*black*) and Balearic Islands (*white*)

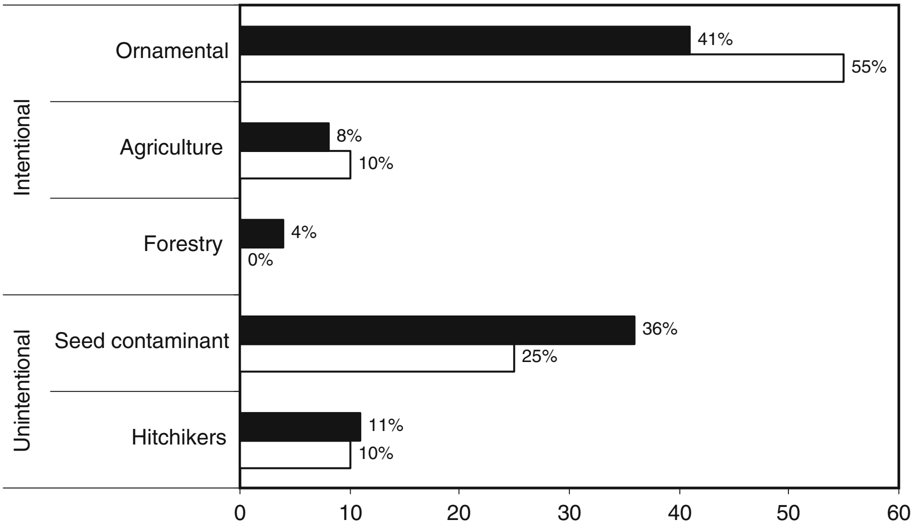

Fig. 6 Comparison of different introduction pathways of invasive species in Sardinia (*black*) and Balearic Islands (*white*)

natural habitats as coastal ones in Sardinia (21% SA, 17% BL) and wetlands in the Balearic Islands (15% SA, 19% BL). Riparian (8% SA, 8% BL) and matorral (4% SA, 2% BL) show lower percentages, while woodlands don't seem to be seriously affected by invasive *taxa*. The Mann–Whitney test confirmed no significant differences between the medians of the samples considered ($U = 7$, $p = 1.0000$). The analysis of each habitat shows that in

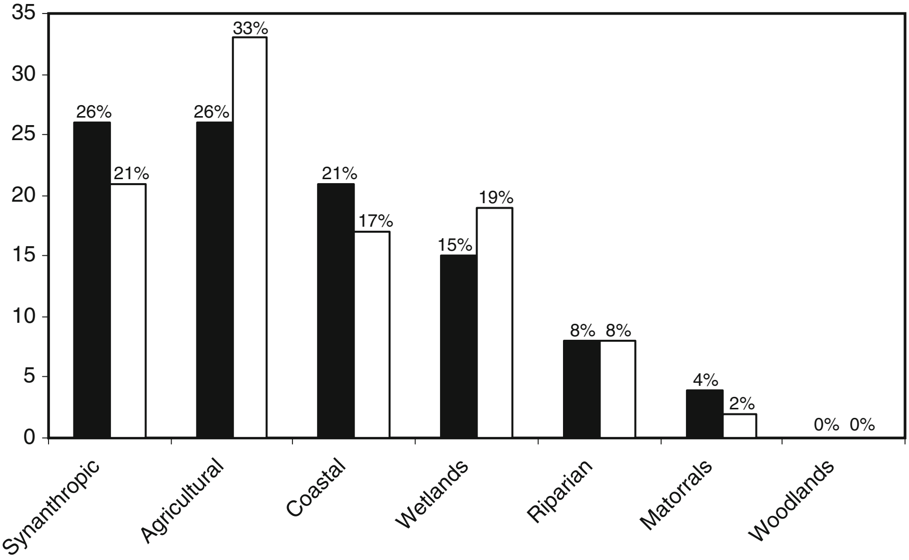

Fig. 7 Comparison of habitats affected by invasive alien flora in Sardinia (*black*) and Balearic Islands (*white*)

Sardinia, the major percentage of invasive species is recorded for coastal habitats (24%; 11 *taxa*), followed by wetlands (15%; 8), matorral (11%; 2), riparian (10%; 4), agricultural (10%; 14), and synanthropic (10%; 14). On the other hand, in the Balearic Islands the habitats with more invasive *taxa* are wetlands (36%; 9 *taxa*), followed by coastal habitats (28%; 8), agricultural (16%; 16), riparian (14%; 4), and synanthropic (7%; 10). In woodlands only one invasive *taxon* was identified, while no invasive *taxa* were recognized in matorral habitats.

The analysis of the negative consequences caused by invasive *taxa* in Sardinia and the Balearic Islands (Fig. 8) reveals that a great part of them mainly produce an environmental impact (34 SA, 28 BL) both in Sardinia and in the Balearic Islands, followed by economic impact (31 SA, 25 BL) and in lower proportion impacts on human health (15 SA, 4 BL). An individual analysis of each component shows that most of invasive species mainly produce an economic impact in Sardinia (31% SA, 40% BL) and an environmental impact in the Balearic Islands (28% SA, 44% BL). The rest of the invasive *taxa* cause both an environmental and economic impact (13% SA, 8% BL), environmental and human-health (13% SA, 4% BL), economic and human-health (6% SA, 2% BL), and there is even a percentage of species which cause the three kind of impacts (9% SA, 2% BL). No invasive *taxon* causes a human-health impact in both territories. The Mann–Whitney test confirmed no significant differences between the medians of the samples considered ($U = 7$, $p = 0.5640$).

4 Discussion

The results of this study improve the knowledge of the invasive flora of Sardinia and the Balearic Islands, both insular continental systems belonging to the same biogeographic

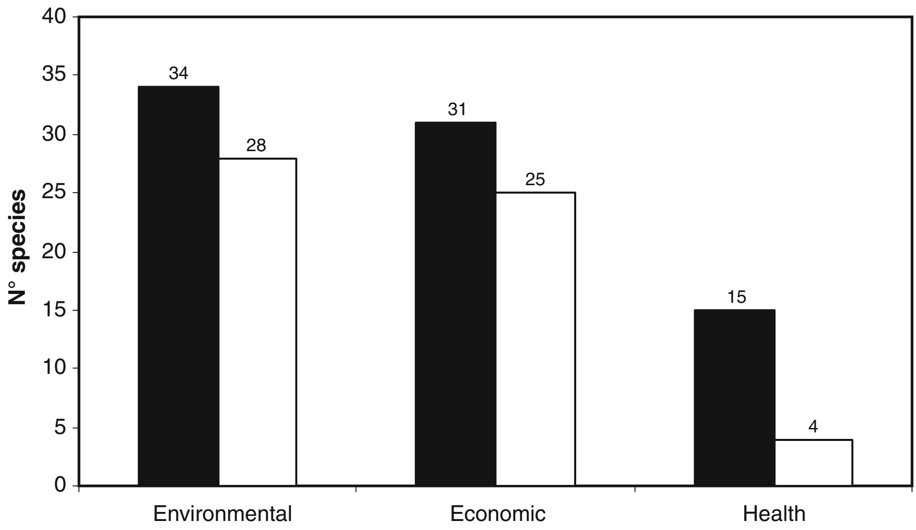

Fig. 8 Numerical comparison of the three different types of impact in Sardinia (*black*) and the Balearic Islands (*white*)

region. These two territories can be compared attending to their floristic composition and to the consequences of invasions caused by alien flora. As we underlined in Podda et al. (2010), similarities between the exotic flora of both areas of study are statistically significant.

Among the 19 *taxa* that have invasive status in both territories, some of them are considered invasive worldwide [e.g., *Ailanthus altissima* (Mill.) Swingle, *Arundo donax* L., *Carpobrotus* sp. pl., *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn., *Oxalis pes-caprae* L., *Paspalum distichum* (Michx.) Scrib., *Pennisetum setaceum* (Forssk.) Chivo, *Xanthium spinosum* L.] (Weber, 2003) and in Europe [*A. altissima*, *Carpobrotus edulis* (L.) N.E. Br., *C. selloana*, *O. pes-caprae, P. distichum*] (DAISIE 2009). Together with *Symphyotrichum squamatum* (Spreng.) G.L. Nesome and except for *C. selloana* and *P. setaceum*, the rest of *taxa* have been recognized as the most invasive ones in the Mediterranean islands (Hulme et al. 2008b; Lloret et al. 2004). The other *taxa* show different status in the two insular systems. For example, some *taxa* as *Canna indica* L., *Echinochloa* sp. pl. or *Ipomoea indica* (Burm.) Merr., with an invasive status in the Balearic Islands, only reach the status of naturalized or casual in Sardinia, as in the case of *Lonicera japonica* Thunb. On the other hand, *taxa* with invasive status in Sardinia as *Agave americana* L., *Opuntia* sp. pl. or *Acacia saligna* (Labill.) H. Wendl. are considered naturalized, or casual, in the Balearic Islands (e.g., *Solanum elaeagnifolium* Cav.).

These data help on the approach to the knowledge of biological invasions in both territories and are considered a precondition to successful management. Due to the similarity of both territories, plants in the Balearic Islands are in the process of naturalization or behave as invasive and are very likely to develop a similar trend in Sardinia. In this regard, it is interesting to point out that 22 *taxa* of the alien flora of the territories are included in the European and Mediterranean Plant Protection Organization lists (EPPO 2010). Three of them are identified in the "quarantine pest" list as most dangerous species for agriculture, forests and wild flora (pests locally present in the EPPO region), of which three are considered in Sardinia as invasive [*Eichornia crassipes* (Mart.) Solms, *Hydrocotyle* *ranunculoides* L. f. and *S. elaeagnifolium*], while only one is casual in the Balearic Islands (*E. crassipes*). Of the remaining, 12 are included in the list of the invasive species threatening environment and biodiversity, and show invasive status in both territories [*A. altissima, C. selloana, Carpobrotus acinaciformis* (L.) L. Bolus, *C. edulis*, *O. pes-caprae, P. distichum*] or at list in one of them (SA: *Azolla filiculoides* Lam.; BL: *Helianthus tuberosus* L.) or were reported as naturalized or casual (*Acacia dealbata* Link., *Amorpha fruticosa* L., *Bidens frondosa* L., *Senecio inaequidens* DC.). Moreover, 5 *taxa* are included in the list of species with phytosanitary impact (Alert list) and one of them is invasive in both territories (*P. setaceum*), one in Sardinia (*Salvinia molesta* D.S. Mitchell), one in the Balearic Islands (*Araujia sericifera* Brot.), while *Fallopia baldschuanica* (Regel) Holub and *Sesbania punicea* (Cav.) Benth. are recorded only for Sardinia, as naturalized species. Finally, the list of potentially invasive *taxa* includes the genus *Cuscuta* sp. pl., *Cotula coronopifolia* L., invasive in Sardinia, and *Elide asparagoides* (L.) Kerguéle naturalized in Sardinia and absent in the Balearic Islands.

Regarding families, the absence of *Agavaceae* and *Cactaceae* in the Balearic Islands, and *Convolvulaceae* and *Onagraceae* in Sardinia has been revealed.

A review of the archaeophytes of the two floras shows that those alien *taxa* introduced before 1500 are quite similar in both territories, while differences were found in the neophytes, not only considering the alien flora (Podda et al. 2010), but also the invasive one. In this sense, it is worth to note that invasive archaeophytes are not significant, assuming a minimum percentage of the total, both for Sardinia and the Balearic Islands. In fact, *Ricinus communis* L., *A. donax*, and *Acanthus mollis* L. for Sardinia and *A. donax*, *Brassica rapa* L., and *Spartium junceum* L. for the Balearic Islands are the only invasive archaeophytes, respectively. In contrast, in both territories invasive neophytes assume a high percentage.

The comparison of biological spectra underlines that following therophytes, the highest percentage in Sardinia is that of phanerophytes, while for the Balearic Islands is that of hemicryptophytes and geophytes. The differences in the percentage of phanerophytes, which is higher in Sardinia, respond to an increased use of exotic woody species in forestry plantations and reforestations, while attending to therophytes, the largest number of species in Sardinia may be due to more extensive areas under cultivation, which abound in pioneer species with short life cycles.

Regarding the introduction pathways of invasive flora, ornamental use results to be the main cause of introduction as a result of proliferation in Mediterranean coastal areas of gardening based on the use of species from areas of similar climates (Hulme et al. 2008b). Although, as recorded by several authors (Hulme et al. 2008a; Lambdon et al. 2008; Pyšek et al. 2009), species introductions are mainly intentional, we should not underestimate the unintended introductions by seed contaminants, which are the second route of entry of invasive species in both territories.

The analysis of the most sensitive habitats shows that coastal environments and wetlands are proportionally more susceptible to biological invasions. Increased invasiveness of coastal ecosystems is a result of strong tourist vocation of both territories and the Mediterranean in general, which promotes the degradation of these habitats and the development of gardening activities which act as efficient vectors in the introduction of alien species (Sanz Elorza et al. 2009). Moreover, a great part of these *taxa* are favored due to the Mediterranean climate of their native regions, as *A. saligna* from Australia, or *Carpobrotus* sp. pl. from the Cape region, or because they belong to families of succulent plants, such as *Aizoaceae*, *Cactaceae*, and *Agavaceae*, adapted to high temperatures, long periods of drought and the absence of significant frost in winter. In this sense, climate change can also affect the frequency and intensity of extreme climate events (ECE) which disturb ecosystems and thus provide increased chances for dispersal and growth of invasive *taxa*.

Moreover, the invasion of wetlands and riparian areas is closely linked to the degradation of habitats due to human activities, always higher in the vicinity of residential areas and in lowlands (Bacchetta et al. 2008; Blondel and Médail 2009; Mascia et al. 2009; Schnitzler et al. 2007) conditions which reduce the competitiveness of native species that are very sensitive to environmental degradation (Howard and Chege 2007; Thiébaut 2007). In this regard, it should be noted that alien species that colonize wetlands are considered dangerous (Celesti-Grapow et al. 2009; Gherardi 2007), regardless their invasive potentiality in other regions with Mediterranean climate (Brunel and Tison 2005), being also included in the Global Compendium of Weeds (Randall 2002). The presence of alien species in wetlands is due primarily to the water and soil moisture regime that allows them to adapt to small areas, islands and passages moist, which promote aggressiveness, especially at local level [e.g., *A. filiculoides, S. molesta, H. ranunculoides, E. crassipes, Ludwigia grandiflora* (Michx.) Greuter].

Furthermore, many invasive species present in at least one of the two territories have "winning" intrinsic ecophysiological features not found in native flora (Richardson and Pyšek 2006). Among these features is the high competitive ability of seedlings (e.g., *C. selloana*, *Abutilon theophrasti* Medik., *Acacia* sp. pl.), the great capacity and rapid clonal propagation through rhizomes, bulbs or other propagules in both aquatic (e.g., *A. donax*, *A. filiculoides, H. ranunculoides*) and terrestrial habitats (e.g., *O. pes-caprae, P. distichum, Pennisetum* sp. pl., *Carpobrotus* sp. pl.), the facility to reproduce both sexually and vegetative [e.g., *Carpobrotus* sp. pl.; *Cyperus* sp. pl., *E. crassipes, Ipomoea* sp. pl., *Paspalum* sp. pl., *Sorghum halepense* (L.) Pers.], the ability of rapid growth with juvenile periods of short duration (e.g., *A. altissima, Asclepias fruticosus* L., *Eucalyptus* sp. pl., *R. communis*), good adaptability to a wide range of environmental conditions (e.g., *A. altissima, H. tuberosus*, *R. communis*), and high frequency of hermaphroditic individuals (e.g., *C. selloana*) that often use also autogamy (e.g., *C. selloana, C. coronopifolia*). To all this is associated the absence of antagonists and the production of allelopathic substances that act as herbicides and are toxic to herbivores (e.g., *A. altissima, A. fruticosus, Datura* sp. pl., *R. communis*).

It is through these features that the *taxa* can cause various types of impact proved dangerous especially in natural habitats. In fact, a qualitative analysis of the impact that invasive species cause in both territories shows that most species cause impact on the environment because of fierce competition with native species, often causing their disappearance and modifying the function and structure of their habitats [e.g., *Opuntia ficus-indica* (L.) Mill. in Sardinia, *L. grandiflora* in Balearic Islands, *Carpobrotus* sp. pl. in both territories]. The high proportion of species that origin an economic impact is due mainly to the impact in artificial habitats caused by crop pests (e.g., *Galinsoga parviflora* Cav. in Sardinia, *A. sericifera* in Balearic Islands, *O. pes-caprae* in both territories) and species related to nitrophilous synanthropic environments [e.g., *Nicotiana glauca* Graham in Sardinia, *Nothoscordum inodorum* (Aiton) G. Nicholson in Balearic Islands, *A. altissima* in both territories]. Some invasive species cause different kinds of impacts at a time; these are the most dangerous species which are a threat not only for the environment but also for economic activities and human health (e.g., *E. crassipes* in Sardinia, *Pennisetum clandestinum* Hochst. *ex* Chiov. in the Balearic Islands, *A. altissima* in both territories).

5 Conclusions

Currently, the exotic flora of Sardinia and the Balearic Islands represent 18,8% (SA) and 19% (BL) of the total flora (Podda et al. 2010). In particular, it highlights a twofold increase in the exotic flora in less than 20 years in Sardinia (9.2%, Viegi 1993), and more than double in just over 10 years in the Balearic Islands (8.4%, Vilà and Muñoz 1999). This phenomenon has led invasive species to currently represent 12 and 14%, respectively, of the exotic flora of Sardinia and the Balearic Islands, which confirms the severity of the problem and the rapid colonization carried out by exotic and invasive flora in particular.

The management of this phenomenon is only possible by establishing effective prevention policies, cooperation and coordination between the states which should pay greater attention to these issues, especially from a regulatory standpoint.

The European Union has not legislated on the issue, defining a directive that addresses the problem of exotic species in a systematic way. In this regard, the Habitats Directive 92/43/EEC (European Community 1992) in the introduction of the Council of the EU only contains a mere consideration in relation to this issue.

In Italy there are standards that suggest the preferential use of native plants instead of exotics, especially in the landscaping projects, forestry legislation, and in catchment plans (Tortoreto 2002). Only a few regions have paid particular attention to the problem of legislating in this area (e.g., L.R. no.10 of 31/03/2008 of the Lombardy Region, BURL 2008).

In Spain the situation is quite similar and beyond the law BOE (2007) on the natural heritage and biodiversity, specific regulatory standards have been issued only at the regional level (e.g., in the Valencian Community, DOCV 2009).

The framework outlined above evidences a regulatory deficit both at the national and European level and a lack of integration of Community policies with the strategies adopted at European and global level.

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