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THE RELATION BETWEEN EXOTIC MAMMALS AND BIRDS AND AGRICULTURE PRODUCTIONS IN ITALY: MODERN CONTAINMENT STRATEGIES

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Abstract

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Ornamental farming is the main source of future diffusion of exotic species, but containment measures for these species are often criticized or disapproved by public opinion, in particular in urban areas in all the European countries. In this paper, the social acceptability of rational solutions for this problem is discussed, thus keeping in mind the importance of the conservation of native species and the impact of exotic ones on agriculture and farmed species. Currently, the most problematic alien vertebrate species in Italy are the gray squirrel, the coypu, the cottontail rabbit and the American mink, while the Rose-ringed parakeet and monk parakeet are considered to be the potentially most dangerous alien bird species. The effects of the presence of these species include competition with autochthonous species, damage to agricultural crops and diffusion of pathologies. Ornamental animal farming is an emerging activity in Italy and throughout Europe, and it is likely that it will be the main source of the introduction of exotic species. The possible solutions to exotic species diffusion are: improving current laws, shared strategies with neighbouring countries, eradication and management of exotic species. This review deals with management of the most invasive terrestrial mammals and birds in Italy as well as with some social and ethical implications.

Key words: exotic animals; Coypu; Grey squirrel; Rose-ringed parakeet; public opinion

Introduction

The increase in the populations of exotic species in a country causes several problems, including ecological imbalances, caused by the impact on biodiversity, economic damage to the natural and urban environment and the spread of new diseases (Bellard et al., 2013; Sagoff, 2005). This diffusion of exotic species has remarkable negative economic consequences in the European Union (Vilà et al., 2010; Sicuro et al., 2016) and the diffusion of exotic species has been considered one of the most relevant environmental challenges for the future (Keulartz, 2015). This challenge has led to social contrast between conservationists and 'well-meaning animal welfare enthusiasts', who oppose any kind of control programs, such as hunting, controlling or eradication (Keulartz, 2015). In the context of the introduction and diffusion of exotic animals, animal farming plays a key role, whether directly or indirectly, such as in the case of the presence of Welsh catfish, which have unintentionally been spread with freshwater farmed fish in Italy. From an historical point of view, there are two main causes of the diffusion of exotic animals in Italy: the first cause is related to traditional animal farming and the second is related to ornamental farming. Ornamental farming has a historical origin in Europe and in Italy (Forcina et al., 2015) and it regards many terrestrial and aquarium animal species. Several control projects have been funded in Italy and Europe in order to control these species and their diffusion, but public opinion and the mass media often hinder the control of these species and their eradication in particular, as these species are considered like pet animals

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and can even be found in public gardens in several cities. For these reasons, it is difficult to realize effective control campaigns as the public agencies that fund these activities are managed by politicians, who are rarely willing to take oppositions against the majority of citizens. It is important to offer a rational perspective for the future management of these species, and to promote a modern concept of wildlife conservation in Italy: It is therefore necessary to explain that some severe measures are required in order to protect the native species.

The aim of this review is to show the state of the most invasive terrestrial vertebrate species in Italy, the effect of these species, in terms of impact on agriculture, public health and native species, and what the perspectives of new forms of farming are.

The Most Invasive Exotic Vertebrate Species in Italy

In general, mammal species are those that can establish more easily and can cause most damage to the flora and local fauna, while the effects of exotic birds are generally underestimated (Kumschick and Nentwig, 2010). At the moment, the most invasive vertebrate species in Italy are: gray squirrel, coypu, cottontail rabbit, American mink, Rose-ringed parakeets, monk parakeets and a few other bird species.

Gray squirrel

Squirrels are one of the most important examples of exotic vertebrate species that have been introduced into Europe and Italy (Figure 1) is the country with the highest number of introduced individuals in Europe (Mitchell-Jones et al., 1999). The replacement of the native Eurasian red squirrel (*Sciurus vulgaris*) by the North American gray squirrel (*Sciurus carolinensis*) is a well-documented example of an invasion by an alien species (Gurnell et al., 2004). Naturalized populations of gray squirrel progressively leads to the extinction of the native red squirrel through competitive exclusion (Bertolino et al., 2014).The gray squirrel is native to the eastern part of North America, but has been introduced into several countries outside its natural range. In Europe, it has been introduced as an ornamental species in Britain, Ireland, and Italy, and it has partially replaced the native European red squirrel in all three of these countries (Bruemmer et al., 1999; Schuchert et al., 2014). Three documented introductions of this animal to Italy have been reported: the first was in Piedmont in 1948 in Candiolo, near Turin. A second documented introduction from the United States took place in 1966 in Genoa, at the Villa Groppallo Park in Nervi. The gray squirrel populations in the Lombardy and Umbria regions originated from the Piedmont population (Signorile et al., 2016). Currently there are many wild populations in the Piedmont region and more than 26 populations of gray squirrel have been recorded in the Lombardy region over the last few decades (Bertolino et al., 2013). It has been estimated that the population could reach 4-6 million animals in the next 100 years. According to some prevision models, there will be a further expansion of gray squirrels: the eastern part of Liguria will be colonized within the next 35-40 years, and the colonization of the Apennines, between Emilia-Romagna and Tuscany, will start within 50-60 years (http://www.europeansquirrelinitiative.org/The_threat_across_europe_-_Italy.pdf). Another squirrel species that is gaining importance in Italy is *Callosciurus finlaysonii,* native of central Myanmar, Thailand, Laos, Cambodia and Vietnam. This species is present in Italy in Piedmont since1982and in the Basilicata region since 1980 (Bertolino et al., 2004).

Fig. 1. Gray squirrel distribution (Sicuro et al., 2016)

Coypu

Coypu (*Myocastor coypus*) is a native species of South America and was first introduced into Europe for fur production reasons (Chapman et al., 1982). In Italy, the first arrivals were reported in 1928 and the number of breeding farms grew from 1960 to 1980 (Figure 2). After that period, since interest in fur production had decreased, many animals were released into the wild. They found ideal conditions for their reproduction in central Italy and in the Po Valley and the introduced population rapidly increased (Bertolino and Genovesi 2007). The coypu prefers watery habitats characterized by lentic water, reed bed areas and channels with low vegetation (16).

Fig. 2. Areas mainly affected by the presence of coypu (Sicuro et al., 2016)

Cottontail rabbit

The eastern cottontail rabbit (*Sylvilagus floridanus*) is a native rabbit species to North America and an invasive species in North and Central Italy (Figure 3). It was first introduced into Europe in 1953 in Spain, France and Switzerland for hunting reasons. However, only in Italy are there naturalized populations (Mitchell-Jones et al., 1999). The first introduction into Italy seems to have taken place in the Piedmont region in 1966 along the river Pellice (Mussa et al., 1996). In Italy, the cottontail rabbit behaves like a typical edge species and its presence is related to natural herbaceous habitats, the edges of crops, and hydrographic networks with their associated riverside vegetation. Currently, their populations are widespread and consistent in Piedmont and in some areas of Lombardy. Small populations have also been reported in the Veneto, Emilia Romagna, Tuscany and Marche regions.

American mink

The American mink (*Neovison vison*) is a semiaquatic mustelid, native to North America, which has now become established as an invasive species in South America, Europe, Russia and Asia; the species has been exported outside its native range for the fur farming industry since the beginning of the last century (Dunston 1993). It was imported into Italy in the 1950s and it was first reported in the wild in the 1980s in

Fig. 3. Cottontail rabbit (black points) and American Mink distributions (black stars) (Sicuro et al., 2016)

the northern regions of the mainland and in Sardinia (Figure 3) (Bartolommei et al., 2013). Bonesiet al. (2013) reported that there were 30 mink farms in Italy, most of which were located in the north-east, and that feral populations were mainly present in central and north-east Italy. The American mink has a great dietary flexibility that allows it to adapt to the local availability of food resources (Iordan et al., 2012).

Birds

There are several species of exotic birds in Italy that have accidentally been released from captivity, or have been introduced for ornamental or hunting purposes (Table 1).

The diffusion of exotic birds has led to several problems, including an impact on biodiversity, economic damage to the natural and urban environment and the spread of new diseases to farmed birds (Kumschick and Nentwig, 2010). Parrot species have wide ecological tolerance and high synanthropy; they are among the most popular cage birds and represent one of the most invasive groups of birds at an international level (Menchetti and Mori, 2014). Unattended escapes have resulted in the establishment of many feral populations in Europe, including Italy (Mori et al., 2013).

In Italy, as in the rest of Europe, the greatest number of exotic bird species has been introduced into peri-urban environments (Clergeau et al., 2006), and most of the exotic bird species are parrots (Psittaciformes). So far, 21 species, representing 72.4% of all the Psittaciformes species detected in

Table1

Principal alien bird species in Italy (Andreotti et al., 2001; Terregino et al., 2003; Mori et al., 2013)

Species	Impact
Pelecanus rufescens	Biodiversity decrease, fish populations
Egretta gularis	Hybridization with *Egretta garzetta*
Threskiornis aethiopicus	N.R.
Cygnus olor	Damage to aquatic vegetation
Anser indicus	Avian flu reservoirs
Branta canadensis	Damage to agricultural crops
Alopochen aegyptiacus	N.R.
Aix sponsa	N.R.
Aix galericulata	Avian flu reservoirs
Oxyura jamaicensis	Hybridization with *Oxyura leucocephala*
Callipepla californica	N.R.
Alectoris chukar	Genetic pollution
Francolinus erckelii	N.R.
Francolinus francolinus	N.R.
Colinus virginianus	N.R.
Coturnix japonica	Genetic pollution with *Coturnix coturnix*
Psittacula krameri	Reservoirs for *Chlamydia psittaci*, damage to agricultural crops
Psittacula eupatria	N.R.
Myiopsitta monachus	Reservoirs for *Chlamydia psittaci*, damage to agricultural crops
Amazona aestiva	N.R.
Amazona ochrocephala	N.R.
Agapornis roseicollis	N.R.
Melopsittacus undulatus	N.R.
Nymphicus hollandicus	N.R.
Leiothrix lutea	*Plasmodium vaughani* reservoirs
Paradoxornis alphonsianus	Competition with native species
Estrilda troglodytes	N.R.
Estrilda astrild	N.R.
Amandava amandava	N.R.
Acridotheres tristis	Competition for nesting sites
Streptopelia decaocto	Newcastle disease reservoir
Phasianus versicolor	Damage to agricultural crops

note: N.R. – no reports

Europe, have been recorded (Di Febbraro and Mori, 2015). Rose-ringed parakeets (*Psittacula krameri*) and monk parakeets (*Myiopsitta monachus*) are the most common species. The first nests of ringed parakeets were found in the mid-70s in Genoa (Spanò and Truffi, 1986), and this species was later observed in the Sicily region in 1990. Monk parakeet, which is mainly found in urban parks and gardens in central and northern Italy, was first observed in Milan in 1934. Other parrots that have recently been found in Italy are: *Amazona aestiva, Amazona ochrocephala, Agapornis roseicollis, Psittacula eupatria, Melopsittacus undulatus e Nymphicus hollandicus* (Andreotti et al., 2001). Other exotic bird species have been introduced almost exclusively for hunting purposes. The Northern bobwhite (*Colinus virginianus*) was imported from Mexico into Tuscany in 1927, and it was later introduced into almost all Italian regions, including Sicily and Sardinia. The last known introduction occurred in 1984 in the Piedmont region, although this practice does not seem to have been completely abandoned in Piedmont and Sicily (Baccetti et al., 1997). The Chukar partridge (*Alectoris chukar*) was first introduced into Sicily in the early 30's, but its introductions was suspended in the 50s (Baccetti et al., 1997). This species can hybridize with *A. rufa* and *A. graeca*, thus causing the genetic pollution of native partridge popula-

tions (Luchini et al., 1999). Among Passeriformes, there are 2 main invasive species: strawberry finch (*Amandava amandava*) and Japanese nightingale (*Leiothrix lutea*).The most invasive species is strawberry finch, which was first introduced in 1974, and since then has successively colonized the Tuscany region (Baccetti et al., 1997), while Japanese nightingale has locally been common in some urban areas in central Italy since 1993 (Andreotti et al., 2001) Canadian goose (*Branta canadensis*) was first observed in Italy in 1970 in the Venice area (Baccetti et al., 1997), while Egyptian Goose (*Alopochen aegyptiacus*) has been observed in northern and central Italy (Baccetti et al., 1997).

Impact of Exotic Species

Gray squirrel

Gray squirrels cause commercial damage to forestry, and they are a nuisance to gardens and maize fields (Signorile and Evans, 2007). When gray squirrels are well established, they are considered very destructive to property and their negative impact is ranked second only to the Norwegian rat (http://www.brc.ac.uk/gbnn_admin/index.php?q=node/31). It is estimated that the bark stripping damage caused by gray squirrels costs the UK timber industry about £14 million per year (Williams et al., 2010). Squirrels can also affect the populations of small birds in woodlands, as they eat their eggs and nestlings. In Italy, the spread of gray squirrels has already led to considerable direct and indirect damage to local poplar plantations (Wauters et al., 1997). There is evidence that in years of good acorn crops, gray squirrel populations can reach very high densities (Bertolino et al., 2014). In the Piedmont region, which is the area in Italy where they are the most common, extended damage to poplars, hornbeams and cereal crops has been recorded (Williams et al., 2014). Damage to plantations and crops in Italy is still limited (Signorile and Evans, 2007), but the potential economic impact for the future has been estimated as 12 Mln €/year (Panzacchi et al., 2007).

Coypu

Curiously, the main impact of coypu is of hydromorphological nature. Coypu causes damage to embankments, especially those of artificial canals, by excavating burrows. A recent survey has quantified the cost of the management of coypu in Italy over the period from 1995 to 2000 (Panzacchi et al., 2007). The compensation paid in the last six years for damage to agricultural activities has reached nearly 1 Mln €, while the damage to embankments has exceeded 10 Mln €. Other problems resulting from the spread of coypu are due to damage to the natural vegetation, agricultural crops and wildlife (Prisons et al., 2005). Coypu can cause a substantial impact on vegetation, with the decline or disappearance of numerous aquatic plants (Bertolino et al., 2000) and a decrease in the populations of aquatic birds (Gariboldi, 1993). The damages caused by coypu in Italy during the 1995-2000 period accounted for more than 11.5 Mln € and the necessary control activities accounted for more than 2.5 Mln €, while almost 221.000 coypu were removed (Prison et al., 2005).

Cottontail rabbit

Cottontail rabbits typically damage woody plants by gnawing bark or clipping off branches and stems. Between 1997 and 2002, the estimated economic damage in Italy was more than 138 000 €.The damage caused by lagomorphs (cottontails and hares) was studied between 2000 and 2011 (Regione Piemonte, 2014), and the estimated damage was found to be almost 1.5 € Mln. As far as interactions with native species are concerned, it is known that cottontails and hares have similar habitat requirements, but no competition has been observed because the two species have a different micro-habitat use (Bertolino and Viterbi, 2010). It seems that habitat heterogeneity has promoted daytime segregation between the two species.

American mink

Several studies across Europe have demonstrated that feral mink can have a serious impact on native species, in particular ground nesting birds and rodents, but also on other mammals (Bonesi and Palazon, 2007). Until now, no effort has been made in Italy to control or eradicate these feral populations, except for a few attempts to re-trap escaped individuals. Recently, the "Istituto Superiore per la Protezione e la Ricerca Ambientale" (ISPRA), in collaboration with the Italian Association of Milk Farmers (A.I.A.V.), has diffused guidelines on the management of escaped mink (Bonesi and Palazon, 2007). At present, its impact in Italy is poorly investigated, but on the basis of the observed impact in other European countries, it is expected that the establishment of feral populations of American mink in Italy will have an impact on the native amphibian, waterfowl and rodent populations (Bonesi and Palazon, 2007). In Ireland, American minks are perceived as real pests by farmers, anglers, fish farmers, gun clubs and poultry producers, primarily due to their predation of livestock i.e. poultry, wildfowl and farmed fish (Kelly et al., 2013).

Birds

Rose-ringed Parakeet (*Psittacula krameri*) is one of the species listed among the 100 most invasive species in Europe (Kumschick and Nentwig, 2010); it is present in Italy (Dodaro and Battisti, 2014), and can cause serious damage to fruit cultivation and wheat fields (Andreotti et al., 2001).

Some researches carried out in Great Britain and Italy on the feeding and habits of garden birds have shown that gregarious exotic parakeets impact on autochthonous birds (Copping, 2014). The introduction of Egyptian goose and Canadian goose has caused damage to agricultural crops (Andreotti et al., 2001), however, their introduction into Italy has not been as relevant as in North European countries.

A few other bird species, such as the common Myna and the Japanese Nightingale, could have an impact on agricultural crops (Male et al., 1998). The diffusion of exotic bird species that are genetically close to autochthonous ones also leads to genetic pollution problems, as in the case of chukar partridges (*Alectoris chukar*) and chukar partridge hybrids that have been released into the wild for hunting purposes.

Sanitary Impact

In order to understand the impact of exotic species, it is important to consider the sanitary aspects related to their presence. These aspects regard not only other animal species, but sometimes also humans.

Gray squirrel

Gray squirrels are believed to be carriers of parapoxvirus infection in the United Kingdom and this disease is invariably fatal to red squirrels (Tompkins et al., 2002; Chantrey et al., 2014). Therefore, the diffusion of this pathology can result in the loss of local populations of red squirrels, even though there is no evidence that parapoxvirus has occurred in red or gray squirrels in Italy (Bertolino et al., 2014).

Experimental infections have shown that the virus causes a deleterious disease in red squirrels, but has no detectable effect on the health of gray squirrels, while an inter – specific infection mechanism has been observed for Adenovirus diffusion (Shuttleworth et al., 2014). Squirrel poxvirus is also potentially transmissible to humans (Tompkins et al., 2003).

Coypu

The most important coypu parasites are flukes (*Fasciola*), bacteria, such as Leptospira (*Leptospira interrogans*) and protists, such as *Toxoplasma gondi* (Bollo et al., 2003) can be transmitted to humans and spread throughout the environment. Leptospirosis in coypu has a high incidence, and is usually present in almost 50% of the individuals.

Cottontail rabbit

Cottontail rabbit is considered a less dangerous species than coypu and gray squirrel. However, it can be considered a vehicle of dangerous diseases, such as tularemia, rickettsial infection, bovine anaplasmosis, piroplasmosis and myxomatosis. Some internal exotic parasites that can potentially infect rabbits and hares can be transmitted by the cottontail rabbit. Cottontail has also been indicated as a possible reservoir of RHDV (Rabbit Haemorrhagic Diseases Virus) and EBHS (European Brown Hare Syndrome) (Zanet et al., 2013).

Birds

Birds, given their ability to move in a fast and wide-ranging way, often constitute efficient reservoirs of pathologies (Table 2). Several researches at an international level have shown that exotic birds play a crucial role in the diffusion of severe diseases and pathogens for reared birds, such as Newcastle disease and *Plasmodium vaughani* (Bonesi and Palazon, 2007). All psittaciformes species are natural reservoirs of *Chlamydia psittaci*. Psittacosis, which is one of the most dangerous zoonoses to human health, is transmitted by ornamental birds (Evans, 2011). The Japanese Nightingale (*Leyothryx lutea*) is also known to be a reservoir of avian malaria (Kumschick and Nentwig, 2010).

Table 2
Main zoonotic pet diseases diffused by exotic birds (Boseret et al., 2013)

Disease	Sensitive species
Blood-sucking mites	All
Chlamydophilosis	Psittacines, canaries, finches
Salmonellosis	All
Tubercolosis	Psittacines (canaries?)
Campylobacteriosis	Mostly estrildidae
Avian influenza	Passerines
West Nile fever	All
Newcastle disease	All
Toxoplasmosis	Canaries, finches, budgerigars, minah birds

Management

The most common measures proposed for the prevention and control of exotic species on one hand regard rules and international directives that discipline the importing of ornamental species, farmed animals and animals suitable for hunting activities, and on the other hand pertain to suggestions on methods that can be adopted against unattended releases.

In the past, in order to control the introduced species, the inhibition of reproduction was proposed by means of hormonal treatments, eradication or indirect control, with various results. Even the promoting of hunting activities against target exotic species has not been a successful strategy as the hunting activity has caused the release of exotic species by hunters. In light of the facts that have been illustrated so far,

it is clear that the future sources of the diffusion of exotic species will be urban and peri-urban areas, where exotic species are more common. These areas will probably serve as artificial reservoirs of these species and specific containment measures are therefore necessary. Different strategies have already been proposed, but there has often been strong opposition from the public opinion, in part because exotic species are particularly common in urban parks.

Gray squirrels

Recent researches on gray squirrel control in the UK and Italy have shown that if containment actions are delayed until these animals are publicly recognized as a problem, it is generally too late for any effective action, due to of logistical, legal and economic reasons. Some containment strategies were proposed without success in the past, such as the inhibition of reproduction, trapping or eradication (Bonnington et al., 2014b; Shuttleworth et al., 2014), however, the keeping and trading of gray squirrels has been forbidden in Italy since 2013 (GU, 2013).Several gray squirrel management initiatives in Italy have been funded by the EU, in particular LIFE projects (http://www.rossoscoiattolo.eu). Following these extensive researches, the main solutions suggested for the containment of gray squirrel are eradication by means of live-trapping, euthanasia in the case of large populations, such as in Piedmont and Lombardy, and eventually surgical sterilization for small urban populations, such as in the Liguria region. Recently, the diffusion of autochthons natural predators, as pine marten, has showed a direct effect on gray squirrel containment (Sheehy and Lawton, 2014).

Cottontail and Coypu

The Council of Europe has recently recommended that Member States should prohibit the introduction of cottontail rabbits and proceed with the active or passive eradication of the populations (Recommendation R 85/14) (Arthur et al., 1983). In the Piedmont region, which is one of the Italian regions in which cottontail is more common, cottontail populations are controlled through hunting or capture. There are no real prevention measures in North Italy and the only management measure is the reimbursement of agriculture damages caused by these species. The Council of Europe also suggests the eradication of coypu (Recommendation no. 77), but, considering the high number of individuals, eradication is believed to be impossible. Old eradicating solutions often included the use of poison, while traps and habitat management have been utilized in more recent studies (Genovesi and Carnevali, 2011). However, the introduced coypu control campaigns have not reduced the population expansion or the increase in damage and economic losses at a national scale (Bertolino and Viterbi, 2010).The use of metallic fences along river banks has also been proposed in order to hamper their borrowing activity. The eradication of cottontails is not feasible, thus indirect measures should be considered in order to decrease their diffusion in North Italy and eventually to promote the expansion of hares. Habitat restoration measures, aimed at increasing the presence of open landscapes and meadows could hamper the diffusion of cottontail and at the same time could have a positive effect on the diffusion of hares (Bertolino et al., 2013). For instance, in one of the most active northern regions, the Piedmont region, the annual amount for agriculture damage was divided rather equally by farmers until 2014, and this sum of money was considered a kind of regular extra income. An alternative option would be the adoption of prevention measures by local authorities or farmers, such as mechanical protections for trees (so-called "shelters") that could lead to a decrease in damage reimbursements, but would imply extra activities for their disposal by the farmers. It is not clear who should provide for these shelter disposal activities in Italy, farmers or public administrations. It is for this reason that damage reimbursement is still the preferred option. The use of repellent compounds has been adopted in Connecticut (USA) (Williams and Short, 2014). The introduction of cottontail in the list of hunted species cannot be considered as a definitive solution. In fact, cottontail has been considered a suitable species for hunting since it was first introduced, but hunting has not hampered the diffusion of cottontail, which, since its introduction, has conversely increased in number in North Italy. Similarly, the catching of another highly invasive species, the Louisiana red crab (*Procambarus clarki*) has been forbidden in North East Italy, because it has been observed that one of the main sources of diffusion is the deliberate release by fisherman.

American mink

Because of its limited invasiveness in Italy, currently there are no management plans, but it is important that strategies for American mink control should be planned for the future, considering that this species has proved to be highly invasive in other European countries. For instance in the Western Scottish Isles, where it has been present since the 50s, a LIFE project, based on the eradication of American mink (LIFE00 NAT/UK/007073), was successfully carried out from 2001 to 2006. This has led to a substantial reduction in the number of American mink on those Islands. Considering its limited diffusion in Italy, it could be still eradicated (Iordan et al., 2012).

Birds

The main invasive exotic species (parrots) have in particular colonized urban areas, where the autochthonous bird popu-

lations are dominated by a few urbanized species. Considering that parrots show a high potentiality of expansion in Italy (Di Febbraro and Mori, 2015), as in other countries, some direct or indirect containment measures could be adopted. The eradication of exotic migratory bird species is only successful when international actions are coordinated, as in the case of the ruddy duck (Robertson et al., 2015).The adoption of alternative cultural corn or sunflower practices in Argentina (Robertson et al., 2015) and direct actions against the nesting sites (Burgio et al., 2010) that parakeets use during the entire year, have been effective. The disposal of automatic feeders containing corn treated with anti-reproductive pharmacological compounds was adopted in the Friuli region (NE Italy) in 2013 (https://it.wikipedia.org/wiki/Specie_invasive_in_Italia) as a containment strategy against the increase of pigeons in the historical cities. The escape of cage parrots can be also limited by preventive methods, such as the application of flying reduction practices (Costa, 2014). Unfortunately, flying reduction, which involves the partial cutting of flight feathers, is considered a cruel practice or even illegal in some Italian region, and is therefore not adopted very often. The public opinion should be informed about the fact that the adoption of this practice is an important way of indirectly limiting negative effects on autochthonous birds. Directive no.1143/2014 introduced the absolute prohibition of reproduction of alien bird species in Italy, and this should lead to a progressive decrease in interest in these species. This directive will probably cause also a sudden increase in wild exotic bird species, as owners and breeders will probably release them.

Conclusions

The diffusion of exotic animals is a natural consequence of domestication. In the past, food animal farming was one of the main sources of the diffusion of exotic animal species, but in the future, ornamental farming will be the real source of diffusion of exotic animals. The spread of exotic species has changed in Italy and in the modern western society, particularly in terms of the ways and geography of diffusion. In the past, the rural environment that was generally colonized by exotic species, as a result of the escape or intentional release from animal farms, as occurred in Italy for coypu, cottontail and American mink. Currently, the scenario is radically changing and urban areas are the modern sources of diffusion of the most invasive exotic vertebrate species, such as gray squirrel and parrots (Mori et al., 2013; Bonnington et al., 2014a). Nowadays, thousands of pet owners have become potential sources of the diffusion of exotic species, and these sources are much less controllable than animal farmers. In this situation, the social acceptability of control strategies is more difficult to achieve. There is no clear awareness of the impact of exotic species on native species, and the public opinion often considers that severe containment measures are neither morally or ethically acceptable. The public opinion is particularly aware of animal welfare concepts and the killing of exotic animals is itself a cause of regret (Verbrugge et al., 2013). It can be stated that the control of invasive species is influenced more by an aesthetic criterion than an ecological and rational idea of sustainable management of invasive species. Besides, in Italy and in other western countries, the decision makers, that is, the public authorities and politicians, are influenced more by public opinion than by scientific considerations, and this fact creates a conflict with management exigencies. At the moment, only a few exotic vertebrates are really invasive in Italy and the Italian laws (e.g. no.1143/2014) substantially limit their diffusion and future introductions. The adoption of these laws has promoted several actions in order to control exotic species and the most common strategies involve the containment, eradication or induction of sterility. In order to able to better manage the diffusion of exotic species in Italy, the public opinion must be involved in taking decisions on exotic animal management, as happened in Scotland as far as red squirrel conservation is concerned (http://scottishsquirrels.org.uk/about/project-overview). Following the example of other countries, educational programs dealing with biosecurity should be developed, as happened during the outbreak of Newcastle disease in 2002 and 2003 in California (Bradley, 2007). A rational approach to these problems, focused on the conservation of native species, must be preceded by a kind of moral suasion on the containment of exotics, but at the moment, the public opinion in Italy and in other western countries is probably not quite ready for this.

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