

Research Article

First account on the occurrence of selected invasive alien vertebrates in Greece

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Abstract

This is the first attempt to outline the occurrence of selected invasive alien vertebrates in Greece, since up to now, there are no “official” or scientific reports except from sporadic sightings and anecdotal stories. Records on the occurrence of: *Lithobates catesbeianus*, *Trachemys scripta* (*T. s. elegans* and *T. s. scripta*), *Neovison vison*, *Myocastor coypus*, *Nyctereutes procyonoides* and *Ondatra zibethicus* were requested through a pan-Hellenic survey. According to the results, the coypu (*Myocastor coypus*) appears to be the most widely distributed of all species, having conquered practically all wetlands of Western and Central Greece with populations exceeding, in most cases, 20 individuals each. On the contrary, there is merely one unconfirmed record of the raccoon dog (*Nyctereutes procyonoides*) while there were no sightings at all for the muskrat (*Ondatra zibethicus*). The American mink (*Neovison vison*) was recorded in the northwestern part of Greece. Regarding the alien herpetofauna, the bullfrog (*Lithobates catesbeianus*) seems to be still confined in Crete where it was originally introduced, while the red-eared slider (*Trachemys scripta*) appears mostly in Crete, Attiki prefecture, and a few more places, showing most probably an underestimated distribution.

Key words: IAS, terrestrial, coypu, American mink, raccoon dog

Introduction

Biological invasions have grown to be a global conservation issue that threatens biodiversity worldwide and has significant impacts on the socio-economical level (Binimelis et al. 2007; Vilá et al. 2010). Invasive alien species (IAS) have been shown to affect ecosystem functioning and native fauna via predation, competition and hybridization, diffusion of pathogens and habitat alteration (Hulme 2007; Strayer et al. 2006; Perrings et al. 2010; Simberloff et al. 2013). The minimum information needed for any country to compile a national inventory of IAS and therefore be prepared to quantify several variables in order to target management strategies is data on the occurrence of the species in question. Likewise, accurate information on alien species distribution is crucial for managing biological invasions globally (Latombe et al. 2016).

On this basis, here we report the results of the first survey carried out in Greece involving the occurrence of selected vertebrate IAS. Terrestrial

alien vertebrates are responsible for the greatest range of impacts across Europe (Vilá et al. 2010) and although marine alien biota in Greek waters are well documented (Zenetos et al. 2009), information on the distribution of vertebrate IAS in Greece is very poor. In addition, Greek metropolitan areas are tremendously vulnerable in invasion events largely due to the large ports of Piraeus, Thessaloniki and Patras: “hitchhikers” can easily travel on cargo ships, containers, cars, yachts, etc. and, in the worst scenario, effortlessly reach the Aegean islands, which are the center of endemism for many animal groups. Then, in geographically isolated systems such as small islands, invasive organisms can even cause the extinction of endemic species (Townes et al. 2006). Only recently, for example, just a few kilometers off the port of Piraeus, a novel colony of the Italian wall lizard, *Podarcis siculus* (Rafinesque-Schmaltz, 1810), was first reported in Greece (Adamopoulou 2015), a fact that represents a potential threat for the endemic lizards of the genus *Podarcis* in the Aegean Archipelagos.

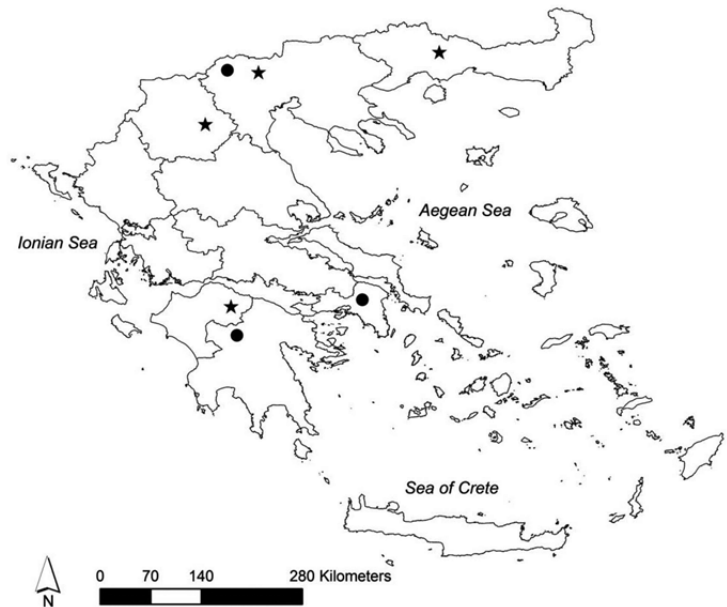


Figure 1. Map of Greece showing the national forestry offices that replied to the survey during 2011 (bullets) and 2016 (asterisk).

Methods

For the purpose of the study we have compiled a questionnaire to obtain information for each species. After filling his/her personal data (name/profession/contact details) the responder had to fill out the form with the following data (for each examined species):

- Location/ village/ county, where the observation took place
- Date and time of the observation
- Frequency of observations. How often does one see the species (if it is more than once) according to the scale: 1= rarely, 2= commonly, 3= very often seen
- Number of individuals of the species in each observation (1–2, 3–5, 6–10, 11–20, >20)
- Habitat characteristics: Any information regarding the overall environment where the animal was seen (such as lake, river, irrigation canal, cultivation, forest, scrublands, urban environment, in or by the water, etc.)

At the end of the questionnaire there was a section for other remarks. Responders were also encouraged to send pictures if available.

During the winter of 2011 we have sent 80 questionnaires to the following groups: 1) all national forestry offices of counties or prefectures covering the entire Greek territory, 2) all local management bodies, 3) non-governmental organizations and

4) scientists working at the private sector (freelance). Each questionnaire included additionally a short description and an identification picture of each species. The terrestrial vertebrate species we chose to include in this analysis are recent invasions that have been observed after World War II and are also listed amongst the 100 worst IAS [DAISIE European Invasive Alien Species Gateway (<http://www.europe-aliens.org/>)]. Furthermore, since this was the first time that a survey of this kind was done in the country, we preferred to include species that could be easily seen and recognised even by non-trained staff. Accordingly, data were requested for the following species: the American bullfrog [*Lithobates catesbeianus* (Shaw, 1802)], the common slider [*Trachemys scripta* (Schoepff, 1792)], the American mink [*Neovison vison* (Schreber, 1777)], the coypu [*Myocastor coypus* (Molina, 1782)], the muskrat [*Ondatra zibethicus* (Linnaeus, 1766)] and the raccoon dog [*Nyctereutes procyonoides* (Gray, 1834)]. During March 2016 we updated the collected data with an online questionnaire this time sent to the same recipients. Once we had collected the responses, the geographical coordinates of the sightings were introduced in ArcGIS 9 for graphical representation.

Results

During the 2011 survey, we collected a total of 24 reports. Three out of the 80 forestry offices of the country (3.7%) responded to our call (Figure 1) and 4 out of 27 (15%) of the local management bodies.

Table 1. Location, geographical coordinates and source of observation for the American bullfrog, *Lithobates catesbeianus*, and raccoon dog, *Nyctereutes procyonoides*.

| Species | Location | Latitude (N) | Longitude (E) | Observer | Year of observation |
|---------------------------------|--------------------------|---------------------|---------------------|--|---------------------------------|
| <i>Lithobates catesbeianus</i> | Agia,-Agia prison, Crete | 35.4764 | 23.9333 | M. Dretakis and I. Roussopoulos (2000)/K. Paragamian | 1994, 2000/2011, common/2014-15 |
| <i>Nyctereutes procyonoides</i> | Prespes | 40.7730 (imprecise) | 21.1489 (imprecise) | Society for the Protection of Prespa | 2009 |

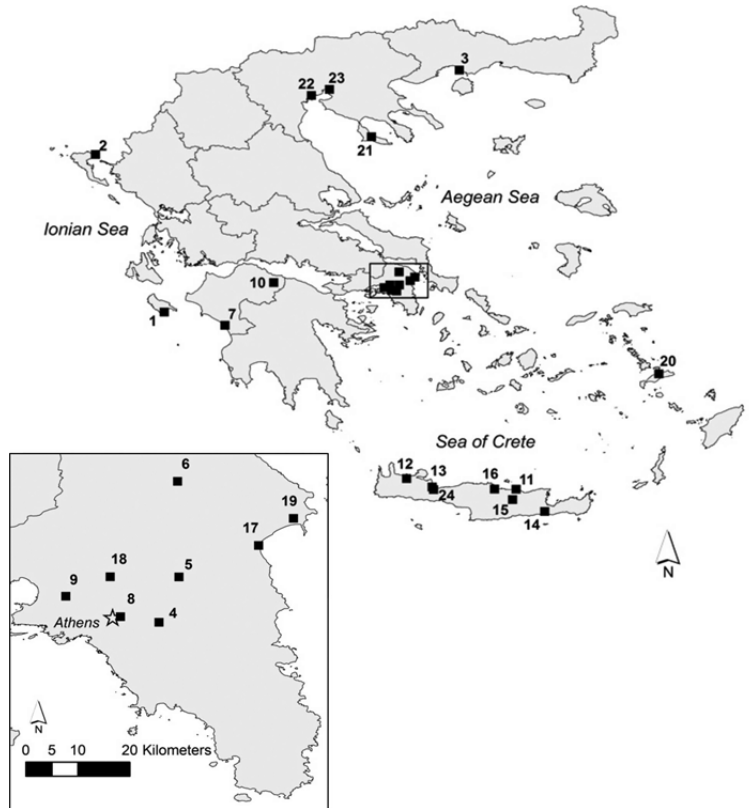


Figure 2. Reported sightings of the common slider, *Trachemys scripta*, in Greece [including one record from Bruekers et al. (2006)]. Each square represents a specific geographical point on the map. Numbers correspond to the exact coordinates given in Table S1.

Most replies came from freelance scientists. On the 2016 online update we had 17 replies (with sightings) and 8 negative ones. In total, 5% of the forestry offices (Figure 1) and 25.9% of the local management bodies replied. Results are shown on Table 1 (for species with few sightings) and Figures 2 to 4 (see the Tables S1–S3 for the exact geographical coordinates). According to our data the only amphibian in the list, the American bullfrog, is confined to Crete (Table 1). Regarding the occurrence of the raccoon dog, an unconfirmed record exists for one individual seen close to riparian woods in Prespa lakes (northwest Greece). The observation was made by a French visitor during July of 2009 and was reported to the Society for the Protection of Prespa. We cannot rule out the possibility of its existence since the species is already reported in Bulgaria and from

the Former Yugoslav Republic of Macedonia (Ćirović 2006). For the muskrat, *O. zibethicus*, we had no records at all. The presence of this species in Greece remains questionable; however, it is known to be present in Southern Bulgaria (Milchev 2007) and Albania (Linzey 2008). The rest of our data indicate that the common slider (Figure 2) and coypu (Figure 4) are widespread in Greece. The American mink (Figure 3) is confined to the northwestern part of the country.

Discussion

According to the guiding principles adopted by the Convention on Biological Diversity (CBD 2002) prevention is the priority response as well as early detection. New sites of incursions need to be quickly

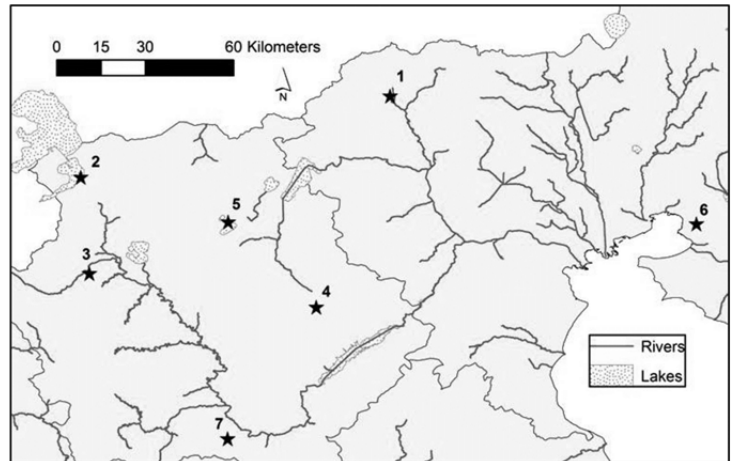


Figure 3. Reported sightings of the American mink, *Neovison vison*, in Greece. Each asterisk represents a specific geographical point on the map. Numbers correspond to the exact coordinates given in Table S2.

detected in order to accelerate management responses (Genovesi 2005). In Greece, a national inventory hasn't been compiled yet, thus we have tried to outline, for the first time the occurrence of selected vertebrate IAS included in the list of the 100 worst species. The data we have collected are certainly not adequate for a national inventory, however, we consider them a good start, enough to trigger several actions concerning the invasion issue in the country. They are presented in a taxonomical order.

Lithobates catesbeianus

One of the most well known invasive amphibians around the world is the American bullfrog, *L. catesbeianus*. It is a species native to North America but it is known to reproduce at least in eight countries in Europe (Belgium, France, Germany, Greece, Italy, the Netherlands, Spain and the UK) (Scalera 2007). In Greece, it was introduced as tadpoles on May 1994, about 3 kms east of Agia lake for commercial farming (Dretakis, pers. com.). Breeding

of the species failed and the farmer dried up the canals, however, some tadpoles survived in the mud. During 2000, M. Dretakis and G. Rousopoulos heard for the first time few bullfrogs in Agia lake together with the native endemic Cretan water frog [*Pelodytes cretensis* (Beerli, Hotz, Tunner, Heppich and Uzzell, 1994)] in abundance. Later on, the species analogy changed in favor of the introduced one (Dretakis, pers. com.).

L. catesbeianus has a negative impact on native amphibians (Kraus 2009) and can host the pathogenic fungus (*Batrachochytrium dendrobatidis*) that has been implicated in global amphibian decline (Hanselmann et al. 2004). Eradication of this species is a conservation priority in particular since the bullfrog doesn't appear to have crossed the Aegean barrier towards other islands or mainland Greece. Such an effort, although costly, would be still efficient in controlling spreading of the species in other parts of the country. In Europe, two such attempts have been successful (Ficetola et al. 2007), but eradication is difficult to achieve as it requires killing of all

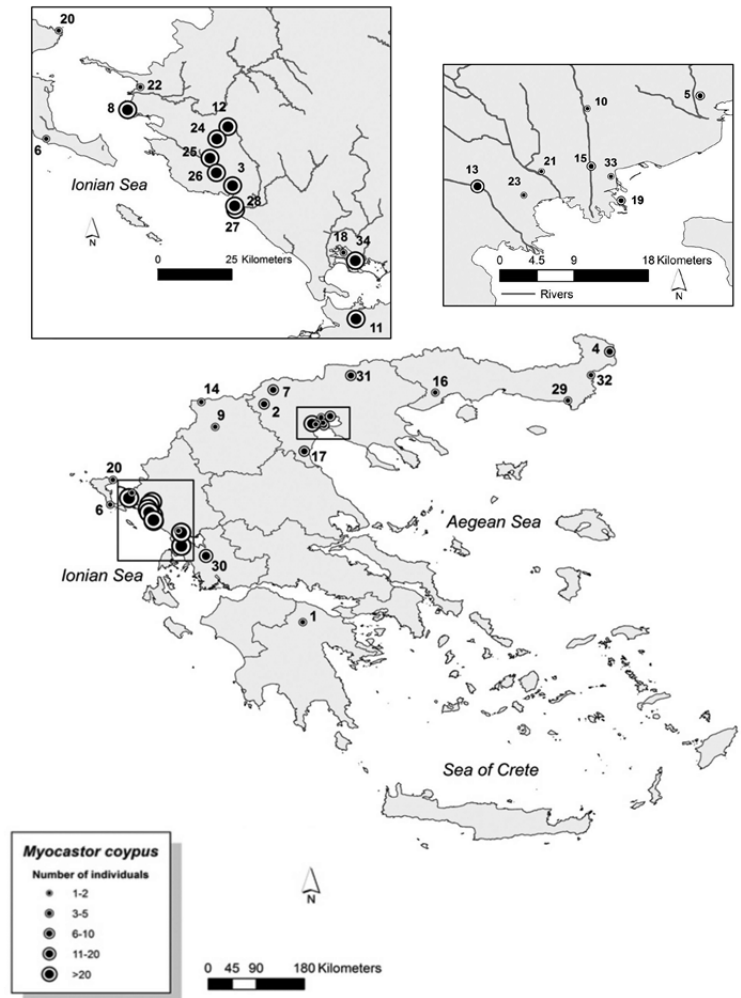


Figure 4. Reported sightings of coypu, *Myocastor coypus*, in Greece. Each symbol represents a specific point on the map. Numbers correspond to the exact coordinates given in Table S3. Diverse symbols represent different number of individuals counted in each observation.

individuals (adults and tadpoles) and the complete drainage of breeding ponds. Whether this is feasible or realistic in Crete depends on many parameters. Careful monitoring of the existing free-ranging population is almost compulsory as a basic management strategy aiming to control dispersal of the species.

Trachemys scripta

The common slider has a natural range in the eastern US and northeast Mexico (Iverson 1992). It is a voracious omnivorous species that is found all over Europe and is considered a threat for indigenous species; it has been found to compete for basking sites, food and nesting sites with the native pond turtles (Cadi and Joly 2003, 2004; Polo-Cavia et al. 2009). The subspecies *T. s. elegans* is known to occur in 12 European countries including Greece, however, breeding populations are documented from

Spain (Pleguezuelos 2002), Italy (Ficetola et al. 2002; Sindaco et al. 2006), France (Cadi et al. 2004; Pascal et al. 2006) and possibly Serbia (Đorđević and Anđelković 2015). It is not known whether it is established in Greece although juvenile animals of approximately 4 cm have been found in Kipos Diomidous, in Athens (Lourida 2014, unpub. data). Still, it is difficult to ascertain whether animals of this size come from local births or recent releases since sliders are sold at the size of just a few centimeters (and none had an evident umbilical scar).

The common slider is mostly reported from Athens (Attiki prefecture) and Crete (Figure 2). Observations in the capital date back in the 1990s while in Crete *T. scripta* was first recorded in 1998. Still, Figure 2, probably underestimates the actual presence of the species in Greece. *T. scripta* is a typical example of human impact on biotic changes. It has been traded since the 1950s being an extremely

popular pet worldwide (Ficetola et al. 2012). In their non-native range animals recorded in the wild (unless populations are documented established) come from unintentional or intentional releases after abandonment by owners who no longer want or are able to keep sliders in their homes. Accordingly, *T. scripta* is expected to be present in all Greek cities that have pet shops and urban parks with ponds. In this case, given that the only pathway of introduction is pet trade, raising awareness among citizens for the biological invasion issues seems to be a one-way approach.

Neovison vison

The American mink has been observed in three neighboring counties (Figure 3) situated in northwest Greece. *N. vison* is a semiaquatic mammal native to North America. Minks were imported in the 1920s in Europe for the fur trade and since then several breeding farms have existed till today across Europe (Bertolino and Genovesi 2007). In Greece animals were introduced for the fur farming industry as well. Feral populations formed either from escapes, or from intentional releases: e.g. during 2010, 52,000 minks were deliberately released by animal rights activists from two breeding farms in Kastoria and Kozani county. Locations of our observations point out that minks have spread mostly towards northeast of the source population, approximately 150 kms from Kastoria. We do not know whether these are self-sustaining populations, however, since the average life expectancy in the wild is 3–4 years, it may be reasonable to assume that populations are naturalized. In Veneto, Italy, Iordan et al. (2016) found that after a little more than 10 years from the release of farm animals, the American mink was naturalized in the region. The American mink is a predator that has a negative impact on ground-nesting birds (Nordström et al. 2002, 2003). Moreover, it competes for food and space with indigenous carnivores such as the European mink [*Mustela lutreola* (Linnaeus, 1761)], the polecat (*M. putorius*, Linnaeus, 1758) (Sidorovich et al. 1999; Sidorovich and Macdonald 2001) and otters [*Lutra lutra* (Linnaeus, 1758)] (Hammershøj 2004). On these grounds, the mink population that is located in Mikrolimni, Prespes (location 2, Figure 3) represents a major threat for the native avifauna. Prespa Lakes is a particularly important area for breeding, staging and wintering birds. It is a Ramsar wetland and a Natura 2000 site that hosts over 273 species of birds. Nesting birds include also vulnerable species such as e.g. the Dalmatian pelican, *Pelecanus crispus* Bruch, 1832. Lake Mikri Prespa hosts the largest colony of

the species in the world. In such a “sensitive” area, eradication, or, in any case, control of the mink population is a requisite and one way to be done would be by selective trapping (Birnbaum 2006). Public awareness should also be promoted as to introduce the species to the public and point out the negative impact on the native fauna.

Minks, however, have an impact also on local economies causing damage to poultry and fisheries (Harrison and Symes 1989). To date there are about 31 fur farms operating in Kastoria County with a capacity of breeding 236,055 adult animals, a fact that calls for the need of permanent control measures. One way would be that local authorities consider *N. vison* a game animal, which could be hunted even without restrictions in terms of season. This is a measure applied in the Baltic countries and Denmark (Birnbaum 2006), having the risk though of the unintentional deaths of non-target animals. Another problem is insufficient precautionary measures on the farms. Prevention of escapes should focus on: 1) making farming conditions very strict, 2) planning ahead an effective and rapid response to new releases or escapes, especially when facilities are close to biodiversity rich areas and 3) banning farming in non-invaded areas (Bertolino and Genovesi 2007).

Myocastor coypus

Coypu seems to be the most successful terrestrial invader in Greece, having more than 30 different sightings located in the northern and western mainland (Figure 4). It is known to be present in Greece at least from 1965 (Agra lake, Western Greece) when it was reported during a field study that was conducted in Poland, Israel and Greece between 1948 and 1966 (Ehrlich 1967). The most southern observation of coypu was in Stymfalia lake (point 1 on the map), Peloponnese, however according to the responders this population probably doesn't exist any more.

Coypu is a South American species, which however occurs in naturalized populations all over Europe. It best exemplifies the widespread damage that invasive terrestrial vertebrates can cause: they damage crops, greatly disturb riverine vegetation by grazing, undermine riverbanks by burrowing, and transmit the bacterial disease leptospirosis (Bertolino and Genovesi 2007). As such, the species is included in the list of alien species that generate some of the highest costs in Europe (Panzacchi et al. 2007, Vilà et al. 2010). Only in United Kingdom has the species been successfully eradicated (Baker 2006), while in several other European countries millions of Euros have been spent on eradication attempts.

Wetlands of north and western Greece seem to host large populations of more than 20 individuals each. The widespread distribution of the animal in Greece probably makes an overall eradication plan impracticable. The only realistic option is control and careful monitoring of populations with priority on those that are found in the most valuable areas in biodiversity terms (Bertolino and Genovesi 2007).

Conclusion

Building on the results of a pan-Hellenic survey we have collected valuable information on the distribution of certain vertebrate IAS in Greece. Having a dynamic response is obviously a prerequisite in backing up the robustness of any scientific survey, which in our case wasn't the expected even after 5 years. "Investing" in citizen-based science could be one way to overcome this issue, while training of relevant staff (e.g. in local management bodies), especially in biodiversity rich areas, can be another. For example, the volunteer recording community has made invaluable contributions in understanding invasion biology within Britain (Roy et al. 2015) however; there is also some skepticism about the quality of the data gathered in certain cases (Crall et al. 2010). Finally but most importantly, the way the society perceives invasions depends on multiple factors, e.g. the appearance or "reputation" of the invader, or the visibility of its impacts (Simberloff et al. 2013) and this is the challenge for the scientists, to transfer knowledge in an effective way so as to educate the public and even use it to generate citizen scientists.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Records of the common slider, *Trachemys scripta*, from Greece.

Table S2. Records of American mink, *Neovison vison*, from Greece.

Table S3. Records of coypu, *Myocastor coypus*, from Greece.

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