

Short note

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**Xenodiversity in a hot-spot of herpetological endemism:
first records of *Trachemys scripta*, *Ameiurus melas* and
Carassius auratus in a circum-Sardinian island**

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Introduced species can induce structural and functional changes in diversity. This xenodiversity (from the Greek: ‘strange’) have become a severe threat in aquatic ecosystems and is implicated both in the declines of many native amphibian species and in the change of related biogeographical patterns, especially in the islands (1, 2). The situation may be critical in contexts where endemic taxa are largely diffused, such as in small islands.

Sardinia is known for its notable levels of distinctive herpetological diversity with a large proportion of endemic species (3). In particular, the circum-Sardinian small islands harbour peculiar assemblages of species populations of high conservation concern (4).

During August 2016, I conducted a non-standardized biological survey in the Island of San Pietro (Sulcis archipelago, Province of Carbonia-Iglesias; South-Western Sardinia; Special Area of Conservation: code ITB040027; Fig. 1), a hot-spot for herpetological endemism at a regional level since here five Tyrrhenian species occur: two amphibians: *Discoglossus sardus* Tschudi, 1837 and *Hyla sarda* (De Betta, 1857) and three reptiles, *Euleptes europaea* (Gené, 1839), *Algyroides fitzingeri* (Wiegmann, 1834), *Podarcis tiliguerta* (Gmelin, 1789). In addition, local Sardinian sub-species such as *Chalcides c. vittatus* Leuckart, 1828 and *Podarcis siculus cetti* (Cara, 1871) are present (4). Regarding amphibians, I devoted particular attention to ponds and artificial reservoirs to directly or indirectly detect individuals. On the island, a limited number of irregular/seasonal streams and temporary natural or anthropogenic ponds (e.g., water tanks for agriculture and sheep/cattle grazing) are present, all highly suitable for amphibians. However, excluding the salt marshes of Carloforte, the largest wetland located on this Island is an inland artificial water reservoir in a non-urbanized context along the Northern sector (Nasca lake; coordinates: 39.1666 Lat N, 8.2571 Long E; size area 3 ha). It was built during the first half of 20th Century as a water supply. The shores of the basin are occupied by a continuous *Typha* reed bed. In the surroundings, a Mediterranean maquis with *Erica arborea*, *Pistacia lentiscus*, *Genista ephedroides*, *Juniperus turbinata* and *Arbutus unedo* is present (*Erico-Arbutetum unedonis* and *Oleo lentiscetum-genistetosum* associations), alternating with Mediterranean open prairies (*Thero-Brachipodieta*).

Inside this water reservoir, we recorded an assemblage of alien freshwater vertebrate species (one reptile and two fishes). Using replicated visual observations, a digital camera and a fishing net (to capture individuals for taxonomic diagnosis: 1-mm diameter mesh), I identified individuals of *Trachemys scripta* (Schoepff, 1792) (max number contemporarily observed: $n = 12$; one individual captured: max length: 25 cm), *Ameiurus melas* (Rafinesque, 1820) (max $n = 11$, ranging between 8 and 25 cm; one juv. captured: 8 cm) and *Carassius auratus* (Linnaeus, 1758): > 150 individuals showing different chromatic phenotype and counted using digital images and Photoshop software for Windows ($n = 10$ captured: range: 6–11 cm). The presence of this non-native assemblage is known from the local people and has probably existed at least since the year 2000 (M. Masnada, pers. comm.).

Regarding *Trachemys scripta*, localized evidence in some urbanized areas (Olbia, Oristano, Cagliari) and inland waters (Baratz lake, Flumendosa and Tirso rivers) exists for Sardinia, but not for the circum-Sardinian islands (5: p. 173, 6, 7, 8, 9). The North American *Ameiurus melas*, introduced in Europe for aquaculture in 1871 (10) and, subsequently, into Italian freshwater ecosystems, including on large islands (11, 12), has a high potential to invade new areas and establish viable population (13, 14). From 1960, this species has been locally introduced into Northern Sardinia (15, 16, 17, 18, 19). Finally, *Carassius auratus*, native of Central Asia, China and Japan, is relatively diffused in Sardinian lakes and ponds (18, 19). For all these species, these are the first records from a circum-Sardinian island. The original agent of introduction for these invasive aquatic vertebrates was probably related to ornamental purposes (pet amateurs; M. Masnada, pers. comm.), analogously to other Mediterranean sites (20, 21).

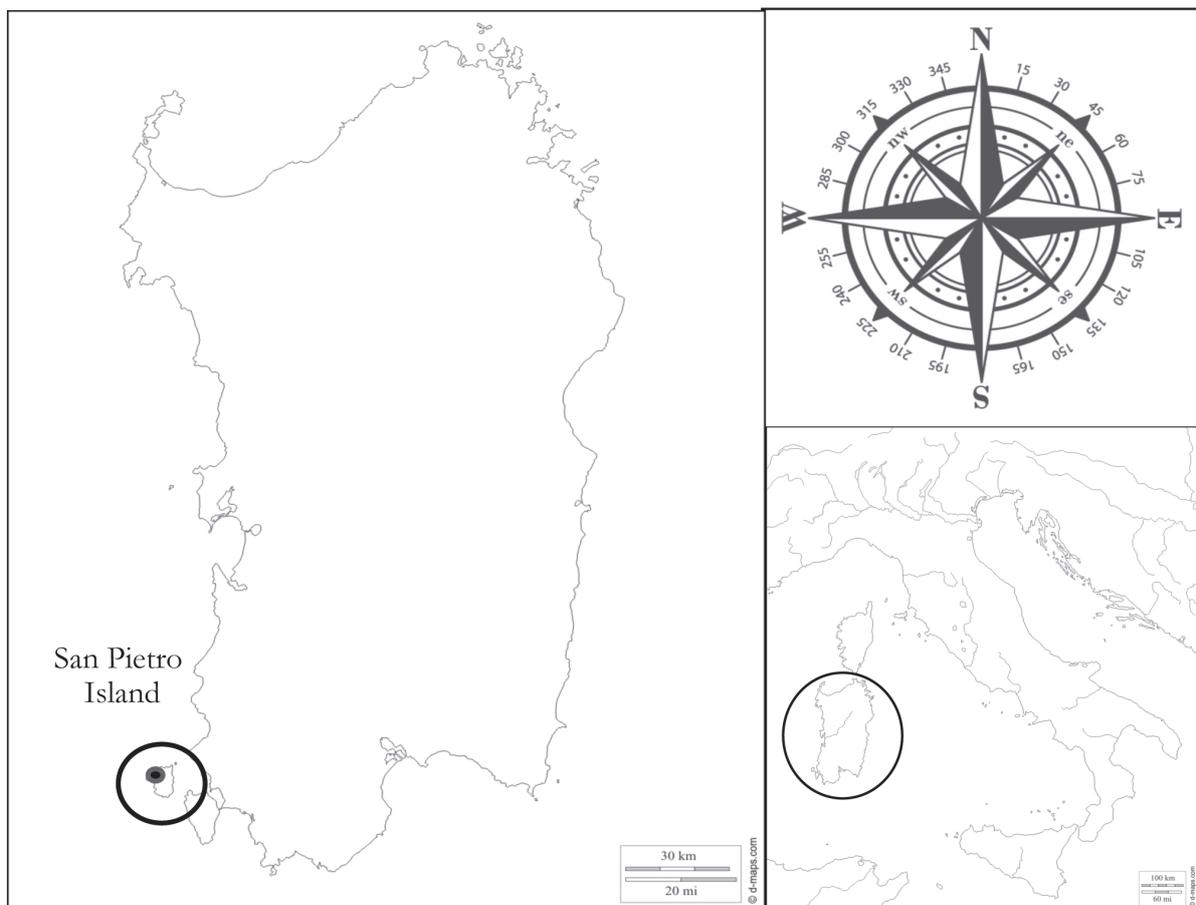


Figure 1 – Map of the study site (right side: Sardinia; left side, in the circle: Island of San Pietro; black point: the Nasca water reservoir).

The introduction of species into an aquatic system has been shown to directly or indirectly impact aquatic fauna with complex effects, apparently depending on density of invaders, macrophyte abundance and community structure of ecosystems (22, 23, 24). In our case, the presence of this alien xeno-assembly may represent a potential threat for the rich endemic herpetofauna (e.g., 4, 25, 26 and pers. obs.), and, particularly, for two species of syntopic amphibians: *Hyla sarda* and *Discoglossus sardus*. Indeed, excluding single records of occurrence (e.g., 26), the distribution at local scale of these two species is unknown but probably it is highly localized.

Trachemys scripta being highly invasive and an active predator (27), has a heavy impact on fish and amphibians species, in particular on those species that lay eggs in shallow waters (28; L. Luiselli, pers. comm.). Moreover *Discoglossus* individuals in larval stages may be predated by the fish (5). In this context, evidence exists regarding a strong regression of this species in Sardinia (4), mainly due to the introduction of non-native fish (29), co-occurring with other causes (e.g., *Chytridiomycosis*: 30). *Carassius auratus* is generally not considered a predator, although field observations have shown a negative direct and indirect impact on some amphibian species (31, 32). For example, survival of eggs and tadpoles might be affected by an increase of water turbidity and a reduction of aquatic vegetation complexity due to the presence of this fish (33, 34). Moreover, this predator may induce abrupt changes in tadpole behaviour and size (35). Finally, *C. auratus* may be a vector for new parasites and diseases (22).

The presence of three alien species (one of them, *Trachemys scripta*, included among the most invasive alien species worldwide; 36), syntopic with two endemic amphibians in a very natural, non-urbanized insular context is cause for concern. In this sense, local governments with territorial jurisdiction (e.g., Public Agency that manage the Special Area of Conservation) should provide conservation measures (sensu 37) in order to maintain the ecological suitability of insular populations of conservation interest. More particularly, (i) species-specific removal projects (e.g., rapid response eradication actions; see 38), and (ii) education actions to prevent pet release in nature, should be developed. Moreover, these measures could be carried out with limited effort given the small size of the area and the relatively low number of people inhabiting the island (about 6,500 inhabitants; 39).



Figure 2 – The lake of Nasca (island of San Pietro, South-Western Sardinia).

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