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A roadmap to an evolutionarily significant conservation strategy for *Cervus corsicanus*

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Abstract

Recent conservation history of *Cervus corsicanus* Erxleben, 1777 is reviewed and future prospects discussed in the framework of increasing knowledge of its evolutionary history. This unique deer is definitively not native to Sardinia and Corsica but owes its survival to a protohistoric assisted colonization by humans. Accordingly, populations in Sardinia (and Corsica) should be managed to maintain maximum genetic diversity while minimizing ecological and economic damages in an unbalanced island ecosystem that must be perceived as "ex situ" from the evolutionary history of the deer. It is increasingly important that steps are taken to reintroduce *Cervus corsicanus* back to the Italian Peninsula.

Key words: Corsican deer, Italian Peninsula, assisted colonization, island unbalanced fauna, anthropochouros taxa

Introduction

Humans have moved wild and domestic animals throughout the Holocene, *de facto* helping some species to cross biogeographical barriers especially to island ecosystems (Martins et al., 2018). Knowledge of such processes is essential to direct conservation of island biodiversity – particularly for true fragile endemic elements, not populations that have been introduced by humans (Clavero et al., 2016). It is however possible that introduced populations, especially those taxonomically distinguished due to unique morphological characters – so-called anthropochorous taxa (Gippoliti and Amori, 2002) – deserve the interest of conservation biologists for their intrinsic biological value. A classic example is the dingo in Australia, certainly anciently introduced by aborigines but now possibly a crucial branch for understanding *Canis* Linnaeus diversity and evolution in the Old World (Crowther et al., 2014). Another Australian example is constituted by its introduced mammal populations onto off-shore islands that are considered important conservation resources as predator-free heavens for native species (Legge et al., 2018).

In the Mediterranean Region there is an increasing emphasis on the control of introduced species for the benefit of native species (Ruffino et al., 2009). Yet, in some cases, conservation policies face a paradox, posted by the conservation value of mammal taxa that have been introduced by humans in ancient times (Gippoliti and Amori, 2004).

The Corsican (or Tyrrhenian) red deer *Cervus corsicanus* (Fig. 1) is not listed by IUCN (Lovari et al., 2018) although it was previously considered as an endangered taxon (IUCN, 1990). It is currently considered as LC in the Italian IUCN Red List as *Cervus elaphus corsicanus* (Rondinini et al., 2013) and it is fully protected by the Habitat Directive (D'Antoni et al., 2003). The taxon was originally found on both Corsica and Sardinia; it disappeared from Corsica around 1970 but was later reintroduced from Sardinia in 1985 (Kidjo et al., 2007). Since 2015 an EU Life project ('One Deer Two Islands') is supporting the conservation of the Corsican deer on the two islands.

Subsequently, both population size and geographical distribution have increased due to this conservation initiative. In Sardinia, the current population is

nowadays estimated to number approximately 10,500 (Murgia, 2018). It is now well-established through zooarchaeology research that no paleoendemic land mammal species survived on the Sardo-Corso system (Vigne, 1992).

The Middle Pleistocene/Holocene *Microtus* (*Tyrrhenicola*) "faunal complex" in Sardinia includes also true endemic deer assigned to the genus *Megaloceros* Brookes, of which a new species has been recently described (Van der Made and Palombo, 2006), but none survives today (Alcover et al., 1999). *Cervus corsicanus* is only known from Tyrrhenian islands' fossil records since ca. 5000 (Sardinia) and ca 2000 (Corsica) years ago, suggesting human introduction as the only plausible agent of dispersal (Dean et al., 2017).

The Corsican red deer is not only the smallest member of the *Cervus elaphus* complex, but also one of the most threatened cervids in the world (Hajji et al., 2008), although the IUCN Red List of Threatened Species does not list subspecies of *Cervus elaphus* separately. This ambiguous taxonomy is a general problem that can be detrimental to efforts on behalf of particular subspecies (Thakur et al., 2018).

The aims of the present paper are twofold: to discuss the future management of this unique lineage on Sardinia and to prospect its reintroduction to peninsular Italy. More generally, we highlight the need to put conservation actions by the European Union in an evolutionary and biogeographic perspective (Gippoliti et al., 2017).

Cervus corsicanus

The main characteristics of *Cervus corsicanus* from Sardinia are - a smaller size, with a shoulder height of 75–90 cm for females (Cetti, 1774; Miller, 1912; Von den Driesch and Boessneck, 1974), and 80–110 cm for males (Vigne, 1988); a stockier morphology with notably shorter legs (Cetti, 1774); the average total body length is 175–185 cm for males and 160 cm for females; the adult weight is 105–120 Kg for males and 70–80 Kg for females (Beccu, 1989); antlers are smaller than in *Cervus elaphus* (average antler lengths for fully developed stags are about 65 cm, weight about 550 g and typically only 3 tines are present (Mattioli, 2003), although larger stags are known with up to 12 tines, antler lengths to 77 cm and weight to 1.1 Kg (Beccu, 1989); bez tine and crown tine are extremely rare (Joleaud, 1913, 1925; Vigne, 1988; Mattioli, 2003); and a darker coat characterizes the species, especially during winter (Fitzinger, 1874; Lydekker, 1898; Miller, 1912).

It should be noted that while molecular data assign the North African taxon *Cervus barbarus* Bennett to the same lineage as *C. corsicanus*, morphologically the African deer are a little larger and paler than their island relative (Lydekker, 1898; Dolan, 1988) (Table 1).

Figure 1: Male *Cervus corsicanus* from "Crocorigas" Montevecchio, Guspini (SU), Sardinia. Photo by Antonello Cocco Lampis.

Table 1: Major physical and genetic differences between four taxa of *Cervus elaphus* complex from the Western Mediterranean Region (expanded from Zachos et al., 2014).

		Taxa			
		C. corsicanus	*C. c. barbarus*	*C. elaphus italicus*	*C. e. hispanicus*
Genetics	Genetic lineage	Sardinian/African lineage B	Sardinian/African lineage B	Intermediate between western and eastern lineages A and C	A-haplotype group
Morphology	Summer coat	Dark reddish brown	Dark brown with some white spots on its flanks and back.	Reddish brown with yellowish spots	A light yellow Brown or buckskin color (Geist, 1998)
	Height at withers	Proportionally low	Proportionally low	Proportionally low	-
	Antler crown	Rare, three-pointed and cup-like, sometimes with a small palmation	Typical cup-shaped crown with two or more branching	Rare, three-pointed, cup-like orfan-like	Some large stags sport *angulatus*-type antlers. This antler form, when present, identifies at once the Spanish subspecies of red deer (Geist, 1998)
Vocalization fundamental frequency		40 Hz (Frey et al. 2012)	Not available	79 Hz (Della Libera et al. 2015)	186 Hz (Frey et al., 2012)

The Corsican deer was listed by the European Community among 50 species of Italian mammals with a priority conservation interest (Caboni et al., 2016). In the 1950s and 60s, this subspecies was on the verge of extinction: around 200 animals were thought to remain in Sardinia (in three disjunct ranges; Jenkins, 1972) while the species became finally extinct in 1972 on Corsica. This decline was due to the fragmentation of the population, which was caused by habitat loss (from deforestation and fires), hunting, and poaching (Kidjo et al., 2007; Caboni et al., 2016).

In Sardinia, the deer population has increased significantly due to one of the most important conservation campaigns carried out in Italy by the Forestry Agency of Sardinia (EFS) and the Italian branch of the World Wildlife Fund (WWF). In 2015 it was estimated to number over 8000 and, in 2018, between 10,000 and 11,000 in Sardinia. In Corsica, three translocations of deer from Sardinia have been performed since 1985. Since 1998, 13 releases of deer from enclosures have been carried out by the staff of the Regional Natural Park of Corsica (Parcu Corsica), totaling 260 deer into 5 different areas (Caboni et al., 2016).

The island's Mediterranean fauna has received considerable scientific attention especially after the publication of Darwin's "On the Origin of Species" (Darwin, 1859). The Corsican deer was originally described as an endemic species, as was customary for the whole 19th century. However, over the 20th century it was generally considered a subspecies of a polytypic *Cervus elaphus* (Dolan, 1988; Geist, 1998). Paleontological research showed the striking former richness of the Mediterranean islands, including Sardinia and Corsica, but that no member of the genus *Cervus* Linnaeus was included in its paleofauna. The Corsican deer has since been regarded as an introduced species and is thought to have been present on the islands since the beginning of the Neolithic culture some 8,000 years ago (Vigne, 1992; Zachos and Hartl, 2006). Yet, in a recent taxonomic revision, Groves and Grubb (2011) recognized *Cervus corsicanus* (with *C. barbarus*, the North African race, as a synonym) as a distinct species, a move followed by Gippoliti (2013).

Doan et al. (2017), through a mtDNA study of subfossil material, established that *C. corsicanus* was the original red deer taxon of the Italian Peninsula (south of the Po Valley and the Northern Apennines), and thus the North African, Corsican and Sardinian populations were likely products of historical anthropogenic activity. With the aDNA data presented by these authors, the African-Sardinian lineage could now be placed phylogeographically in the context of the Late Pleistocene and Holocene distribution history of the red deer. Doan et al. (2017) revealed that *C. corsicanus* is the refugial lineage of the Italian Peninsula, which is known to have harbored red deer during the Last Glacial Maximum. However, this study showed that there were two genetically distinct autochthonous populations of red deer in mainland Italy: one inhabiting the northern region and the second occurring in the central and perhaps southern Italian Peninsula, as hypothesized by morphometric studies of Holocene red deer remains (Di Stefano et al., 2015).

These data do not explain the differences known to exist between the deer of Sardinia and those of North Africa (*C. barbarus*). On the other hand, the study of mtDNA needs to be extended to South Italy and Sicily. It is here that small-sized *C. elaphus* deer have been reported during the late Pleistocene (Di Stefano et al., 2015), and a distinct taxon has been described from Sicily, *Cervus elaphus siciliae* Pohlig (Gliozzi et al., 1993). Although cervids may change body size rapidly as a response to insularity (Lister, 1989), ancient deer figures in Sardinian art let us believe

that current physical characters were already evident during the Bronze Age (Carenti, 2012).

Red deer disappeared as a wild species in Peninsular Italy around the XVII-XVIII Century, surviving only in fenced reserves. Yet larger *C. elaphus* from abroad, and even Wapiti *Cervus canadensis* Erxleben, were imported for enhancing the size of trophies (Comba, 1872; Ghigi, 1911). Further, there is evidence that the various taxa treated as subspecies of *Cervus elaphus* maintained their distinctiveness from around 50,000 years despite migrations and limited hybridization (Meiri et al., 2018).

After all, the Corsican deer was not a small-sized island endemic, but another Mediterranean adapted lineage unique to the Italian Peninsula (Gippoliti and Groves, 2018). A comparative morphological study between late Holocene *C. corsicanus* from the peninsula (and Sicily) vs. modern populations on Sardinia is badly needed but is made difficult by the scarcity of Italian specimens.

However, comparison with *C. barbarus* from North Africa and reference to the ancient iconography of red deer in Sardinia - that always shows poorly developed horns typical of the taxon - is partially supporting our argument that no significant insular dwarfism occurred in the 5000 years of presence of *C. corsicanus* on Sardinia and Corsica. The potential importance of the Tyrrhenian red deer has been somewhat anticipated by Gippoliti and Amori (2006) while discussing the conservation value of anciently introduced island populations of mammals. "Their conservation value is therefore low compared with native taxa, unless they are the only descendants of now extinct continental populations (Gippoliti and Amori, 2002).

This may be the case for the *Cervus elaphus* of North Africa and Sardinia, forming a distinct clade in a phylogenetic tree based on analysis of variation in cytochrome *b* (Pitra et al., 2004). Further studies may possibly elucidate the exact geographical origin of this clade, helping to generate a meaningful conservation strategy beyond the present human-mediated distribution" (Gippoliti and Amori, 2006: 42–43).

So far, it seems that no steps have been made in the direction indicated by these authors, and conservation has been confined to the two islands, as if this deer was native to the Sardo-Corso system. However while these efforts have highlighted the growth of populations on the two islands, no upper limit on the population size has been apparently established (http://www.onedeertwoislands.eu). This is cause for concern, as both Sardinia and Corsica have no natural predators of the deer, and on Sardinia, the species is fully protected, with no hunting allowed at the moment. The increased number of deer is cause for concern by some in the agricultural sectors that are damaged by wild ungulates (http://www.onedeertwoislands.eu).

Sustainability is based on fundamental principles which should be developed in harmony: environmental, economic and social improvement. Over-abundant ungulates, even native species, can often create serious problems for native vegetation, as has been reported for other islands where native predators were extirpated; for example in Japan (Takatsuki, 2009). *Cervus corsicanus* is no exception, as it seems to affect forest structure in enclosed areas (Maillard et al., 1995), although studies of free-ranging deer is lacking.

Establishment of a management strategy for the Sardinian red deer, in the long-term, is anticipated as a major cause of concern. Currently, hunting is not allowed because there is strong public opposition to its use as a control strategy (cf. Perco, 2020). It is therefore a high priority that education programs fully acknowledge the uniqueness of insular ecosystems and the true evolutionary history of *Cervus corsicanus*, including the last phases of human-mediated dispersion.

A new perspective in Sardinia

While the numerical increase of *Cervus corsicanus* is certainly a positive step, the species is not native to Sardinia (and Corsica). Therefore, a management plan that pays attention to the artificial and unbalanced status of the Sardinian mammal fauna, and hence to the necessity that this artificial population is managed to maintain levels that are sustainable without disrupting ecological and social conflicts, is urgently needed. Considering the huge number of Sardinian endemic plant species (186), which make Sardinia a biodiversity sub-hotspot in the Mediterranean hotspot (Fois et al., 2018), a cautious approach requires that endemic plant species and communities are monitored to prevent overgrazing by both feral and wild herbivores (Pisanu et al., 2012).

Eventually, a system of quotas can then be established for trophy hunting of a few males, an activity that is widely used in some European countries (such as Spain). The subsequent financial gains can be used for the management of the local protected areas. Hunting is another hopeful approach as hunting regulations often direct the harvest to particular sex/age categories, depending on the harvest or population goals (Kokko, 2001).

Managers either seek to harvest enough animals to prevent some type of habitat or health degradation (such as allowing forest regeneration or decreasing the risk of epizootics), or to avoid overharvesting and thereby maintain the ability to harvest the population in the future or to increase long-term yield (Caughley and Sinclair, 1994). This type of practice aimed at the sustainable removal of different classes of the population would allow a sustainable use of the "deer population" resource, present opportunity for economic

benefits through the establishment of a meat supply chain, and furthermore, help to reduce damage to agriculture.

And in Peninsular Italy

The survival of this small red deer lineage is actually due to a unique case of protohistoric "assisted colonization" of Corsica, Sardinia and North Africa. Sardinia's unique role in the conservation of this taxon must be recognized as "ex situ" conservation. In contemporary conservation practice, a parallel may be found in healthy populations of Africa's Saharan ungulates which are maintained on private ranches in Texas. They constitute unique precious resources for the conservation of 'Extinct in the Wild' taxa such as *Oryx dammah* (Wildt et al., 2019).

As such, every effort must be made to pursue the reintroduction of *Cervus corsicanus* to mainland peninsular Italy, and particularly to southern Italy. The Po Basin population of the Mesola red deer *Cervus elaphus italicus* (Zachos et al., 2014), apparently the only *Cervus elaphus* really native to the Italian Peninsula, seems clearly separated phylogenetically from the ancient peninsular red deer (Zachos et al., 2014; Doan et al., 2017).

Therefore, *C. italicus* is obviously unsuitable as a source of deer for reintroduction to Central and Southern Italy. Of course, the reintroduction of red deer from Germany (or from the North Central Apennines that originated from foreign stocks) is also contraindicated if we wish to maintain the original diversity (Queirós et al., 2020).

The first step should be the creation of breeding herds of *Cervus corsicanus* in semi-captive situations, such as those of the fenced Castelporziano Reserve and the Circeo National Park. The opportunity to create small populations in zoos should also be considered, with the main goal to increase local and European awareness of the conservation problems and history of this taxon (cf. Robovský et al., 2020). While the northern-central Apennine population of allochthonous *Cervus elaphus* seems to be too well-established to be removed now, all ongoing projects in Southern Italy (Calabria, Lucania) need to be stopped immediately and the small free-ranging populations removed (Fig. 2).

In the case of a successful first step, the next one should be the identification of one or two protected areas in Southern Italy and Sicily where the reintroduction of *Cervus corsicanus* could be attempted. This vision could create a project capable of integrating the preservation of a unique Mediterranean mammal lineage with the restoration of local ecological integrity.

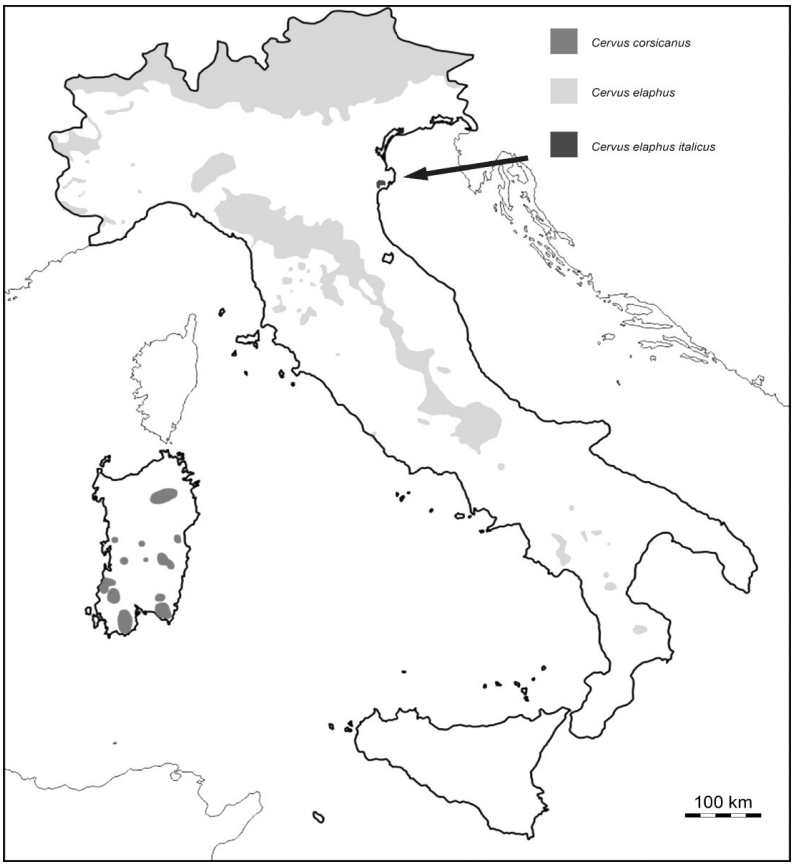

Figure 2: Distribution of members of genus *Cervus* in Italy (modified from Varuzza, 2019).

Conclusions

Despite continuing calls to integrate evolutionary aspects into conservation policies, there is ample space for improvements on this issue. The islands of Corsica and Sardinia furnished a refuge for an otherwise doomed continental population, but caution is needed to prevent this rescued population from causing problems with truly native species; including endemic plant species and communities that may suffer overgrazing. In addition, every reasonable effort should be made to repatriate taxa to their native range so that evolutionary trajectories can be fully reactivated. In the present case-study, while more research is needed to understand some phenotypic differences between the North African and Corso-Sardinian *Cervus* populations, the point remains that *Cervus corsicanus* conservation should be refocused on its true native continental range.

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