

## ERADICATION OF GOATS AND OTHER FERAL HERBIVORES

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### 1. Introduction

Isolation among populations, species, and higher taxa has been a main factor in promoting the evolution of the diversity of life. Humans have been an important dispersal vector of animals and plants. Migrations of human populations in prehistoric and recent times resulted in the introduction of many species outside their former range. Some species were deliberately introduced, others were accidentally transported to new territories, yet other species were cultivated plants or domesticated animals that escaped human control and became feral. In recent times, these introductions have been considered to be ecological invasions and regarded with great concern. Invasive species are now considered to be among the main causes of loss of biodiversity throughout the world; therefore the Convention on Biological Diversity calls on parties to the convention to "prevent the introduction of, control, or eradicate those alien species which threaten ecosystems, habitats, or species" (Article 8h).

Islands ecosystems are most vulnerable to different kinds of biotic invasion; they host a high proportion of endemic species, which are particularly vulnerable to the introduction of exotic species. Around 90% of bird extinction since 1600 has happened on islands and in 30% of cases the introduction of alien species was the cause.

Many mammalian herbivores have been introduced outside their spontaneous (prehuman) range, become invasive, and invaded natural and seminatural ecosystems, where they interfere with natural processes and damage natural communities. Not all alien herbivore species are to be considered as pests: some are beneficial to humans, as livestock and producers of raw materials for industries. Others seem to be neither harmful nor beneficial. In a few cases, alien herbivores proved to be compatible with the maintenance of natural processes where the ancestral species have disappeared because of human interference. Therefore, before deciding about the best management option to put into practice, a careful examination of pros and cons of the matter should be carried out.

## **2. Negative Aspects of Alien Herbivore Presence**

### **2.1. Damage to Natural and Seminatural Ecosystems**

The presence of a significant biomass of introduced herbivores is mostly detrimental to natural vegetation. The coevolutionary processes between plants and animals which feed on plants is a very slow process and produces reciprocal adaptations; this results in an equilibrium between producers and primary consumers allowing the maintenance of viable populations and communities of both groups of organisms. If a new herbivore species is suddenly introduced into a habitat, plant species could lack adaptations to resist grazing or browsing by the newcomer. The original vegetation structure is damaged and a new equilibrium may be reached; a few plants, which are resistant to browsing, become dominant. Alien plants are frequently more successful in adapting to the new conditions and overwhelm the indigenous species, as is the case of the exotic tree *Ailanthus altissima* on the Island of Montecristo in Italy, where goats reach high density and mostly feed on plants of the Mediterranean maquis. In many cases, no new equilibrium is reached and plants are heavily damaged, soil erosion takes place, and their effects are irreversible. If overgrazing is widespread and is not eliminated within the lifespan of a localized plant, extinction of the latter is the consequence. In New Caledonia, a Pacific island, the endemic tree *Pittosporum tanianum* became extinct because of the action on seedlings by introduced red deer and rabbits.

### **2.2. Competition with Autochthonous Species**

Competition can take the form of interference, when one species directly damages the others, or exploitation competition, when one species consumes resources that are necessary to the other species. Feral goats and donkeys on Isabela Island, one of the Galapagos archipelago, damage the native fauna with both mechanisms. They (a) trample the nests of tortoise and the burrows of land iguanas, (b) consume the same plant which would be eaten by tortoises and iguanas, and (c) reduce vegetation cover. This latter process has important effects on the thermoregulation of large tortoises and on sex ratio of tortoise eggs, which is temperature dependent.

### 2.3. Storage of Pathogenic Organisms

Feral rabbit populations have periodic outbreaks of myxomatosis, which can be transmitted to domestic populations. Feral populations of some ungulates may be bearers of pathogens to which the feral populations have developed immunity but that can be transmitted to the domestic population.

Since Neolithic times, the artificial diffusion of new, human-protected species became a threat to the endemic herbivores, and these may well have been the cause of extinction of native mammals. Support for this view can be seen on the Balearic Islands, for example, where it seems that domestic sheep and goats did not arrive until around the second millennium BC, and this coincided with the extermination of the endemic caprine, *Myotragus balearicus* Bate, 1909. This could have happened from a disease to which the *Myotragus* had no immunity, such as foot-and-mouth disease (caused by pathoviruses) or anthrax (*Bacillus anthracis*), which was carried by domestic livestock.

## 3. Positive Aspects of Alien Herbivore Presence

### 3.1. Historical Aspects

It is becoming ever more evident that humans have played an active role in the dispersal of many mammals during the last 12 000–10 000 years in many parts of the world, and no other places have been so heavily affected for such a long period by human activities as the Mediterranean region. Although biological invasions affected continental areas too, it is only on islands that the fossil and/or subfossil record offers unmistakable evidence of anthropogenic introductions. Different opinions exist in the conservation community concerning the treatment of exotic, human-introduced taxa, rooted in different and sometimes conflicting conservation philosophy views. This problem is particularly acute when artificial introductions are very ancient and not historically documented, as in the case of Mediterranean islands, where the Pleistocene mammalian fauna has been almost totally replaced. There is now evidence that in early Neolithic times humans acquired the capability of seafaring and that we were also able of bringing with us the animals we needed as economic supplies for the colonization of the new geographical areas. Herbivore species introduced onto Mediterranean islands include those imported voluntarily by humans, such as sheep, goats, deer, cattle, hares, rabbits, and dormice, and those synanthropic with man, such as several kinds of small rodents. The descendants of several of these old introduced populations still survive on the Mediterranean islands, such as the mouflon (*Ovis orientalis*) Gmelin, 1774, of Corsica, Sardinia, and Cyprus, and the wild goats (*Capra aegagrus*) Erxleben, 1777, of Crete and several Tyrrhenian and Aegean islands. These ungulates, introduced not really in a domestic state but after having only experienced some cultural control by man, returned to the wildlife in the new territories of introduction, maintaining the morphology and the biology of their wild continental counterparts. These old introduced populations may be regarded as important, not only for the value they represent as cultural heritage elements, almost at the same level as an ancient painting or another kind of craft object, but also for the ecological role they have played in highly modified habitats since very ancient times. Furthermore, the importance of the existence in these populations of peculiar genetic combinations or traits that reveal them as unique among the extant

representatives of their taxa should not be neglected, also in view of the very ancient chronology of the constitution of their breeding stocks. After the extinction, for example, of the fallow deer (*Dama dama*) (L., 1758), of Sardinia in the late 1960s, the fallow deer that still occur on the island of Rhodes (Dodecanese, Greece) may represent the only insular population of ancient anthropochorous origin that still survives in the Mediterranean. It is usually reported that the fallow deer was introduced from Asia Minor by the Knights of Saint John of Jerusalem, who conquered Rhodes at the beginning of the fourteenth century. However, the finding of osteological remains of the species among the Neolithic insular contexts possibly suggests that this importation occurred much earlier, around the sixth millennium BC. A recent genetic survey shows a kind of variability within the Rhodian deer that is absent from other European populations, which are characterized by a very low—if any—genetic variability, suggesting that the population of the Rhodes deer differs to a certain extent from the European and Turkish fallow deer. Another example of this is given by the imported hares that are still dispersed on several of the Aegean and circum-Cretan islets. The future survival of these populations will depend on continuing and rigorous protection. In the light of this, a feasibility study of the introduction of these herbivores into other protected areas of the Eastern Mediterranean region would be advisable with the aim of continuing their study and intensifying their protection.

### **3.2. Feral Populations Originated from Domestic Animals**

Feral populations are those that originated from domestic animals belonging to local or mixed breeds that gained freedom in past times. These alien species may have also differed in their degree of domesticity at the time they were first introduced, having experienced different levels of cultural control, being at the first steps of domestication or completely domesticated. In time, they may have been introduced more than once, using different source populations. In some cases, they may represent the only survivors of populations otherwise extinct.

Some feral populations have characteristics that could make them desirable for conservation. These characters are summarized as follows.

- Feral populations might be of great naturalistic value if they coevolved with insular biota during centuries or millennia and are unique as a source of biodiversity at the species level.
- Feral populations may have relict characteristics or genetic variants that either are absent in modern breeds or exist only in rare or minor breeds of livestock and may be of present or future commercial or scientific value not found in modern livestock.
- Feral populations may be of great historical or aesthetic value. The Soay sheep of the Islands of Hirta and St. Kilda, in Scotland, has the characteristics of unimproved primitive sheep, possibly introduced by Vikings. Albino donkeys inhabiting the Island of Asinara National Park, in Northern Sardinia, Italy, are the symbol of the island and a main touristic attraction.
- Feral species may be of important scientific value if the ancestral species are extinct in the wild. Only feral populations maintain the remaining characteristics of the species and may be studied for ethological, ecological, and phylogenetic purposes. This is the case of the horse, the cow, and the one-humped camel, whose wild

ancestors no longer exist, and of the donkey and the two-humped camel, which are almost extinct in the wild.

- Feral populations may have novel or rare characteristics or adaptations to extreme environmental conditions such as temperature stress, drought, high parasite load, or other characters of commercial or scientific value.

These features might be even more extreme than in some rare local breeds, because feral populations are frequently confined to marginal land. An example is given by feral sheep living on Santa Cruz Island, California, USA, which originated from domestic animals of various breeds that have been wild for at least 70 years. There is, in fact, a category of domestic animals that are in a permanent condition of unstable equilibrium between the domestic condition and the wild state, representing a relic of a very ancient breed still used in several economically marginal areas of the world. One may, for example, not overestimate the importance of the islands inhabited by free-ranging populations of herbivores, which represented living depositories of animal proteins available at any time along the marine routes of antiquity since prehistorical periods. Indeed, some of the species, such as the rabbit and the goat, most adaptable to peculiar environmental conditions even of small islands, were brought by sailors and let loose on islands so that they could breed and provide a store of fresh meat that would be readily available for the passengers of ships. For centuries, these islands were better known for their richness in certain animals, more useful as a source for meat than for their faunal repertoire in general. This is reflected even in the names of several Mediterranean islands, especially some of the smaller ones, such as Conejera, Isola dei Conigli, Levrera, Cabrera, Caprara, Caprera, Capraia, Capri, Egadi Islands, and Polyaeigos.

Feral populations may be ecologically important if they substitute for the action of wild species that have been locally eliminated by humans in prehistorical, historical, or recent times and if they exert the same effects on vegetation. One of the main arguments of people battling to preserve feral horse populations in North America is that the same function of the "mustangs" was exerted by a true wild horse, belonging to the same genus, *Equus*, which roamed free in grassy plains until eight thousands years ago and were wiped out by the first humans who colonized the continent. However, this "overkill" hypothesis is not accepted by all paleontologists; some of them propose that climatic changes were responsible for the disappearance of true American autochthonous horses. Feral animals may also be the main prey of another alien species which, in the absence of the former one, would prey on autochthonous and vulnerable species.

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## Biographical Sketches

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