

Review

When Domestic Goats Go Wild. Effects of Feral Goats on Ecosystems and Management Strategies

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Simple Summary

Despite the fact that the feral goat, *Capra hircus*, has been studied and is globally distributed, there are still many unknown biological and ecological aspects, as well as a lack of knowledge of its distribution, resulting in a challenge to manage populations. The aim of this study was to review the current global knowledge of the feral goat, identify its gaps and provide insights into possible future research. The information is particularly encompassed in terms of population distribution, habitat use, monitoring methods, potential environmental impacts and management strategies. However, their role as a food supply for endangered fauna taxa is not sufficiently understood. Further scientific investigation regarding the role played by the feral goat is advised. The insights obtained from deeper research could benefit management and conservation decision-making.

Abstract

The feral goat, *Capra hircus*, is an important example of the feralisation of a domesticated species. The intentional abandonment of herds, escapes, rural depopulation and abandonment of livestock and traditional agriculture have led original domestic goats to freely occupy different habitats. The aim of this study was to review the current global knowledge of the feral goat, identify its gaps and provide insights into possible future research. The majority of publications focus on islands in the Mediterranean Basin and Oceania. The information is particularly encompassed in terms of population distribution, habitat use, monitoring methods, potential environmental impacts and management strategies. The feral goat is considered one of the 100 worst invasive species, especially on islands; thus, there are abundant studies supporting their eradication fundamentally due to their negative impact on vegetation. However, their role as a food supply for endangered fauna taxa is not sufficiently understood. Oceania is the main advocate for feral goat eradication, along with meat production exploitation. The most widespread management approach is eradication, notably favoured in insular ecosystems. There is still a lack of updated numerical data available on the efficacy of eradication interventions. The insights obtained from deeper research could benefit management and conservation decision-making.



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1. Introduction

The origin of domestic goats remains uncertain and controversial. However, archaeological evidence indicates that the goat was one of the first animals to be domesticated 10,000 years ago during the Neolithic period in the Fertile Crescent [1,2], or even 11,000 years ago [3].

There seems to be a broad consensus among researchers [4] to consider domestic goats as descendants of the wild goat or bezoar, *Capra aegagrus*, although some introgression events with other wild goats were also possible [3]. The wild goat was described from Dagestan in the north-eastern Caucasus (Russia), harbouring the typical subspecies *Capra aegagrus aegagrus* Erxleben, 1777 [5]. Some authors, following the initial rules of the International Commission for Zoological Nomenclature (ICZN), used the name *Capra hircus* for both wild and domestic goats [5]. Later, other authors, inspired by the correction of the ICZN (2003) [6], kept the name *Capra aegagrus hircus* for the domestic goat and *Capra aegagrus aegagrus* for the wild one. In practice, most authors opt to use the names *Capra hircus* and *C. aegagrus* for domestic and wild goats, respectively [6].

The domestic goat has played a crucial role in the Neolithic agricultural revolution and in the expansion of human civilisations around the world [1]. Today, the goat is an essential livestock species worldwide, fulfilling agricultural, economic, cultural, and even religious roles [2]. An important aspect of domestic goats' biology worldwide is their capability to become wild, a phenomenon called feralisation. This process is due to the abandonment or escape of these animals, which constitute populations that are not under human control.

There are two main approaches when it comes to studying feral goats: (1) environmental impact, especially focused on islands, which is prominent in the Mediterranean Basin; and (2) population control, which is mainly promoted in Oceania. The article addresses these two approaches.

Although the feral goat has been studied worldwide, some aspects of its biology remain poorly understood. This makes it difficult to manage or conserve populations [7]. For this reason, the development of this work is beneficial, as it compiles current knowledge on feral domestic goats and identifies areas for improvement and further research.

The objective of this study is to complete a synthesis based on scientific literature reviews regarding the current global knowledge about the feral goat, identifying the ongoing gaps and providing insight into possible lines of research that support the importance of understanding the role that feral goats play in ecosystems.

2. Materials and Methods

To assess the knowledge of feral goat populations, a thorough bibliographic narrative compilation of scientific and technical literature (scientific articles, technical reports, books, official websites, etc.) has been carried out, using suitable search engines and an appropriate strategy to obtain reliable, high-quality and updated sources of information using Boolean operators.

Exclusion criteria were based on the inclusion of some preliminary research in later publications, which included the previous results to avoid redundancy. References were excluded based on several criteria to ensure the relevance and rigor of the review: preliminary studies were omitted when their findings were already integrated into later, more comprehensive publications to avoid redundancy; additional exclusions were made from

sources lacking thematic relevance. Duplicated entries across databases were also removed to maintain clarity and coherence.

The search engines used were Web of Science, Google Scholar, Science Direct, and Dialnet. The bibliographic repository ResearchGate was also visited. In addition, specific bibliography was provided by experts. The searches were based on the following terms: ungulate, bezoar goat, *Capra hircus*, *Capra aegagrus*, Mediterranean goats, islands, Australia/Oceania, eradication, impact, conservation, management and diseases. Once the first terms (ungulate, bezoar, goat, *Capra hircus*, *Capra aegagrus*) gave the first results, two main areas with information on feral goats appeared: The Mediterranean and Oceania. For this reason, these two terms were added to the search to increase results. The languages used were English and Spanish. Sources of information covered the period from 1966 to 2022.

3. Results

The number of publications reviewed for the elaboration of this article was 224, and the number of publications cited was 98, avoiding redundancies and focusing on the most relevant. Of those reviewed, the most frequent aspect studied was management strategies (58, 26%), followed by pathology (32, 14.2%), island focus (27, 12.0%), behaviour (20, 8.9%), historical background (17, 7.5%), diet (17, 7.5%) and reproduction (15, 6.6%). The scarcest ones are technical reports (8, 3.5%), ecological impacts (8, 3.5%) and hybridisation (7, 3.1%).

The preliminary topics allowed the creation of new subsections adapted to the current knowledge on feral goats.

The subsections were structured based on thematic patterns identified during the literature review, with the aim of organizing the content into coherent categories aligned with the current state of knowledge. While the manuscript highlights the most frequently studied aspects across the reviewed publications, the subsections were not designed to mirror those frequencies directly, but rather to provide a logical and comprehensive framework for discussing the ecological, demographic, and management-related dimensions of feral goat populations.

It should be borne in mind that there are publications holding a large variety of information and thus cannot be placed into a single category. As an example, the study of impacts on the ecosystem (4.1%) is closely linked to management strategies (29.9%). Both issues are predominantly studied on islands (13.9%). Articles on hybridisation are relatively recent, with the latest studies concentrated since 2018.

3.1. Distribution

The feral goat is an important example of the feralisation of a domesticated species. The intentional abandonment of herds, escapes, rural depopulation and abandonment of livestock and traditional agriculture has led domestic goats to occupy different habitats. Their integration into the environment and feralisation was facilitated by the lack of predators and competitors, thus favouring the increase of feral goat populations [4,8–11]. With regard to feral goats inhabiting islands, populations are considered, in many cases, ancient feral breeds derived from domestic goats introduced as a food source [4], generally by European sailors [12]. This occurred in the Mediterranean islands after the end of the 9th millennium BCE, currently existing on five islands—Crete, Youra, Antimilos, Majorca and Montecristo [4]. As for the Eastern Atlantic islands, goats were introduced between 1000 and 2000 BCE in the Canary Islands (Spain) [9], before 1481 in the Madeira Archipelago (Portugal) [7] and in 1513 into the Island of Saint Helena (UK) [13]. During the early 16th century, domestic individuals were introduced into several Pacific Islands [12], the West Indies [14] and into the Caribbean dry forests of Mona Island (Puerto Rico) [15], reaching the tropical dry landscape of the Hawaiian Archipelago in 1778 [13] in the 18th century [12].

In the 19th century, feral goats reached Guadalupe Island (Mexico) [16]. By 1959, goats had reached the Galapagos Islands (Ecuador) [17].

In Continental Europe, feral goats originated from rural abandonment as a result of human migration to major industrial centres [8,18,19]. During the 1960s in Spain, this occurred in Galicia [18] and in Aragon [10]. Studies confirm that nowadays in Aragon, populations are stable from a distribution perspective [20–22]. In the region of Piedmont (Italy), this transition took place in the 1990s [19].

In Oceania, goats were introduced by European settlement [23] in 1773 into New Zealand [13] and in 1788 into Australia [24]. In Australia, feral goats are found in all states, on the mainland and on offshore islands, although high densities occur in the highlands of the Great Dividing Range [23]. In New Zealand, feral goats inhabit 11% of the territory, mainly occupying land reserved for the conservation of the indigenous biota [25].

Despite the fact that the feral goat is widely distributed, there is still a lack of global distribution maps [4]; however, local maps are available [11,20].

3.2. Habitat Use and Diet Selection

Feral goats are the most adaptable and geographically widespread feral livestock species [2]. Rocky areas and pasture-scrub lands are their preferred habitats, where safety and isolation are highly guaranteed. Habitat selection is influenced by shelter and water availability, as well as the abundance of preferred food species [26–29].

They are versatile herbivores, able to process a higher number of plant species than other livestock [30]. They are also capable of surviving by eating grasses, forbs, browse, and even marine algae [31]. They avoid plants with high levels of bitter oils or poisonous compounds [13,32–35], although they can also show some tolerance to toxic plants such as *Hedera*, *Taxus* or *Cirsium vulgare* [27,36]. In tropical latitudes, the fungus *Auricularia* sp. is a principal and preferred food in the goat's diet. They actively select the most palatable and highest-quality forage first, such as *Cyathea*, *Pseudopanax arboreus*, *Melicytus r. ramiflorus* or *Coprosma* [37]. When this forage is consumed, poor-quality forage is used to sustain populations [14,25,28,38,39].

These resistant animals are tolerant to drought in semi-arid areas [14] and are capable of surviving in insular environments, some of which are characterised by low food availability and lack artificial food supply [7]. Goats have a minimum water requirement, deriving from plant foods the amount of hydration they need. This trait enables feral goats to thrive in arid insular environments [31]. Survival in such habitats is complemented by exploiting mineral salts, either by licking the deposits that form on the seashore or by consuming guano. For example, the goats of Montecristo Island occasionally feed on the guano of yellow-legged gulls *Larus m. michahellis* [7].

3.3. Population Structure and Dynamics

In mild and uniform climates, feral goats breed throughout the year, producing up to three goatlings and can double their population every 1.6 years [14,40]. Under these favourable conditions, mixed-sex groups are frequent, travelling to areas of recent vegetation green-up following pulse precipitation events [12]. In contrast, at higher latitudes (e.g., NE Atlantic islands, Scotland), where climatological conditions are less favourable, breeding is restricted to a few months (e.g., January to March in Isle of Rum, NW Scotland) [41,42]. Under these circumstances, single-sex groups are prominent during spring and summer, while mixed-sex groups form during winter [42]. Segregation in feral goats populations is due to predation, forage quality, social preferences, activity patterning [12] and day length [42].

Male feral goats use two distinct tactics for mating: tending and coursing. Tending is used by mature (≥ 4 years old), higher-ranking males, and it is a more successful strategy for achieving mating success. It consists of defending mature (≥ 2 years old) oestrous females from other males. Coursing is preferred by males of all ages and dominance ranks, especially younger males. It consists of disturbing a tending pair, therefore gaining access to oestrous females [43,44]. The gestation period is 150 days [14]. The feral goat lifespan is 10–15 years [4].

Sexually mature feral goats belonging to the same herd may come into heat simultaneously. Oestrus is thought to be synchronised by male sexual activity [45].

Hereafter, Table 1 indicates the available information regarding feral goat populations in various locations around the world.

Table 1. Occupancy and density of some feral goat populations throughout the world. *: part of a much larger population.

Continent		Location	km ²	Individuals	Reference
Europe	Iberian Peninsula	Guara Natural Park, Spain	474	2245 *	[21]
		Serra da Capelada, Spain	12	511	[18]
	Mediterranean islands	Crete, Greece	150	1000–1500	[4]
		Youra, Greece	11.05	200	
		Antimilos, Greece	8	300	
		Majorca, Balearic Islands, Spain	3640	1500–2000	
		Montecristo, Italy	10.39	200	[46]
		Es Vedrà, Balearic Islands, Spain	0.6	20	
	Eastern Atlantic islands	Bugio, Deserta, Madeira archipelago, Portugal	14.21	60	[7]
		Inagua Natural Integral Reserve, Canary Islands, Spain	39.2	189	[47]
		Fuerteventura, Canary Islands, Spain	1660	88,000	[48]
		Wicklow Mountains National Park, Ireland	24.2	207	[43]
		Isle of Rum, Scotland	104.6 (10 km cliff line)	190	[42]
Oceania	Australia	Western New South Wales	809,444	3.38 million	[23]
	New Zealand	-	267,707	300,000	[25]
		Egmont National Park	341.7	1047	[49]
Pacific Islands	Ecuador	Pinta Island, Galapagos Archipelago	60	20,000	[50]
		Santiago Island, Galapagos Archipelago	585	79,000	[51]

3.4. Hybridisation

Anthropogenic activities such as habitat degradation, domestication and translocation of animals have increased the rate of hybridisation events worldwide [45]. Hybridisation between wild and domestic species is a special case of anthropogenic hybridisation [19]. This phenomenon can be detected morphologically and confirmed through molecular data [45], although the development of standardised, effective protocols for hybrid identification is advised [19].

In Europe, hybridisation is relatively common amongst almost all European wild ungulates [45]. With regard to the genus *Capra*, hybridisation events occur mostly between

wild and domestic goats. There is evidence of hybridisation between Alpine ibex *Capra ibex* and domestic goats in the Alps [19,52]. The presence of these hybrids is more frequent in the Western Alps (Italy, France, Switzerland, and Austria), where the density of Alpine ibex is the highest. Likewise, there is hybridisation evidence between free-living Iberian wild goat *Capra pyrenaica* and domestic goats in the Pyrenees [53,54]. Recently, the first cases of leucism in the Iberian wild goat have been reported, suggesting a hybridisation event and renewing interest in the poorly investigated hybridisation phenomenon between wild Caprinae and feral goats [55].

In Africa, the risk of hybridization between the feral goat and the endangered Walia ibex *Capra walie*, living in Simien Mountain National Park (Ethiopia), has been expressed since the late 1990s [56]. However, no evidence of hybridisation has been reported between the two species [57,58]. To exclude the possibility of hybridization occurrence in the future, the eradication of feral goats from the National Park is advised [58].

Although hybridisation is generally perceived negatively when considering conservation, it may be vital for the survival of some taxa under rapidly changing environmental conditions [58,59]. On the other hand, the spread of domestic genes in native wild populations is of concern for conservation [52] if the introgression jeopardises the genetic integrity of wild species, or if it leads to changes in their ecology or behaviour [18]. In the current management paradigm, hybrid populations are not given equal protection in many countries compared to ‘pure’ populations [52]. Clear guidelines on hybrid management are required [19,60].

3.5. Impacts on Ecosystems

Feral goats have caused major problems worldwide, mainly because of their negative impact on vegetation and as potential disease vectors. In 2004, the International Union for Conservation of Nature (IUCN) updated the list of the world’s 100 worst invasive alien species, including 14 mammal species, of which the feral goat is one [18,30,61].

Feral goats are responsible for overgrazing native vegetation. Communities are often unable to recover from persistent herbivory, resulting in their replacement by more tolerant and resilient non-native species, causing the desertification of entire islands. On Santa Fe Island (Galapagos, Ecuador), feral goats eliminated 100% of seedlings from large trees [31]. It is generally considered that densities above 20 goats km⁻² can cause damage to vegetation [14], although this depends on the habitat, the degree of isolation of the area and the presence of species vulnerable to the action of these herbivores [18].

They cause habitat destruction to vertebrate and invertebrate fauna through overbrowsing [9], often leading to ecosystem degradation and biodiversity loss [13,62]. They also modify food webs [9], alter nutrient cycles [31], nitrify soil [50] and produce erosion [61], particularly on sand dunes, caves and watering points [40].

Feral goats have been introduced to at least 397 islands worldwide [17] and are considered a common pest in island ecosystems [39], accountable for a great part of the damage caused in insular ecosystems worldwide [9]. Primarily, islands are important for conservation because they harbour high rates of endemic species, act as refuges for the last remaining translocated individuals [40] and are considered areas with interesting population genetics. Insular endemic species are highly vulnerable to herbivory due to a lack of defences against introduced herbivores, a low tolerance to herbivory or high palatability [50].

The removal of feral goats from islands has shown positive effects in regard to endemic insular species of fauna and flora [31,50]. However, the success rate is higher on temperate islands than on tropical islands [63]. Amongst tropical islands, there are two main examples of success in terms of invasive species management: Seychelles [64] and Hawaii (USA) [65].

There are multiple examples of success following feral goat removal from islands: On Santiago Island (Galapagos, Ecuador), the Galapagos crane *Laterallus spilonotus* has been recovered [31]. Ecological replacement tortoises (*Chelonoidis* spp.) have been proposed as substitutes for extinct native herbivores on Pinta Island (Galapagos, Ecuador), resulting in effective ecosystem restoration agents for plant communities [65]. A presumed extinct shrub taxon *Ceanothus arboreus* has been recovered from seed banks on Guadalupe Island (Mexico). Other Mexican Pacific islands (e.g., Espiritu Santo Island and María Cleofás Island) are following the same steps, clearing their territory of herbivores [16]. In the Caribbean, on Desecheo Island (Puerto Rico Archipelago), the Indian fig opuntia *Opuntia ficus-indica* resurged from the suppression caused by herbivory [63].

With regard to vegetation, although direct benefits are not often seen from feral goat presence on islands, it is possible that native species could benefit from nutrients that are being moved from inaccessible areas through fertilisation via faeces. In addition, goats are known to be used as a biological control method for weeds, improved pasture management and vegetation control in fuel breaks [31,66].

3.6. Disease

Feral goats can carry and are susceptible to many diseases listed by WOA (World Organisation for Animal Health) including Foot and Mouth Disease (FMD), Pest des Petite Ruminants, Bluetongue, Rift Valley Fever, Goat Pox, Ovine epididymitis, Salmonellosis, Scrapie and Tuberculosis, among others [67]. This variety of bacteria and viruses can affect both feral goats and domestic livestock, raising concerns in terms of animal health and zoonoses. Most papers refer to the possible occurrence of these pathogens in feral goats [14,26,28,31,68–70], with only a few descriptions and most of them prior to the 21st century.

Tuberculosis, caused by the *Mycobacterium tuberculosis* complex (MTBC), is an example of a zoonotic disease, and the possibility of transmission between livestock and wildlife is a subject of ongoing speculation [71]. However, there are only two reports describing cases of tuberculosis in feral goats grazing in endemic areas of New Zealand [72,73].

Some of the zoonotic pathogens identified include *Anaplasma phagocytophilum* in Northern Ireland [74] and in Scotland [75], *Coxiella burnetii* [76] and *Salmonella* spp. in Australia [77] and *Leptospira interrogans* in New Zealand [78].

Concerning animal health, *Corynebacterium pseudotuberculosis* [76,79,80] and *Trueperella pyogenes* (previously *C. pyogenes*) [80] were identified in Australia, *Pasteurella multocida* and *M. haemolytica* (previously *P. haemolytica*) in the USA [69] and *Mycobacterium paratuberculosis* in New Zealand [81].

Feral goats have been found to carry parasites and diseases that infect livestock, especially sheep, *Ovis aries*. One of these diseases is foot-and-mouth disease (FMD). It is a highly contagious viral disease that affects cloven-hoofed animals. It is transmitted directly through saliva and aerosols from respiration, and indirectly via the consumption of infected tissue [80]. It is present in many parts of Africa and Asia [68]. Australia has been free from FMD since 1872 [82]. Nonetheless, there have been recent cases of FMD in Europe, the first in the United Kingdom in 2001 and the second in Bulgaria in 2011. Recovered or vaccinated animals subsequently exposed to FMD may become carriers, and subclinically infected animals are contagious [68], acting as viral amplifiers [82].

Lumpy skin disease (LSD) is a vector-borne viral infectious disease that affects cattle, *Bos taurus*, and several wild ruminant species, including feral goats. European goat and sheep breeds are more susceptible to infection than African and Asian breeds [68].

The first report describing feral goats as intermediate hosts of a species of the parasite *Linguatula* was published in Australia [23]. Zoonotic diseases such as tuberculosis, brucel-

lois, rabies [31], Halzoun or Marrara disease [23] are potentially transferable to humans. Apart from this recent report, the last scientific effort made within this field was in the 1980s [23,83]. Further studies are required regarding feral goat biology, ecology, and their potential biosecurity risks [23].

3.7. Food Webs

Feral goats are considered pests in numerous environments, responsible for grazing endemic plant species to extinction or, at least, very close to reaching this outcome. However, their populations also have an important positive effect: supporting native and endangered avian scavengers and predators [49,84], such as the bearded vulture *Gypaetus barbatus* in the Pyrenees [84] and the endemic Egyptian vulture *Neophron percnopterus majorensis* in the Canary Islands (Spain) [49]. Although the bearded vulture is considered a bone-eating species, small animal prey are vital for their young during the breeding season [84]. Nonetheless, in this case, the authors do not distinguish between the domestic goat and the feral goat.

Other species that include feral goats in their diets are the Eurasian buzzard *Buteo buteo*, the common raven *Corvus corax* [49] and the dingo *Canis lupus dingo* [27]. Reports on feral goat relationships with grey wolves *Canis lupus* are absent [85]. In addition, there is a need within conservation projects to integrate extensive grazing systems and hunting practices for wild ungulates into local economies and traditional cultures [49,84].

3.8. Management, Monitoring and Conservation

3.8.1. Management and Monitoring

Learning about population trends is essential to guarantee their effective management and conservation. Depending on the geographical area, the management of feral domestic goats has different objectives: conservation, eradication, population control and exploitation.

Feral goat management is more effective when combinations of techniques are used [86]. The techniques mentioned below are lethal and rely on technology and highly skilled staff, allowing goat eradications over larger areas within a shorter time period and with increased cost-effectiveness [87].

Mustering, that is, gathering together animals such as feral goats, is an intensive capture method [47] that can be performed using motorcycles, horses or specially trained hunting dogs to aggregate goats into large herds [27]. The option with dogs was the preferred measure used in an integral natural reserve in Fuerteventura (Canary Islands, Spain) due to the high number of difficult access areas [48].

There are two types of shooting: ground and aerial, using airplanes or helicopters. The first one is labour-intensive but can produce adequate results if control programs are well planned and the effort is maintained [27]. On occasions, bait poisoning [41,82] and habitat alteration via fire [88] are used with ground shooting. The second one, although costly, is highly effective, especially when the number of feral goats to be reduced is large [14,27,41,88,89].

Another important technique is the use of the Judas goat—GPS-collared sterilised goats, which find feral goat groups that can then be targeted and eliminated [39,88]. This method is fundamental for detecting goats at low densities and a vital monitoring tool to confirm eradication [87,88,90]. Judas goats have been used successfully in a number of eradications: San Clemente and Santa Catalina Islands (California, USA); Kahoolawe Island (Hawaii, USA); Ile Malabar and Ile Picard (Seychelles); Woody Island (Australia); and Pinta Island (Galapagos, Ecuador) [87].

Geographic information systems (GIS) and remote sensing technology provide information on home range use and movement patterns followed by feral goats, which are especially useful in high-density vegetation habitats (e.g., tropical dry islands). The

Normalised Difference Vegetation Index (NDVI) is also a valuable tool to study habitat selection and movement [12].

Other techniques for managing feral goats are trapping and the fixed-point methods, which consist of a goat-proof fence surrounding a water point that is entered through one-way gates or ramps [13]. During an eradication plan carried out in the Canary Islands, intensive trapping appeared to be the most efficient population control method in terms of effectiveness and risk minimisation [48].

The fixed-point method is a monitoring methodology that consists of counting the number of individuals taking advantage of the geographical features in mountainous and steep areas and using them to sample the visible territory [10].

3.8.2. Eradication and Population Control

The eradication management approach is by far the most widely used. When it comes to eliminating populations of alien vertebrates, New Zealand is the highest contributor, followed by Australia, the USA and Mexico [64].

In Oceania, the eradication approach has been implemented since at least 1966 [91]. Feral goats have been hunted intensively every year since 1972 on Raoul Island (New Zealand) [37]. On Kangaroo Island (Australia), an eradication program (2005–2016) was carried out using white Judas goats [39]. Amongst tropical islands, in Seychelles, eradication procedures have been taking place since the 1920s [64]. The largest goat removal efforts on the Pacific islands have been made in Hawaiian National Parks [64]. On Desecheo Island (Puerto Rico Archipelago), goat eradication was completed in 2003 [63], and on Guadalupe Island (Mexico), it was concluded in 2007 [16]. Most European countries lack clear regulations enabling procedures for effective removal of feral goats [19].

The main techniques proven to successfully eradicate goats from islands include Judas goats, ground and aerial hunting [17], resulting in successful eradications from 120 islands worldwide [87]. The construction of fences to exclude invasive mammals from ecologically important areas is widely used when island eradication is unfeasible, considering island size, topography, habitat complexity, or lack of public support. This method has been applied in New Zealand and Hawaii (USA) to protect important seabird colonies [64].

The reasons eradication campaigns fail are primarily due to lack of political support, the use of inappropriate methods, lack of effort, and the absence of implementing a monitoring program post-eradication to detect the final goats at low densities [17,87].

The last research paper analysing the efficiency of feral goat eradication campaigns on insular regions was carried out over more than 15 years ago [87]. In the following Table 2, numerical data are presented regarding the number of feral goats removed during these campaigns since 2006 to the present day. Despite this management method being the most preferable worldwide, there is still a lack of updated information and numerical data available.

Table 2. Number of feral goats removed during eradication campaigns since 2006 to the present day.

	Location	km ²	Goats Eradicated (Years)	References
Mediterranean Islands	Es Vedrá Island, Balearic Islands, Spain	0.6	66 (2016–2019)	[47]
Oceania	Kangaroo Island, Australia	1400	1200 (2006–2016)	[39]
Pacific Islands	Galapagos Islands, Ecuador	7194	201,825	[92]

Nevertheless, killing large mammals is contentious and increasingly faces opposition from the public [39,93]. Fertility control is a non-lethal adaptive management approach to limit population size that is being explored in North Wales [93] and which is also very expensive. On the other hand, some studies [47] show that if feral goats are not completely eradicated, especially from islands, their impact on native flora reappears a few years later. Hence, their complete eradication is required to preserve the natural plant communities in insular ecosystems over the long term [47,87]. Conversely, multiple forests transitioned into grasslands or bare ground even after feral goat eradication [94] on Nakoudojima island (Japan) [95], suggesting that canopy trees died due to natural disturbances in addition to the lack of seedlings caused by the grazing of feral goats.

3.8.3. Exploitation and Trophy Hunt

In Australia, the goat industry is providing a viable alternative livestock enterprise to livestock producers [96]. These goats are considered to provide an excellent basis for exploitation and exportation [28,97]. The focus is on cashmere, mohair, leather and meat production [24]. Feral goats make up approximately 90% of goats sent to slaughter in Australia, mainly coming from the arid areas of western New South Wales (NSW) and South Australia [23]. Once processed, the majority of goat meat (95% in 2020) is exported, mainly to the USA (64% of export volume), followed by Taiwan, South Korea, Canada, Japan and Trinidad and Tobago. Live exports by air to Malaysia, the Philippines and China also take place [96].

In the Mediterranean Basin, the Island of Rhodes (Greece) has recently established a new management program for feral goats along these lines. The aim is to donate the meat produced from the captured animals to charitable organisations. The public is also involved and can actively participate by submitting digital data (photos, coordinates) of feral goat sightings, thus enhancing the efficiency of municipal services provided [98].

On Majorca Island (Balearic Islands, Spain), there are two feral goat breeds: the old one, the Majorcan boc, which went wild around 7000 years ago, genetically close to the Crete breed, and the recent one, which feralised during the 60s of the last century. The first is appreciated for its historical and cultural values, which include a traditional hunt with dog and loop. Both interbreed, and it is a matter of concern for the conservation of the genetic identity of the Majorcan boc. This has been recently recognized as a trophy hunt species by Safari International and the International Council for the Game and Wildlife Conservation (CIC) and is part of the international trophy hunt market [99].

3.8.4. Conservation

In the Mediterranean Basin, the feral goat is considered to be of unique historical and cultural significance. Therefore, its protection and study could provide an opportunity to test different evolutionary theories [100]. The current situation has changed. Environmental management has developed to eradicate goats in many parts of the world in order to restore the natural equilibrium on islands, and these efforts have been especially intense in the Mediterranean Basin since 2020 [47].

However, it is likely that feral goats inhabit protected areas, such as National Parks or areas included in the European Natura 2000 network, thus benefiting from the protection strategies offered by the territory [85].

The current conservation criteria aim to prevent the spread of domestic or non-native genes in native populations. Therefore, it is advised that current and future conservation plans determine the genetic origin of possible source populations, protect native populations from the risk of crossbreeding with non-native ones and establish permanent monitoring [45].

4. Discussion

In regard to the feral goat, the categories that inspire the most research within the scientific community are the impacts caused on ecosystems and the management strategies associated. Both issues are predominantly studied on islands. Currently, distribution maps of feral goat populations are only available at a regional level [20]. There is still an absence of global distribution maps for this species [4].

There are abundant studies supporting feral goat eradication, fundamentally due to their impact on vegetation. However, their role as nutrients and a food supply for endangered fauna taxa is not sufficiently understood [49]. Similarly, further investigation is recommended regarding feral goat biology, ecology, and their potential biosecurity risks [23]. Additionally, there is a contradiction amongst the scientific community on how to proceed with hybrid individuals [52].

Countries in Oceania are the main promoters of feral goat eradication, and it has been occurring at least since the early 20th century [64,91], gaining popularity and momentum in recent years. Nowadays, it is the most widespread approach when it comes to dealing with these herbivores, particularly favoured in insular ecosystems. However, there is still a lack of updated numerical data available on the efficiency of eradication interventions. In spite of a non-lethal management approach being suggested, there has been a paradigm change from a conservation approach to an eradication, and even exploitation [98], approach in the Mediterranean Basin [47].

It is encouraged that the role played by the feral goat is investigated further, as a good understanding of the population's life-history characteristics is essential for decision-making. This further research could provide useful insights for the optimal management of the species and the conservation of the remarkably diverse ecosystems it inhabits.

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