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Conservation and management of fallow deer (*Dama dama dama* L.) on Lemnos Island, Greece

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Abstract: A small population of European fallow deer (*Dama dama dama* L.) was transferred to Myrina, Lemnos Island, Greece, in the early 1970s from the island of Rhodes. Since the Rhodian population may preserve a remarkable proportion of the original genetic diversity, it is necessary to preserve its offspring population. Our objective was to estimate population size, vegetation cover, and key stakeholder attitudes towards deer on the island, based on personal interviews. Following the visual inspection method, we estimated that there were 47 fallow deer in the fortress area (38 females, 3 males, and 6 fawns). For the total ground cover inventory we used the subplot sampling method. In most areas trees were either browsed or frayed, vegetation cover was insufficient, and dry mass amount was not adequate to support the entire ungulate population. However, lack of nutritious matter supply is covered by additional food and water supply provided by the Myrina municipality and volunteers. In general, the key stakeholders of Lemnos expressed a positive attitude towards fallow deer; however, all concluded that the deer population should be kept at its current size and restricted to the fortress peninsula to avoid potential vehicle collisions and damage to crops and gardens.

Key words: Deer conservation, fallow deer, Greece, Lemnos Island, urban deer

1. Introduction

Worldwide, there has been a connection between humans and deer dating back thousands of years (1,2), and many examples can be found in ancient Greek mythology. Archaeological findings from the Greek region of Macedonia have revealed domestic cattle bones. Remains from red deer (*Cervus elaphus* L.), roe deer (*Capreolus capreolus* L.), and fallow deer (*Dama dama* L.) were commonly found together (3), indicating the more practical aspects of human–deer connection.

European fallow deer is one of the most common deer species in the world. However, since it was indigenous to a small area in the eastern Mediterranean, today it has been extirpated from most of its historic range (2). Its current worldwide distribution derives from its introduction as a farm or game animal (4). One of the earliest introductions, probably dating from Neolithic times, was to the island of Rhodes in the Aegean Sea (5). At present, fallow deer on Rhodes represent a distinct genetic cluster characterized by an 80-bp mitochondrial DNA (mtDNA) lineage, not found elsewhere (5). The fallow deer population on Rhodes may retain a greater proportion of the original genetic diversity of the indigenous population than other populations of this species. Thus, the preservation and management of the fallow deer of Rhodes is an important conservation objective (5).

Various "daughter populations" from the Rhodes population have been established on other islands in the Aegean and eastern Mediterranean seas, which can safeguard this genetic variant against loss in their native range (4). Two females and a male fallow deer from Rhodes were introduced to the island of Lemnos (NE Aegean Sea) between 1968 and 1970 (6) as a gift from the mayor of Rhodes to the mayor of Lemnos. The deer were released and inhabited the ruined Byzantine fortress peninsula in Myrina, the capital of Lemnos (6). The purpose of the introduction was to provide a sense of nobility to the town; however, deer soon became a tourist attraction and were depicted on tourist maps and souvenirs. The deer population in Myrina increased to 70 by 2006 (7) and was managed by local politicians who made decisions based on community tolerance and affection, rather than science (6,7). However, our recent conversations with local stakeholders revealed that, from their viewpoint, this population is currently in decline.

Our objectives were to provide an estimate of the current fallow deer population size on Myrina of Lemnos, to make a vegetation cover inventory, and to assess the

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capacity of the peninsula to nutritionally support the animals. We also aimed to evaluate the attitudes of key stakeholders associated with urban deer management towards fallow deer on the island.

2. Materials and methods

2.1. Study area

Lemnos Island is located in the northern Aegean Sea, Greece (39°52′46″N, 25°04′27″E). It covers 482 km^2 and is characterized by low hills, all below the altitude of 429 m (8). The climate is subhumid, with a mean annual precipitation of 500 mm and frequent winds from the north or northeast contributing to the arid climate of the island (9). Lemnos is a rural island, dominated by agriculture (80%) and forestry (15%) (10). Agricultural areas are distributed among phryganic grazing land (48%), arable land (35%), fallow land (7%), permanent crops (2%), and heterogeneous agricultural areas (8%) (10).

The fortress peninsula in Myrina covers 28.5 ha and rises 80 m above sea level (9). It is characterized by steep rocky slopes in the north and flatter surfaces in the south (9). The peninsula connects to the main island in the east by a 350-m isthmus, which borders most urban areas of Myrina without any fencing (Figure 1).

The area is dominated by open spaces of low vegetation and sporadic stands of Turkish pine (*Pinus brutia* Tenore), oak (*Quercus* spp. L.), Mediterranean cypress (*Cupressus sempervirens* L.), locust tree (*Robinia* spp. L.), and tree of heaven (*Ailanthus altissima* (Mill.) Swingle).

Dominant understory species include thorny burnet (*Sarcopoterium spinosum* (L.) Spach), false dittany (*Ballota acetabulosa* L.), and branched asphodel (*Asphodelus ramosus* L.).

2.2. Study design

Since the counting of fallow deer groups should occur at the end of winter or in early spring when deer females, fawns, and yearlings are in herds (11), in order to estimate fallow deer populations we worked on Lemnos Island in late January 2013. We used visual observations to count all large herbivores (fallow deer and feral goats (*Capra hircus* L.)) on the peninsula. Topography permitted visual access to the majority of the site from the top of the fortress, where we obtained observation distances of <400 m. Two observers situated at the top of the fortress scanned the area with binoculars at 0800, 1300, and 1800 hours for 5 consecutive days. All surveys returned the same population count, excluding the possibility of double-counting of the same group on different occasions. We used the same method to survey the area within a 1-km radius of the fortress to estimate the population size of the newly established, escaped fallow deer.

We classified deer by sex, age class (i.e. fawn or adult for females; 1–2 years (without antlers or simple unbranched spikes or knobs), 2–4 years (brow and trey tines developed in sorels, 2 spikes), and >4 years (palmate shaped or antler with more than 2 tines or points; the palmation does not appear until the buck is 4 years old) for males according to antler shape (12)), activity (i.e. grazing, resting (lying on the ground or standing still), moving (walking or running)), and interactions with other large herbivores.

We established 27 transects on the peninsula, inside and outside the fortress, evenly distributed on relatively flat, vegetated surfaces, spaced at least 50 m apart (Figure 1), to measure vegetation cover and availability. At 10-m intervals along each transect, we established circular subplots (radius = 2 m; 367 subplots covering 4612 m^2 of the peninsula). We recorded ground cover as rocky outcrops, shrubs (understory vegetation with a voluminous crown), and grassy vegetation (small-sized grasses, herbs) (13).

We measured the individual height of shrubs to the nearest centimeter as the distance to the ground of a top touching plane, and grass height was measured with a sward stick (14) as the average of 40–80 recordings on each transect. Dry grass matter was measured by clipping ten 50 × 50 cm quadrats to ground level and drying the collected vegetation in a fan-assisted oven at 90 °C for 24 h.

Tolerance towards deer by the local community is considered as important as food availability; therefore, we assessed the attitudes (15) towards fallow deer on Lemnos by conducting interviews with representatives of the major stakeholders in Myrina. Those interviewed to assess tolerance towards urban deer were not chosen randomly and were not considered representative of the attitudes of the entire island. Rather, they represented the position of the decision-making group. We therefore purposefully focused on individuals who were most likely to be appointed to a municipality advisory group that developed management strategies (16). Moreover, the omission of other recognizable stakeholder groups occurred because there was no identifiable representative. Personal interviews were conducted in the same time period, after field work had been accomplished. Respondents encompassed officials from the Department of Rural Economy (n = 6), Lemnos Island Department of Forestry (n = 2), Lemnos Island Police Department (n = 5), Municipality of Myrina (n = 2), key persons from deer-feeding volunteers (n = 3), and local media representatives (n = 3). We inquired about the views regarding tolerance to fallow deer on the peninsula, in Myrina, and on the island of Lemnos. We obtained information through short interviews by asking 5 questions (Table):

1. Do deer cause any damage? If yes, please specify.
2. What is your general attitude towards deer presence in the fortress area?
3. What do you think about using an alternative (fenced) area for deer translocation?
4. What are your general management suggestions for the deer on Lemnos?
5. Any additional comments or information?

2.3. Statistical analysis

We analyzed vegetation cover data using boxplots, scatterplots, and histograms in Minitab 16.2.2. We used scatterplots and histograms to describe the ground cover classes (rocky outcrops, shrubs, and grass) in each transect and in the entire study area. Boxplots were used to assess and compare ground cover distribution and availability of each cover class and to display all data from the transect areas. We used histograms to compare frequency of occurrence between recorded shrub species.

3. Results

3.1. Fallow deer population size

In total, we recorded 47 fallow deer in the study area. Thirty-two fallow deer (24 females, 3 males, and 5 fawns) and 7 feral goats were observed on the fortress peninsula, and 15 fallow deer (14 females and 1 fawn) were observed within a 1-km radius of the peninsula. We found 1 yearling (without antlers), 2 subadults (2–4 years with >1 spike on antlers, no palm) and no adult males (>4 years, spiked and palmed antlers) in the population.

All fallow deer were active or resting during the observation periods. No territorial interaction was observed between deer and goats, although both ungulates were using the same area.

Interviews with stakeholders revealed that the bulk of the fallow deer population on Lemnos Island is associated with the Myrina fortress peninsula (all respondents agreed). Respondents reported that groups of fallow deer were identified in nearby Myrina locations, such as Kaspakas and Petasos Hill; a few individuals were also observed in more remote parts of the island such as Kornos, Agios Dimitrios, Plati, Evgatis, and Marula (Figure 1), although never at a radius wider than 10 km from Myrina.

3.2. Vegetation cover

All subplots had similar species composition; however, they were found in different proportions throughout the 27 subplots.

Rocky outcrops, shrubs, and grasses occupied 1319 m^2 (n = 367, SD = 2.9, 95% CI) 1290 m^2 (n = 367, SD = 2.5, 95% CI), and 2003 m^2 (n = 367, SD = 3.0, 95% CI) of the sampled area, respectively. Shrubs and grasses occupied 71% of the area.

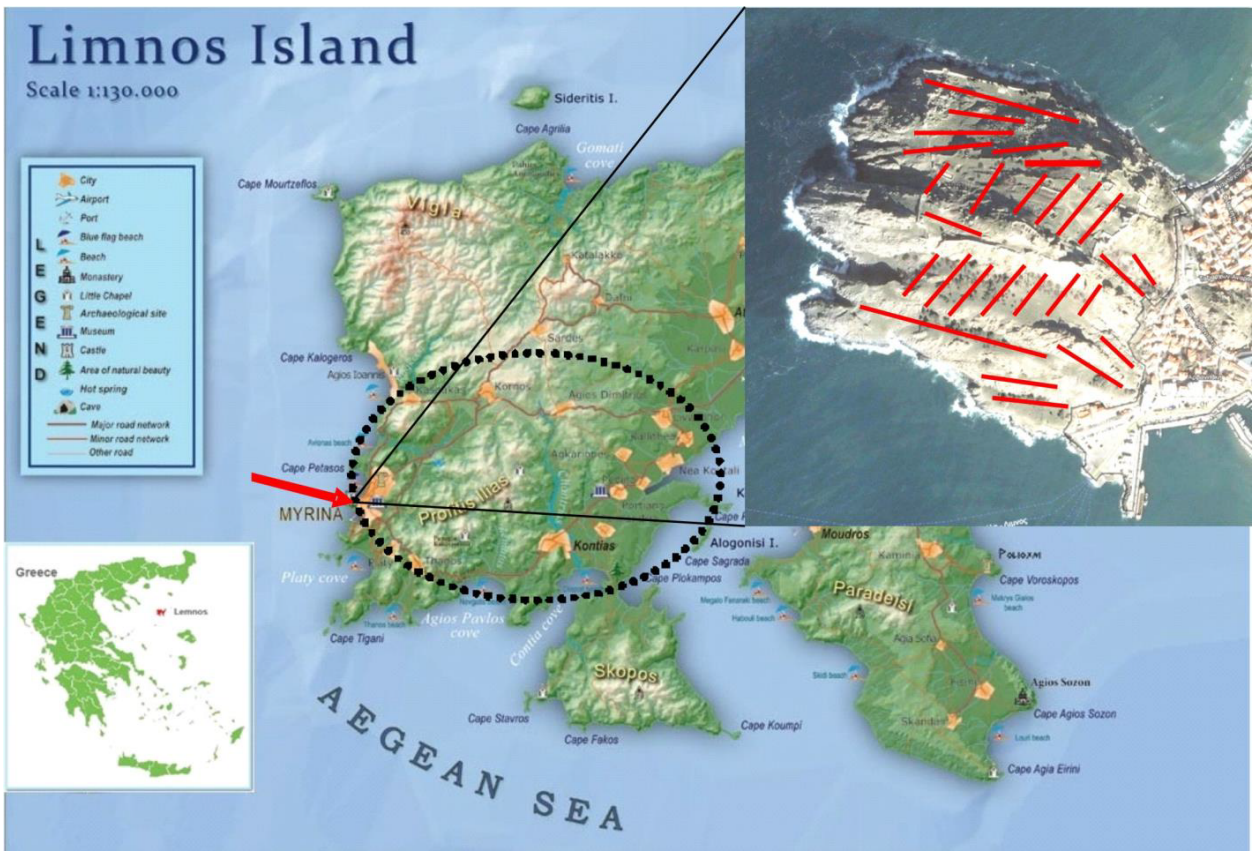

Figure 1. Map of Lemnos with approximate fallow deer distribution (black dashed line), according to respondents. Map source: Chamber of Lesvos (http://www.lemnosrooms.gr). The red arrow marks the location of Myrina Peninsula with its fortress. Small inset: Locations of 27 transects (red lines) to measure vegetation on the fortress peninsula of Lemnos, Greece, in 2013. Map source: Google Maps.

We recorded 3 shrub species including thorny burnet, false dittany, and branched asphodel with an average of 52 cm (n = 367, SD = 0.3, 95% CI), 23 cm (n = 367, SD = 0.4, 95% CI), and 34 cm (n = 367, SD = 0.5, 95% CI), respectively. False dittany was browsed least, although more abundantly than the 2 other species combined (Figure 2). Thorny burnet was commonly used by feral goats, although we often observed use by fallow deer.

Average available dry grass mass for the 27 transects was 192 g/m^2 (n = 367, SD = 107.4, 95% CI) with average height of 2.8 cm (Figure 3).

Most trees (>90%) in the sample plots (Turkish pine, oak, Mediterranean cypress, locust tree, and tree of heaven) were heavily browsed or frayed, probably due to attacks by male fallow deer during rutting activity.

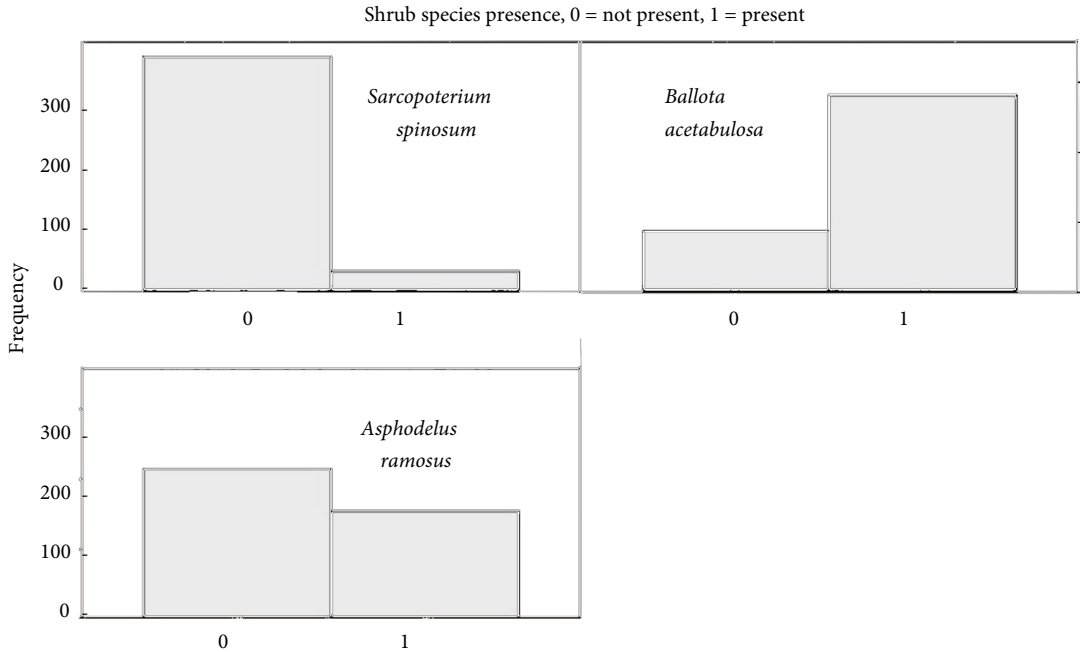

Figure 2. Frequency of shrub species (pooled data from all sample plots).

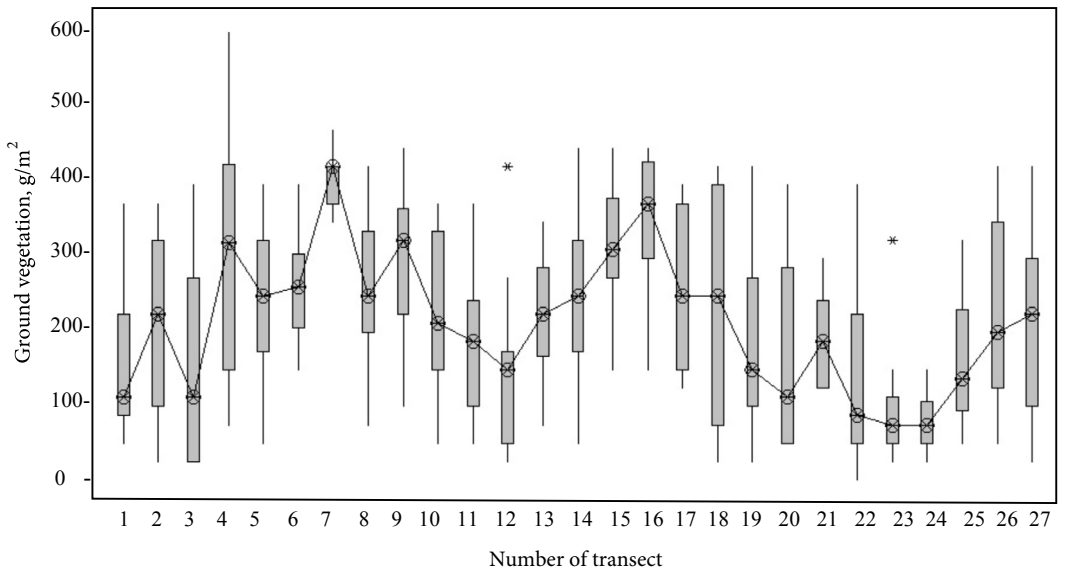

Figure 3. Statistical mean value distribution of available dry mass amount per transect, g/m^2 (⊛ = mean central tendency, □ = mean ± standard deviation, | = variability from min–max).

3.3. Stakeholder attitudes

The interviews revealed a generally positive attitude of all respondents towards deer presence on the island (Table). There was an overall desire to maintain such an emblematic animal (based on Greek history and mythology) for aesthetic reasons and as a tourist attraction. However, the majority of respondents also preferred deer to be restricted to the fortress to avoid conflicts with agriculture and private property.

All respondents (n = 21) identified problems of habitat suitability and food availability in the fortress peninsula. Respondents suggested that to maintain the population in the area, additional forage and water should be provided to the animals, as stated in the Deer Farming Guidelines of the Food and Agriculture Organization (FAO) of the United Nations (17).

4. Discussion

According to earlier reports on the population size in the fortress peninsula, the herd ranged from 65 to 70 individuals (6,7), of which 60% were adult females (7). Moreover, it was reported that in 2005 the population contained 11 fawns and 12 males (5 = 2–3 years, 5 = 4–6 years, 2 >6 years) (7). The decline in herd size on the fortress peninsula, the absence of mature males, and the small number of fawns is an indication of the difficulties encountered by this population. A well-balanced population has a sex ratio of 1:1.1 to 1:1.3 M/F, and adults usually have a high fertility rate (80%–90%) depending on the population and environmental conditions (18).

Studies on reproductive strategies of ungulates concluded that when population densities are high, females reduce their reproductive efficiency to allocate energy resources for survival (19). Therefore, the apparent female reproductive failure in fallow deer on the fortress peninsula can be explained, in part, by the lack of mature adult males (>4 years) (18) as well as by limited feed availability. Moreover, the observed low fawn ratio might also be due to feral dog attacks (6 fawns were reported to have been killed by feral dogs during the past 4 years) and either directly or indirectly falling off cliffs during chasing.

Although deer are a protected species in Greece (20), illegal hunting still exists in rural and suburban areas of Lemnos Island (no official data on poaching are available), causing a decrease in the number of deer on the fortress peninsula and nearby areas. Stakeholders agreed that deer should be restricted to the fortress peninsula and strictly controlled in order to prevent the possibility of spreading throughout the island and damages to crops and gardens that are already under pressure from wild rabbit (*Oryctolagus cuniculus*) overpopulation (21). A public awareness campaign, started in November 2013 and involving the local media, seeks to train farmers in environmental skills, inform tourists to be aware of deer habits (i.e. decreasing disturbance), educate local deer-feeding volunteers about nutrition, and inform the general public about local flora–fauna interactions to avoid conflict caused by deer damage to crops and gardens.

Fallow deer may require up to 3.0 kg of dry matter/day of good quality forage for maintenances and reproduction, while lactating deer require higher amounts (22). According to previous studies (23) and our data, total forage dry matter production on the peninsula is estimated at about 38 t/year, which can support approximately 35 ungulates (fallow deer and goats).

Our results indicate that ground cover and forage availability is uneven throughout the peninsula, and topography limits accessibility of forage to deer. Fallow deer prefer flat ground (7) and are generally considered nonselective herbivores or mixed feeders and grazers (22,24); thus, they are dependent on grazing or browsing for survival. Continuous grazing on most of Lemnos Island has eliminated many species and, at the same time, has led to the expansion of plants that are unsuitable for grazing (i.e. foul-tasting, poisonous, prickly, and weedy) (9). This is also the case for the fortress peninsula, so it is not surprising that deer had to adapt their diet or search for alternatives beyond the peninsula, leading to their potential spread from the area. In Greece, a large part of the land is allocated for grazing by local municipalities (25), and arable land is limited, making farm size small compared to most of Europe. These characteristics are more intense on the islands. Therefore, crop damages seriously challenge local community tolerance for fallow deer.

Although the fortress peninsula does not provide adequate forage to nutritionally support the ungulate population, it does provide sufficient shelter among fortress ruins and in rock cavities (7). This feature is important for the protection of animals against adverse weather conditions (heat in summer, strong winds in winter, etc.), close contact with humans, and predation threats. Additional feed (alfalfa (lucerne) hay (*Medicago sativa* L.)) and water are provided by the Myrina Municipality and volunteers on a daily basis. Such practice of supplemental feeding is quite common in deer farming in Europe, such as in Scotland (26), Finland (27), the Netherlands (Oostvaardersplassen) (28), etc.

A study on the management of Myrina deer was commissioned in 2005. This study recommended the translocation of a large part of the herd to a newly fenced area (29); however, preparations were aborted for a variety of reasons (e.g., concerns about animal welfare, lack of sufficient forage production in the new area, and concerns

Table. Interview summary with representatives of major stakeholders in Myrina (decision-making group position, to be appointed to a municipality advisory group to develop management strategies).

Main stakeholders vs. question	Lemnos Island Department of Rural Economy (n = 6)	Lemnos Island Forestry Service Department (n = 2)	Lemnos Island Police Department (n = 5)	Deer-feeding Volunteers (n = 3)	Municipality of Myrina (n = 2)	Local newspaper (n = 3)
Deer damages?	Private gardens, vegetable yards, arable crops.	Private gardens, vegetable yards, arable crops, 20 vineyards, no forest damages.	Vehicle collisions (2008–2011, 6 deer killed, no human injuries or fatalities).	Small ornamental trees, private gardens, bushes.	Private gardens, small plantations, one vehicle collision.	Escaped deer in Myrina searching for food in garbage bins inside the city.
Attitude towards deer presence in fortress area?	Positive. Good tourist attraction. No deer outside fortress.	Positive. Need to address insufficient food supply (competition with feral goats).	Positive.	Positive. No deer outside fortress area, need additional food.	Positive. No deer outside fortress area.	Positive. Need information for tourists and locals.
Translocation to another fenced area?	Negative. Problems with catching and transporting deer. No food supply in new site. Addition to problem with wild rabbits (overgrazing).	Negative. Difficult to keep deer from escaping. No fenced wildlife.	Positive.	Negative. No fences: Greek culture dictates free-roaming wildlife.	Negative. No deer outside fortress area So, no damage to private property and no illegal hunting.	Positive. Keep deer in open territory.
Management suggestions?	Deer farms? For protection of deer and public admiration. Environmental protection (food supply and suitable habitat).	Part of population in fortress, supported with supplemental food and water. Portion in restricted area. Granting few shooting licenses? (€300/deer).	Keep deer safe, as well as private property. Damage control implementation.	Management guidelines. Local society education. Licenses (€300/deer). Deer farms. Additional trees and plants.	Improve productivity of existing vegetation (i.e. plant clover species (Trifolium spp.). Fence fortress area to prevent deer from escaping.	No deer outside the fortress. No deer farms. Management advice for locals, media, and pupils.
Additional information	Management tips for farmers on correct course of actions if deer are on their property.	Deer hunting forbidden by law (population control by hunting would require changing the law).	Police often receives reports on deer damage to vegetable gardens.	Many complaints, some unsubstantiated.	Difficult to capture and transport deer (requires animals to be kept under welfare standards). Existing wild rabbit and feral dog problems.	Feral dog problems. Locals express willingness to feed deer with vegetable leftovers.

about losing this emblematic animal from the fortress). Fallow deer on the peninsula cannot be considered a wild and free-roaming population, since they are regularly supplemented with food and water and restricted to the fortress peninsula. Therefore, principles of deer farming management and not of wild deer population management should be adopted, according to the FAO Deer Farming guidelines on practical aspects (17).

A regular assessment of the population size in the fortress area and culling of the surplus animals would be useful for maintaining a healthy population and for protecting the landscape of the peninsula. It is necessary to take into account inbreeding issues within such a small 'founder' population, possibly with the introduction of a buck from Rhodes. In order to maintain the genetic integrity of the population and to protect the genetic line in the case of disaster, and because they appear to be on the edge of carrying capacity, it would be worth translocating some deer to other territory/islands, so that they will form multiple populations. While much remains unclear about fallow deer management in a limited area such as the fortress peninsula of Myrina, conservation measures need to be implemented without delay to prevent further decline of fallow deer population or even extinction from the island of Lemnos.

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