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Rural communities under Human-Wildlife Conflict: transforming the wild rabbits problem to a food source and an opportunity for local economy

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Abstract The European wild rabbit (*Oryctolagus cuniculus*), outside its natural habitat, is usually considered an agricultural pest. In Lemnos Island, Greece, during the last decades, a large increase of the wild rabbit population (WRP) has become a plague on the island's biodiversity, ecosystems and crops. This disturbance affects local economy, imposing the need for WRP control, and builds conflicts regarding conservation, an issue known as Human-Wildlife Conflict (HWC). Although, various management actions were implemented by local authorities, the results were minimum and localized, increasing the local HWC.
In this research, the potential use of wild rabbits as a biotic resource was detected by studying Lemnos local communities' perceptions, focusing on local agricultural development, WRP impact and management, and natural conservation. Interviews from stakeholders and 318 citizens' questionnaires were collected. Results showed common expectations on local development, but diverse opinions on WRP control policies and conservation values management. The nutritional value of wild rabbit, its positive hunting legislation and the increase of local hunting tourism, enhances the opinions for using wild rabbits as a local food and touristic innovation opportunity. This proposed sustainable management strategy for WRP control, slowly acquires popularity, even though building consensus is difficult under the ongoing Lemnos HWC.

Keywords: *Oryctolagus cuniculus*, food chain, citizens' perceptions, sustainable development

1. Introduction

Mediterranean ecosystems, as parts of a complex mosaic between nature and human presence combine a slow and ongoing biodiversity evolution along with intense human activities occurring during the last few millennia (Bengtsson et al. 2000; Blondel 2006). The effects of this coexistence can be detected from richness in species and endemism, to landscape diversity, cultural plurality and significant economic growth. This complex system, defined in literature as a socio-ecological system (SES) (Biggs et al. 2015), due to significant economic and social changes over the last decades, is under extreme pressure, mainly in the Mediterranean islands, setting its core characteristics out of balance and affecting overall its food chains and agricultural production (Christofakis et al. 2009). Moreover, external pressures, such as fires, storms, floods, pests, biological invaders, habitat fragmentation, aggravates the pressure on ecosystems in a wide range of spatial and temporal scales (Fischlin et al. 2007).

The European wild rabbit (*Oryctolagus cuniculus*), due to the significant declining of its population that has been reported in recent years, is characterized by the IUCN as *'Near Threatened Species'* (Smith and Boyer 2008). However, outside its natural habitat, it is considered an agricultural pest where its removal is a priority for conservation (Lees and Bell 2008). The wild rabbit population (WRP) increase could cause a wide range of ecological disturbances and has a significant economic impact on local communities, with examples being recorded thru history in various regions around the world, especially in Australia (Williams et al. 1995; Bird et al. 2012).

In Lemnos Island, Greece, during the last decades, a large increase of WRP has become a plague on the island's biodiversity, ecosystems and crops (Kontsiotis

et al. 2013). This disturbance has been enhanced by the abandonment of cultivated land in many rural areas of the northeastern part of the island, due to economic and social changes happening during the same period. These multilevel changes in the local SES, has affected parts of the island's natural and agricultural ecosystems as well as its local agro-economy. Moreover, it has built up conflicts between local stakeholders regarding (a) conservation priorities, an issue known as Human-Wildlife Conflict (HWC) (Madden 2004), and (b) significant effects in agricultural production, and thus imposing the need for a wide WRP control on the island.

Several management practices have been implemented mainly aiming on increasing the mortality of the wild rabbits and therefore, limiting their spread around the world. These practices include rabbit-proof fencing, systematic hunting, biological control, introduced predators, warren ripping, fumigation, poisoning and explosives (Williams et al. 1995). Although various control actions were applied by the local authorities to address this issue in Lemnos Island, the results were minimum, controversial and localized, and thus, the HWC is still occurring.

Consequently, a deeper understanding of the local communities' perceptions involving this ongoing WRP conflict will support the designing of a more appropriate management model to control a critical component of the island's food network. The main question emerging from our case study is if the overabundance of the *Oryctolagus cuniculus* (a) should be treated as one of the largest plagues in Lemnos Island or (b) could it become a significant biotic resource with a positive potential distribution to the local economy. The main focus of this research is to detect the local (a) agricultural development priorities, (b) WRP impact and HWC management up till now along with potentially new opportunities, and (c) opinions on natural conservation.

2. Materials and Methods

2.1 Study area

The study was carried out on Lemnos Island, Greece, which is located in the Northeastern Aegean Sea (39°55'24.81"N, 25°14'0.75"E) covering an area of 482 km^2 and inhabited by approximately 17000 residents. The climate is typical Mediterranean and its annual precipitation is about 500 mm (Panitsa et al. 2003).

2.2 Questionnaire design

A questionnaire was designed in order to investigate Lemnos residents' perceptions and views towards the wild rabbits' population problem. The questionnaire consisted of three main sections, with each divided into two categories and a fourth focusing on demographic characteristics of respondents. The first section of the questionnaire included people's views concerning the island's agricultural production in relation with the degradation problems and the potential development prospects. The problems related to the overpopulation of the wild rabbits and the effects of their presence on Lemnos Island as well as their exploitation prospects as a biotic resource, were enclosed in the second section of the questionnaire. The third section investigated respondents' perceptions on issues associated with the island's biodiversity conservation as well as promotion and exploitation prospects of the natural environment in general.

The fourth section included respondents' socioeconomic information, such as (a) gender, (b) age group, (c) profession, (d) educational level, (e) place of residence, and (f) annual net income. Each section of the questionnaire contained both closed-ended and open-ended questions, with 23 being closed-ended (dichotomous, multiple choice, scaled) and 10 open-ended. The scaled questions were on a six-point Likert scale from entirely disagree (1) to entirely agree (6).

2.3 Questionnaire Survey

The designed questionnaire was evaluated and tested by 23 undergraduate students of the Department of Food Science and Nutrition, University of the Aegean, who were trained as interviewers, under real conditions via a pilot study that was conducted to 26 Lemnos residents. In order to ensure consistency on the procedures of conducting this survey, the interviewers during training conducted the interviews in small groups, under coaching and supervision. The final set of questionnaires was given to residents of Lemnos Island through face-to-face interviews, and clarifications were provided when necessary. The interviews were conducted, from November 2016 to January 2017, only to local permanent residents, in order to ensure that they had a deeper knowledge of the wild rabbits' overpopulation issue and an interest of its effect to their island.

2.4 Sample characteristics

A total of 318 questionnaires were collected and analyzed. A confidence interval of 95% and a sampling frame with maximum confidence level of 5.5 was calculated in order to estimate the sample size. The sample characteristics in relation with the respondents gender was 60.9% male and 38.4% female, the mean age was the group of 46 to 55 years old and the main profession was freelancers (29.1%) followed by private employees (20.6%) and public servants (18.8%). The educational level of the respondents was high, as 32.5% had graduated from high school and 30.3% from universities. More than half of the respondents (54.4%) were living in the capital of Lemnos Island, respectively to the total population distribution, and even more of them had a low annual income from 0 to 10000 euros (62.2%).

2.5 Data analysis

IBM SPSS Statistics was used in order to process and analyze survey data. The responses for the closed-ended questions were codified with numerical values proportional to each question. The research variables, according to their measurement scale, were classified on the basic types of categorical and quantitative variables in gradation scale. Chi-square statistics and one-way analysis of variance (ANOVA) were used for testing significant differences between the groups on all four sections of the questionnaire. For all cases concerning statistical control, the p = 0.05 was adopted as a minimum level of statistical significance.

3. Results and Discussion

3.1 Risks for agricultural production and effects caused by its degradation

Agricultural production's main risks are often associated to climatic conditions, pests and diseases and increasing production costs (Oerke and Dehne 2004). From the sample, 41.5% of the respondents consider that the increasing production costs have the most significant effect on agricultural production, followed by the climatic conditions (34.7%). Regarding the impact of the degradation of agricultural production, the majority of the respondents agree that the dominant problem is the depopulation and abandonment of the rural areas, but statistically significant differences were observed between age groups (X^2 (30, N = 318) = 61.135, p < .001), professions (X^2 (40, N = 318) = 69.370, p = .003) and educational levels (X^2 (35, N = 318) = 76.544, p < .0001). Despite the problems observed in agricultural production, there was a convergence of views (89.7%) in terms of focusing on cultivating local varieties for sustainable development of the primary sector of Lemnos Island. However there were significant differences between age groups (X^2 (30, N = 318) = 125.531, p < .0001), professions (X^2 (40, N = 318) = 114.581, p < .0001) and educational levels (X^2 (35, N = 318) = 153.270, p < .0001).

3.2 Economic impact, management practices and future prospects regarding the wild rabbits' overabundance

As it is well documented in scientific literature, wild rabbits may have considerable impacts on farm productivity and natural ecosystems, leading to financial loss and environmental damage (Manchester and Bullock 2000). According to this sample, two key economic impacts caused by wild rabbits on Lemnos Island were detected: (a) the decrease in harvesting agricultural crops (58.8%), and (b) the management costs due to damages (22.7%). Moreover, between respondents there was an acknowledgement that rabbits cause significant environmental damage mainly through systematic grazing (53.7%), with no statistical differences between respondents' socio-economic profile, which has an effect on preventing or inhibiting the regeneration of native species, trees and local agricultural varieties.

To prevent degradation of crops and ecosystems, respondents agreed that direct management measures were needed. It was observed that between available management practices (legal and illegal), (a) fencing and (b) systematic hunting were considered two of the most promising solutions, in regard to others (Table 1). However, a series of statistical tests of variance between variables showed that there were significant differences regarding the proposed actions, in relation to both residence area and profession for every respondent, as well as their age group.

Table 1. List of management practices related to wild rabbits population control and Lemnos residents opinion.

Management Practices	**Respondents' Perceptions (%)**					
	Entirely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Entirely Agree
Fencing	16.3	3.8	8.1	7.8	15.0	48.4
Systematic Hunting	16.3	5.9	6.3	11.3	15.9	43.8
Biological Control	43.1	7.2	8.8	9.7	8.1	22.5
Introduction of Predators	41.6	6.6	11.3	9.7	15.0	15.3
Warren Ripping	47.5	10.0	15.3	9.4	6.9	10.3
Fumigation	58.8	13.1	5.9	13.1	4.1	4.4
Poisoning	81.9	5.9	3.1	2.5	1.9	4.1
Explosives	87.5	5.3	3.4	0.9	0.3	1.9

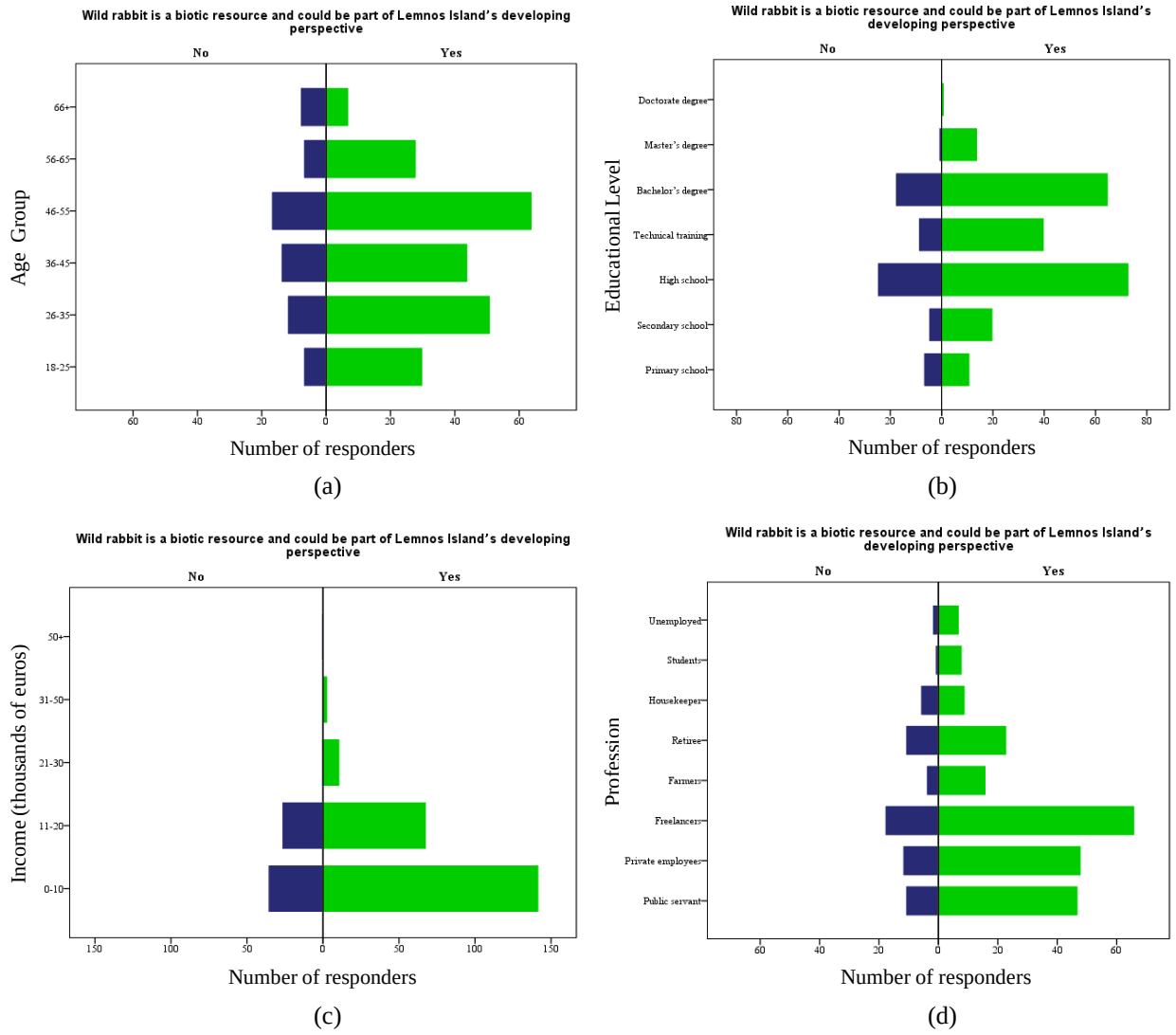

Figure 1. Perceptions (number of yes/no answers) about using wild rabbits as a biotic resource and a part of the island's developing perspective, grouped in: (a) Age Group, (b) Educational Level, (c) Income and (d) Profession.

To evaluate the nature of differences, the statistically significant ANOVA was followed-up with post hoc comparisons using the Tukey HSD test which indicated a specific group that (a) lives in areas affected by wild rabbits, (b) whose main profession is farming, and (c) belongs to the age group of 56 to 65, and significantly differ from the other respondents. This differentiation is mainly reinforced by the opinions of those affected by the overpopulation of the wild rabbit (farmers, freelancers) who live outside the Lemnos capital and belong to the higher age group (46 and above).

On the other hand, there is a general consensus between the respondents (70.3%) that the wild rabbit should be used as a biotic resource and could be operated either as a consumer product (69.1%) or via hunting tourism (53.1%) as a part of the island's developing perspective (Figure 1). Wild rabbits's meat is of significant nutritional value since it contains bioavailable micronutrients and proteins of a high-biological value, due to its increased essential amino acids composition while it is generally low in calories, fat and cholesterol (Hoffman and Cawthorn 2012). This fact in combination with wild rabbits' positive changes to hunting legislation over the past years and the slow increase of local hunting tourism, enhances the opinions for potential use of wild rabbits as a local food and touristic innovation opportunity. These new perceptions slowly acquire popularity, even though building consensus is difficult under the ongoing Lemnos WRP conflict.

3.3 Perceptions and views associated with Lemnos Island's natural environment

In general, all respondents recognize a series of pressures in the natural environment of the island which are related to habitat loss (33.1%), thyme area degradation (25.3%) and biodiversity decline (34.4%). However, differentiation between groups shows that

the importance of each pressure depends on the place of residence, occupation, age group and educational level.

Additionally, most of them (80.2%) believe in a sustainable economic development of Lemnos Island, in which the natural environment should play a critical role. This potentially could be accomplished by combining the development of (a) high quality local products, and (b) alternative forms of tourism and ecotourism, with the conservation of cultural, architectural and environmental aspects of the island. Nevertheless, no clear opinions have been detected on the process of achieving these added values from the island's ecosystem services, agricultural and natural, especially by its expanded network of protected areas both terrestrial and marine.

Conclusions

This research focused on studying the perceptions of Lemnos' residents concerning the human-wildlife conflict due to the wild rabbit population increase and its potential resolution. From these initial results, it is clear that the wild rabbit overabundance issue could be converted from a conflict field between local residents, to a biotic resource with potential economic benefits for the local community.

Even though the local community showed diverse opinions on wild rabbits' population control policies, mainly because any efforts until now had minimum and localized results causing an increase of HWC, a common vision on a sustainable local development strategy has been revealed. This consensus reinforces the increasing opinions that the commercial exploitation of wild rabbits could constitute a viable management option, as a local food source and touristic opportunity, mainly through systematic hunting. This goal requires a combination of multi-level management measures on a regional and an institutional level, but more importantly a systematic information effort to the local community.

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