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Alarm guard systems for the prevention of damage produced by ungulates in a chestnut grove of Middle Italy

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Abstract. Wildlife populations, in particular ungulates and carnivores, have had a significant increase in most Italian regions over the last decades and for this reason ecosystems and agricultural and forest productions are threatened by damage produced by wildlife. In order to evaluate effective methodologies and technologies to mitigate the impact of this phenomenon, innovative protection systems, such as electronic acoustic alarm guard sensors, were tested. These devices are able to randomly produce a significant number of sounds and light projections. At the same time, camera traps were used, as a support instrument to show the presence or absence of wild fauna. Video analysis has provided information on the effectiveness of security systems, on the most suitable methods of installation and management of devices and their ecological impact. Experimental trials were carried out in a chestnut grove located in an Apennine area of the Middle Italy during the harvesting period (autumn). The results obtained have shown that these technologies seem to be particularly suitable for crops that concentrate production in a short time (e.g. vine and chestnut) and in areas not excessively large. Widespread use of devices could mitigate the conflict between public bodies involved in the management of wildlife and farmers.

Key words: alarm guard systems, camera trapping, forest productions, wildlife populations.

INTRODUCTION

In the last fifty years, the Italian territory has undergone significant changes in the structure of the rural territory due to the radical changes in the socio-economic characteristics of the country.

Many wild animal species were strongly affected by the transformations of the agricultural and forest ecosystems. In particular, the reappearance and the spatial and numerical spread of the large mammal populations (herbivores and carnivores) was observed. Repopulation actions, not accompanied by the adoption of suitable management techniques, together with the abandonment of marginal agricultural areas and the spread of forest ecosystems, have encouraged the increase of some wild species (especially ungulates). This phenomenon has led to significant problems of cohabitation between wild fauna and human activities. In Tuscany, from 2000 to 2009 the increase of ungulates around 51% was estimated (Ponzetta et al., 2010).

The abundant presence of wild fauna has led to a series of problems such as damage that animals cause to agricultural and forest productions, in addition to those determined by carnivores (e.g. wolf) to livestock activities. In the last years, the requirement to identify suitable technologies to prevent damage has represented a primary need of the agricultural and forest sector, in order to mitigate the conflicts between wildlife and agricultural activities. In Tuscany, negative impacts on agricultural and forest crops were produced by wild boar, roe deer and deer. The kinds of damage were mainly due to the direct consumption of the product, in addition to behavioral aspects such as the search for food (browsing, rooting, fraying, etc.). The consequences of these actions were a decrease of productions and, in some cases, the modification of the evolution of the forest structure (e.g. affects the natural regeneration). Many solutions were proposed, but most of these lack information experimentally verified on the methods of realization and management of the equipment.

Among the prevention methods adopted, it is useful to remember the use of dissuasive feeding based on the stimulation of smell and taste (Avery & Mason, 1997), of shelter protections for the defense of plants, in addition to the traditional and electrified fences (Berzi et al., 2010; Capaccioli et al., 2017). In the past other acoustic alarm guard systems (e.g. compressed air or propane guns, detonators loaded with blanks, etc.), and bio-acoustic and ultrasonic emitters were widely used, especially tested on birds (Bishop et al., 2003; Arnet et al., 2013). The effectiveness of these protection systems was limited for the animals' habit towards repeated sounds and lights, which were always the same. Furthermore, not all alarm systems are worrying for the animals, also in relation to the different degree of anthropization of the environment.

The aim of the research was to verify the efficacy of last-generation remote alarm guard systems, able to randomly emit a significant number of different sounds and noises, in addition to light projections. This research was carried out to test the capacity of these devices in order to remove wildlife populations and safeguard the production of a chestnut grove in an Apennine area in the Province of Florence (Middle Italy). Camera traps were a support equipment to record the movement of animals within the protected area (Kays et al., 2009; Rovero et al, 2013). These non-invasive devices, effective in any environmental and meteorological conditions, of simple setting and installation, have recently found different applications in faunal field as for the study of habitat use patterns and behavioral patterns of wildlife fauna (Silveira et al., 2003; Bowkett et al. 2007; Rovero & Marshall, 2009; Manzo et al., 2012; Meek & Pittet, 2012).

MATERIALS AND METHODS

Electronic devices

For the purpose of the research, remote automatic devices of alarm guard and detection were tested.

The protective device was the Alarm Guard (patent N° R 2011 000010) manufactured by Ziboni srl Company. The Alarm Guard (AG) is internally composed of loudspeaker, SD card slot (1Gb), on which the audio files (in mp3 format) are archived and modified, a keyboard for setting with display and a rechargeable load acid battery of 12V – 7.2 Ah. Both the loudspeaker and the SD card slot card are equipped with their electronic circuit. The power autonomy of battery depends on the number of events recorded by the AG but if the system works well, this battery type allows a long operation time (minimum 30 days). Externally, the loudspeaker output, the passive infrared sensor (PIR), the flashing light (or LEDs) and a socket to connect the alarm guard sensor battery to any supplementary solar panels are located (Fig. 1, a, b). The hardware components are protected by a special polypropylene box, which isolates the electrical circuits and makes the device waterproof.

Figure 1. Alarm guard sensor (AG): a) device fixed on wooded pole at 1 m above ground in the study area; b) internal view of device with electrical and electronic components.

Two metal brackets for fixing the instrument on any support are placed behind the device.

The AG are automatic devices activated by timer and by the passage of animals in front of the passive infrared sensor (PIR) which, by detecting the animal body heat , triggers the emission of sounds in a random way. Sounds for animals potentially accustomed to anthropic disturbance were selected (e.g. noises of human activities), not easily recognizable by the wild fauna. The devices were also provided with high brightness LEDs (blue and white lights), which are activated before the sound emission. The detection distance of the AG is variable from 8 to 15 m, according to the setting of the sensitivity of the PIR (normal or high). This detection distance can be increased by adding wireless sensors (WS), which remotely activate the AG through a specific emission radio module. The wireless sensors can be positioned up to a maximum distance of 100 m from the main device, depending on the morphology of the territory.

The camera traps Scout Guard SG-550 model were used as device of detection. Camera traps combine a video-photographic recording device with a passive infrared sensor, working automatically in the same way of the AG. Cameras take a picture whenever they sense movement in the surrounding environment. These instruments can be set in order to define their sensitivity, the working time, the video length and the intervals between them. Pictures or videos are stored in a SD card. Another technical component of the camera is the IR-flash for night video with a detection distance of about 10–12 m.

Study Area

The study area was located in the municipality of San Godenzo (FI). The municipal territory falls partly within the National Park of 'Foreste Casentinesi, Monte Falterona e Campigna' and partly outside the borders of the Park. The study area was about 3 ha and was exclusively suited for chestnut growing. It was located at an altitude of 700 m, characterized by average slopes around 30%. The surrounding wooded areas were represented by the intercropping of oaks (in particular, *Quercus cerris*), black hornbeam (*Ostrya carpinifolia*) and chestnut (*Castanea sativa*).

The economic and historical-cultural value of chestnut growing in Tuscany until the end of the nineteenth century by the presence of over 150,000 ha was witnessed (Maltoni et al., 2009). The demographic abandonment of the mountain territories in the '70s and' 80s has led to a reduction of the chestnut areas up to about 32,000 ha. Many areas are in a state of neglect due to the recent attacks of the cinipid insect (*Dryocosmus kuriphilus*), which has strongly reduced the production. This criticality was particularly felt in the Central Apennines in order to safeguard fruit productions of recognized importance at Community level (Council Regulation EEC No 2081/92).

The study area (Fig. 2) consists of 2 areas: area A, with central watershed and a flat summit area, and area B, connected to the previous one through an obliged passage.

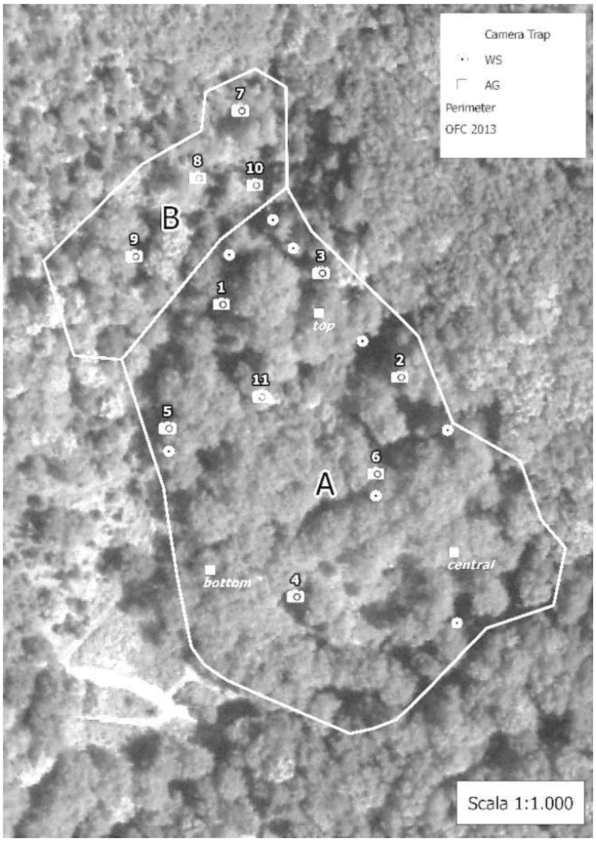

Figure 2. Study area and placement of electronic devices.

Area B is an area with few chestnut trees but with a pool of water used by animals as a watering area. For the research, the area A was considered as a protected area, while the area B as a free zone, without any protection systems.

Study design and methodology

The sampling design of trial was carried out in 4 phases for about 5 months.

The preliminary phase (1), from 23/09/2016 to 7/10/2016, has allowed to identify the access points to the study area, basing on the recognition of wildlife trails, footprints, dung piles, etc. According to them, the placement of 11 camera trap sites was selected: 7 devices were placed in area A, 4 in the top zone (No 1, 2, 3, 11) and 3 in the bottom zone (No 4, 5, 6); 4 camera traps were placed in area B (No 7, 8, 9, 10). In this phase, it was decided not to use food baits, since the fruits on the ground already represented the element of attraction.

In the phase 2 (from 8/10/2016 to 30/10/2016), 3 AG were placed inside the area A (one in the top, one in the bottom and one the central zone) when the fruits were ripe. In order to enhance the action of AG and obtain the maximum protection of the area, 8 WS were used. During the processing/working of the protection systems, camera trapping was also active with 8 devices. The sampling design of the research was flexible in terms of spatial arrangement of devices, even if the camera's detection parameters and sensitivity values of the PIR sensors were respected, in order to ensure a total coverage of the area (Tobler et al., 2008).

AG with following settings were scheduled: triggering of devices by PIR during the night time interval (5.00 pm–8.00 am), AG with maximum volume, triggering interval time after each event (1 s), high sensitivity of PIR sensor. The higher degree indicates that the devices are more easily to be triggered by motion, recording more videos. Camera traps were programmed for video length of 30 s, to allow the recognition and behavior of the target species, trigger interval time (1 s), date and time stamp on. During the trial the cameras and AG were checked every 7 days to download videos, PIR events and check the batteries.

The phase 3 (from 31/10/2016 to 30/12/2016), concerned the shutdown of the protection systems after the chestnut harvesting and the continuation of the camera-trapping, to assess the time of return of the animals in the protected area.

In the phase 4 (from 31/12/2016 to 15/02/2017), the second period of operation of the AG was scheduled.

RESULTS AND DISCUSSION

The data recorded by each camera trap, considered as a sampling unit, were elaborated in order to understand the effective functioning of the AG, in respect of the wild fauna.

The 11 camera traps were operational for 170 days, recording 188 videos for 1,870 camera days; the average video for camera trap was 17.09 No video/camera (Table 1).

Table 1. Camera traps data

	Placements	Days	Camera days	Videos	Video for camera trap (No video/camera)		
					Mean rate	Min.	Max.
Cameras	11	170	1,870	188	17.09	2	35

Estimating the frequency for each camera station, it was observed that devices No 7, 10 and 2 had higher values than the others which are between 2 and 17 trap events per camera (Fig. 3). The highest number of animals photographed per three unit areas may suggest to monitor carefully these zones placed along intensively used wildlife trails and very close to dense forest.

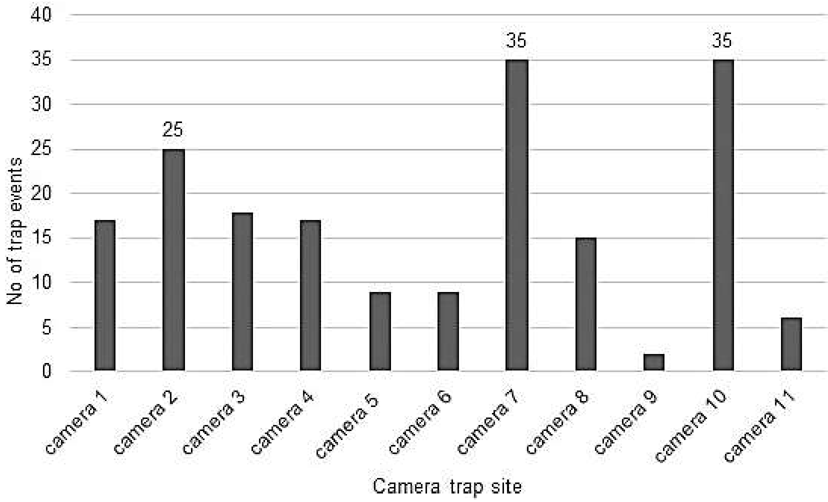

Figure 3. Frequency of detection for each **c**amera trap site.

The AG were operating in two separate periods for 71 days. In the phases 2 and 4 with AG working, the total number of videos recorded was 53: 31 events in protected area A (58%), 22 events in area B (42%). The highest values for zone A could be in contrast with the predicted forecasts, but the most conspicuous food supply of the protected area (A) could have represented an element of attraction for the animals. Behavioral analyses have been shown that attempts to enter were followed by immediate waivers for the activation of AG. The number of AG events recorded in these phases, were respectively 84 (40 AG events in the top zone, 44 AG events in the bottom and central zone), and 361 (154 AG events in the top zone, 207 AG events in the bottom and central zone), highlighting an intense wildlife activity (Table 2).

Table 2. Videos and AG events recorded for each phase

	Phase 1	Phase 2	Phase 3	Phase 4
No video – area B	5	4	57	18
No video – area A	24	2	54	29
No AG events – area A	-	84	-	361

A greater attendance of the animals in the two areas was evident when the AG were not activated (phase 1 and 3).

Another aim of the research was to assess the permanence of the animals inside the study area, multiplying the video length (30s) by the number of animals recorded. Therefore, the movie length of each event was counted and the simultaneous presence of a group of animals was evaluated in terms of grazing time (Forconi et al., 2009; Sorbetti et al., 2011). Processing camera-trapping data, it was calculated a grazing time of 3 min 30 s during the phase 2 and of 1 h 42 m 30 s during the phase 4. Most of the events (54.7%) were made by camera traps No 2 and 10, located in the top zone of the chestnut grove, while 23% of movies were made by camera traps No 4, 5, and 6, located in the central part of the study area (Fig. 4).

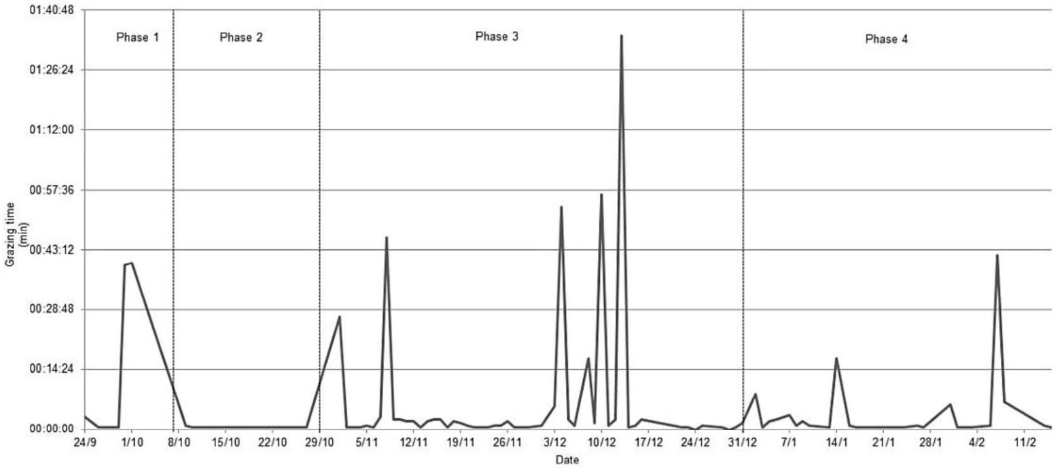

Figure 4. Wild fauna grazing time during the trial.

In phase 3, it was possible to calculate a wild fauna grazing time of 11 h 51 min 30 s: 39.8% of movies from cameras No 7 and 10 (area B) were taken, 33.9% and 14% of videos were respectively made in the top and in the central zone of area A.

Analyzing videos, it was possible to observe that the most numerous detections were made for Roe deer (*Capreolus capreolus*), Deer (*Cervus elaphus*) and Wild boar (*Sus scrofa*) during the phase 3 without disturbance. The presence of Roe deer (*Capreolus capreolus*) was more frequent, but the feeding activity of the animals inside the area was reduced if compared to the events connected to the simple passage in front of devices. Few attendance instead for other species during the working of devices were recorded.

CONCLUSIONS

The acoustic alarm guard method was particularly suitable for crops that concentrate their production in a short time, such as vine and chestnut. For surfaces that are not too large (max 2 ha) these devices were suitable. A behavior of removal in relation to the type of selected sound event was shown by the monitored animal species. Furthermore, it should be observed that this system is an ecological method of prevention, unlike traditional fences, which can represent barriers for some species and obstacles for agricultural, forest, hunting, hiking activities, etc.

The camera traps have represented a non-invasive investigation device for monitoring the ungulates reactions to the AG activation, without interfering with the animal behavior. An attitude of curiosity or indifference towards the camera traps was expressed by the wild fauna; not perceiving them as a potential source of danger. The video analysis was also useful to provide suggestions to improve the effectiveness of the AG equipment, in terms of selection of sounds and light emissions.

The effectiveness of AG cannot be separated from their correct application. Non-specialized employees can also manage these electronic devices, but it is useful to provide some essential precautions both during placement in the field and during the period of working.

At the end of trial, a positive opinion on the equipment tested was expressed by the farmer. In fact, the production of chestnuts of the year 2016 (8,000 kg) was higher if compared to that of previous years (5,000 kg in 2015).

The authors hope to disseminate the use of these devices, both through an awareness-raising project on prevention methods and through a system of supplies funded by public institutes responsible of wildlife management. The authors also suggest a continuous development of the equipment (hardware, software, etc.), to be done between companies and research institutions. Improving the performance of devices will be possible to think about the design of a remote sensor network for the protection of agricultural productions on large scale.

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