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VIGILANCE BEHAVIOUR IN ROE DEER (*CAPREOLUS CAPREOLUS* L.): PRELIMINARY DATA FOR THE ROLE OF HUNTING PRESSURE IN NP VITOSHA, BULGARIA

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Abstract: Vigilance is an aspect of animal behaviour, which is often underrepresented in camera trap studies. In the current study, we provide preliminary camera trap data analysis on the differences in vigilance behaviour in two areas of Vitosha Mountain, Bulgaria (with and without hunting pressure). Our results suggest that in locations where hunting is permitted through the year, roe deer tend to be more vigilant (explained by the heightened perceived risk) but some of them are more sedentary, spending relatively longer periods of time in front of the camera trap. This could be attributed to the supplementary feeding in the hunting area, which results in higher densities of ungulates (thus increased competition and consequently smaller home ranges).

INTRODUCTION

Camera traps have been used extensively to study biodiversity, species richness, distributions and habitat use. In recent years more and more studies were focused on animal behaviour issues, such as reproductive behaviour, feeding behaviour, intraspecies and interspecies interactions (competition, predation, etc.) and the effect of human-induced disturbance on all of these processes.

The vigilance behaviour exhibited by many species that leave the safety of their shelters to forage is relatively underrepresented in these studies. Vigilance is a type of behaviour associated with heightened perceived risk either by competitors, predators or humans. It is often costly during foraging as it decreases

the time available to locate and consume food resources. Therefore, there is a trade-off between the two, which could be influenced by a number of factors, such as food availability, predator densities, disturbance or hunting pressure, habitat visibility etc.

Most of the existing studies regarding vigilance behaviour focus on ungulates and are working on a single area with or without hunting/predation pressure (Altendorf et al., 2001, Le Saout, 2015) or during or outside the hunting season (Benhaiem et al, 2008). To our knowledge, our study is the first to study the differences in vigilance, relative to hunting pressure by comparing camera trap data from two sites sharing similar habitat characteristics, where one is in a hunting reserve (hunting is allowed through the year) and in the other hunting is allowed only during open season.

MATERIALS AND METHODS

Study area

The study sites are located in Nature Park Vitosha, Bulgaria (N 42° 33' 44", E 23° 17' 9"), on the southern slopes of the mountain. The study sites were labelled Zone 2 and Zone 6 for consistency with previous work. Zone 2 is in the area above Bosnek village, in the premises of the Vitoshko-Studena Hunting Reserve, whereas Zone 6 is located above Zhelezhnitsa village. Hunting is permitted throughout the year (and supplementary food is provided – e.g. corn) within the area of the Hunting Reserve, whereas in the other study area (serving as a control), hunting is restricted to the open season (October – February). Both study areas are inhabited by wolves (*Canis lupus*) and their effect on the roe deer's behaviour is presumed to be similar in the two zones.

Camera trapping

20 camera traps (Ltl Acorn 5210) were deployed in the two study areas (10 in each zone) between May and September 2015 (Fig. 1). The camera traps were set up on animal trails in forest habitats, according to a predetermined grid (Kilshaw and Macdonald, 2011). They were programmed to take 3 photos and a 10-sec video when activated by a passing animal, allowing the analysis of behaviour. The camera traps were checked regularly to replace batteries and memory cards.

A standard form was filled for each camera trap location, including information on the habitat characteristics. During the day, visibility was estimated (following the method used by Le Saout, 2015) by using a 1m pole with 10 alternating white and red 10 cm stripes, which was placed directly in front of the camera trap. Visibility was assessed as the number of stripes visible from a distance of 10 m in the four cardinal directions. A visibility index was then estimated as the proportion of visible stripes relative to the total number of stripes (ranging from 0 to 1, where 0 is a dense forest with low visibility and 1 is an open forest with

high visibility). For the analysis of the behaviour during different parts of the day, 3 categories were used: day – the time between 30 min after sunrise and 30 min before sunset; twilight – the time within 30 min before and after sunrise and sunset; night – the time between 30 min after sunset and 30 min before sunrise. The exact times of sunrise and sunset were taken from the Astronomical calendar of the Bulgarian Air Force (Bulgarian Air force – Meteorological Center, 2015).

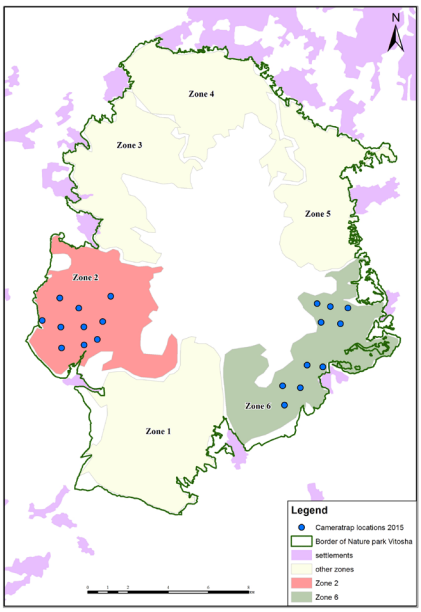

Figure 1. Map of the camera trap locations in Zone 2 and Zone 6

Behavioural data and Statistical Analysis

The resulting photos were imported and analysed through CameraBase 1.6. (Tobler, 2013) translated into Bulgarian and complemented to adapt the needs of the study (Zlatanova 2014, unpublished). A total of 652 independent roe deer registrations were recorded in 2124 camera trap nights. Relative abundance index (RAI) was calculated for the two zones as the number of roe deer registrations per 100 camera trap days (ctd). For each registration, the following parameters were estimated: total time in front of the camera (sec), time spent displaying vigilant behaviour (sec), time spent displaying non-vigilant behaviour (sec) and the ratios between them. Vigilant behaviour is described as the posture of the animal where its head is above shoulder level and it's scanning the surroundings (Appendix Fig. A1, a). Non-vigilant behaviour is any other behaviour – including grooming, browsing, feeding etc. (Appendix Fig. A1, b). Behaviour was analysed only when the head of the animal was in the frame. Photos and videos displaying roe deer, but not suitable for behavioural analysis were included in "time spent in front of

the camera", but excluded from all other calculations. Roe deer behaviour was successfully identified in 88,51% of the registrations, whereas the other 11,49% were labelled as "unknown behaviour".

Statistical analyses were performed in R v. 3.1.0 (R Core Team, 2015).

a) **b)**

Figure A1 Camera trap photos of a male roe deer displaying a) vigilant and b) non-vigilant behaviour

RESULTS AND DISCUSSION

A summary of the resulting camera trap photos and the behavioural data derived from them is presented in Table 1. Due to malfunctions of part of the camera traps the total operational time (camera trap days) is different between the two zones. The RAI shows a considerable difference in the abundance of the roe deer. In Zone 2 (within the Hunting reserve) the index is much higher, indicating a more abundant population, which is expected considering the supplementary food provided to the animals there.

Table 1. Summary of the camera trap and behavioural data

	Zone 2	**Zone 6**
Registrations of roe deer	478	174
Camera trap days	1158	966
RAI (registrations/ 100 ctd)	41.28	18.01
Number of registrations displaying vigilant behaviour	207	75
Percentage of registrations displaying vigilant behaviour	43,31%	43,10%

The number of registrations in the camera trap locations is mapped and presented in Fig. 2.

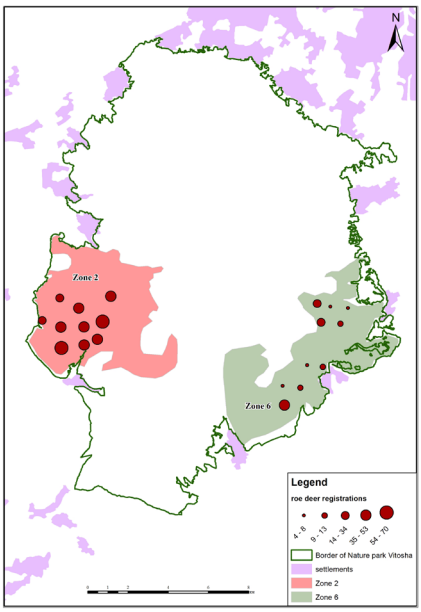

Figure 2. Roe deer registrations in the two zones

The total time spent in front of the camera (Fig. 3a) appears to be shorter in Zone 2 than in Zone 6 when comparing the median values. There is, however, an interesting distinction to be made – the presence of outliers with high values of time spent in front of the camera in Zone 2, one even reaching more than 2 minutes. It seems unexpected at first to observe individuals spending comparatively such a long time in one place, especially when faced with hunting pressure and disturbance. In our case, this could be attributed to the difference in the abundance of roe deer (and other ungulates, notably the red deer *Cervus elaphus*, which is virtually absent from Zone 6) between the two zones. The high roe deer density and the added presence of red deer in Zone 2 lead to increased competition for space and food. That in turn limits the territory that is available for foraging to a single individual and causes it to spend more time in the same location utilizing the accessible resources at hand to the maximum.

The total percentage of registrations displaying vigilant behaviour in the two zones are very similar, but the differences are visible in the analysis of the duration and proportion of vigilant behaviour in each observation (Fig. 3). The box plots for the duration of vigilant events (Fig 3b) show little difference between the zones in terms of the median and the spread of the distributions. However, a larger number of outliers are present in Zone 2, some holding values 2-3 times bigger than those in Zone 6. This could be explained again with the higher densities

(resulting in smaller home ranges and the need to avoid competitors) in Zone 2, and the data points to increased vigilance in the individuals that spend more time in front of the camera.

The analysis of the proportion of time spent vigilant in each registration (Fig. 3c) shows a noticeable difference in the two zones. Vigilance levels are higher in the zone with hunting pressure with a median of 0,67 and much lower in Zone 6 (median = 0,50) which emphasizes the role of hunting on roe deer behaviour. This is in agreement with the result of Sönnichsen et al. (2013) and Benhaiem et al (2008) that report heightened vigilance during the hunting season.

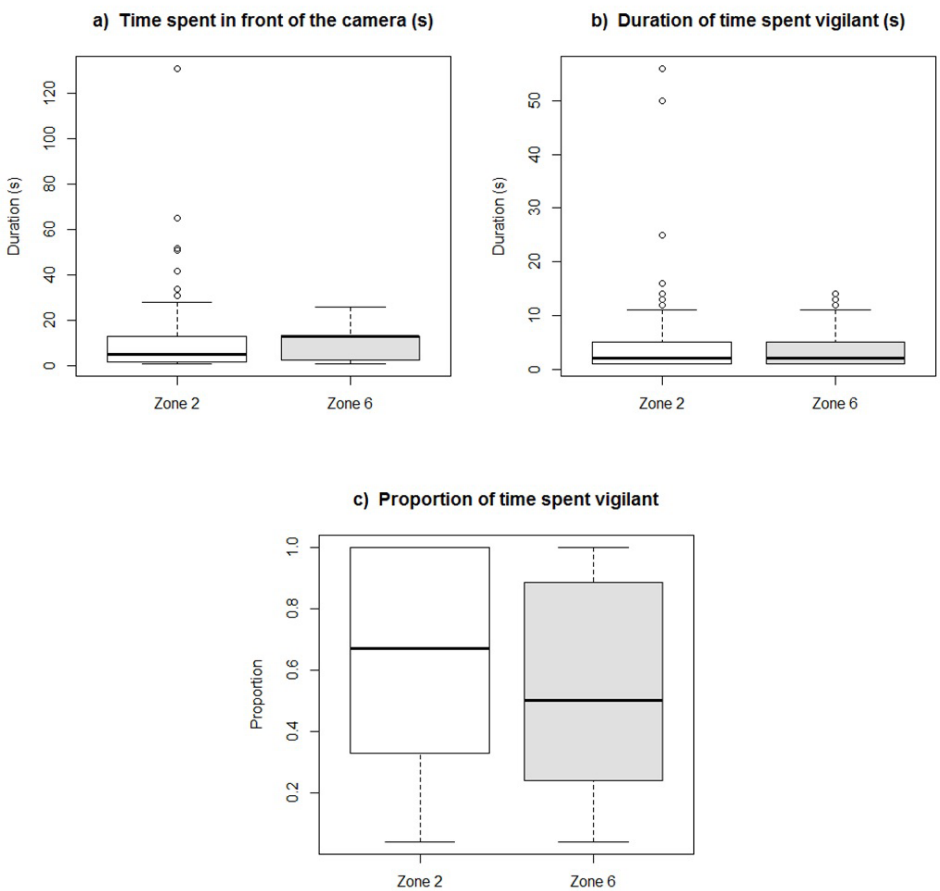

Figure 3. Effect of hunting pressure on roe deer behaviour. Total time spent in front of the camera **(a)**, duration **(b)** and proportion **(c)** of time spent vigilant in Zone 2 (in the Hunting enterprise, hunting pressure through the year) and Zone 6 (control, without hunting pressure outside of the open season)

When considering the different times of day, further patterns emerge. The number of registrations displaying vigilance during the day, twilight and night differs significantly between the two zones ($\chi^2 = 7{,}215$; d.f. = 2; $p < 0{,}05$). The proportion of the time spent vigilant (Fig.4) is higher and more variable during the day and night in Zone 2, whereas higher levels of vigilance are observed in Zone 6 during twilight. The effect of hunting is reflected in higher vigilance during the day. The increased vigilance during the night in Zone 2 could be explained by the concentrations of ungulates in the area (due to supplementary feeding) which attract carnivores. In the conditions of high hunting pressure in this area during the day, the wolves are limited in their activity patterns and need to forage during the night. Under normal conditions (in the control Zone 6) the wolves are active predominantly in twilight, which is reflected in the higher vigilance levels of the roe deer there.

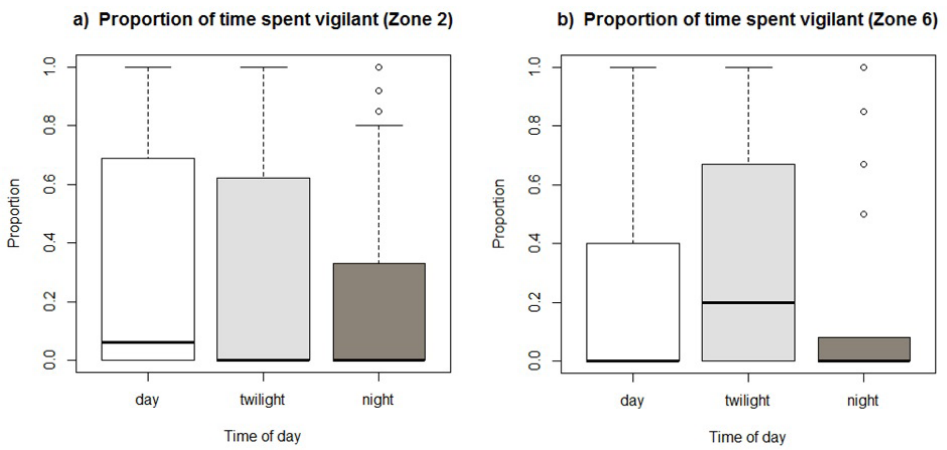

Figure 4. Proportion of time spent vigilant at different times of day in:
a) Zone 2 – with hunting pressure and **b)** Zone 6 – without hunting pressure.

The roe deer in Zone 2 are more vigilant during the day and twilight than during the night, which supports the conclusion of Eccard et al. (2015) in their similar results in Germany. The authors suggest that this is a long-term adaptation to daytime hunting. These results are also in agreement with those of Sönnichsen et al. (2013) from the Białowieza Primeval Forest in Eastern Poland.

With regards to the visibility (Fig.5), in the hunting zone locations with denser forests tend to have roe deer registrations with higher levels of vigilance, whereas in the non-hunting zone vigilance levels are relatively stable in the different visibility classes. This is in agreement with the findings of Benhaiem et al. (2008) that during the open season roe deer are less vigilant when they were close to woodland, but this is not the case outside the open season.

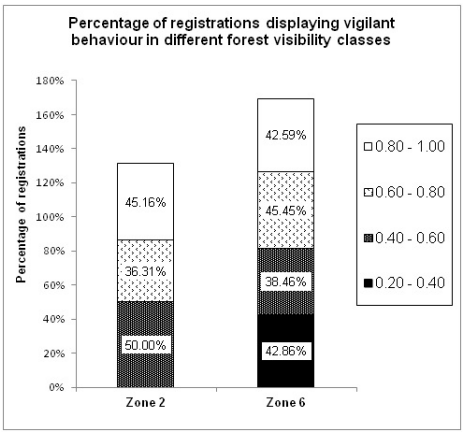

Figure 5. Proportion of time spent vigilant at different times of day in: **a)** Zone 2 – with hunting pressure and **b)** Zone 6 – without hunting pressure.

In locations where the forest is relatively dense (forest visibility class 0.20 – 0.40) roe deer are more vigilant in the hunting zone. Such habitats provide concealment to hunters and roe deer need to be more alert in order to spot a potential threat early enough. In more open forests (class 0.60 – 0.80) there is a reverse relationship – with higher vigilance levels in the non-hunting zone where the only threat can be attributed to predators. In the open forest with very high visibility (class 0.80 – 1.00) the vigilance levels are similar.

In Zone 2 the percentage of registrations displaying vigilant behaviour are lower in the open forests than in the dense forests which points at visibility as one of the factors that determine roe deer behaviour. In conditions of high visibility, the animal is capable of detecting danger much easier and thus does not need to be alert as long. This is especially true in Zone 2, where the main threat are the hunters, who can easily be heard and seen in an open forest. These results are in agreement with the conclusions of Altendrof et al. (2001) for the behaviour of the mule deer in Idaho, USA and those of Le Saout (2015) for the Sitka black- tailed deer in Canada. Kuijper et al. (2014), however, suggest that olfactory cues (in their case wolf scat) are more important than visual ones when assessing risk in dense forests.

Additional environmental and habitat variables could be studied in order to further understand the dynamics of roe deer behaviour. The seasonal shifts in territoriality, hunting pressure, foliage (altering visibility) and food availability should all be taken into account when attempting to explain the differences in roe deer vigilance. Roe deer density, presence of other ungulates acting as competitors (red deer), as well as carnivores, could also play an important role. Furthermore,

it is interesting to test the effects of characteristics such as sex, age and group size on vigilance behaviour (Lashley et al. (2014) provide an insight on white-tailed deer vigilance in these aspects).

CONCLUSIONS

The results of the current study suggest that hunting pressures does cause changes in the behaviour of roe deer that is reflected in heightened vigilance not only during the day (when hunters are active), but also at night. Forest visibility plays a role in determining vigilance levels, mainly in the hunting zone. Due to the high density of the roe deer population in the hunting zone (caused by the abundant supplementary food provided by the Hunting reserve) some individuals are limited in space by their competitors. They tend to spend more time in the same location and show high levels of vigilance.

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