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# Apostatic or Anti-apostatic? Prey Selection of Wolf *Canis lupus* L. (Mammalia: Canidae) in the Osogovo Mountain, Bulgaria

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**Abstract:** In a study conducted in 2018-2020, we tested the hypothesis that the wolf in Osogovo Mtn was selecting its prey opportunistically, with a preference for the most abundant prey (apostatic selection). To achieve this, scat analysis was performed simultaneously with prey density assessment through objective camera traps data, Random Encounter Model (REM) and selectivity analysis. The results showed that the wild boar was the most preferred prey by the wolf, complemented by the domestic horse. The roe deer had a smaller, close to insignificant share. The selectivity index also confirmed the wild boar dominance in the wolf diet, which was consistent through the years and seasons. The active selection towards wild boar was anti-apostatic in nature as the wild boar densities were 10-times lower than those of the roe deer. Our results differed from those obtained by a previous study in the same region in 2002–2003, where the roe deer accounted for 71.9% of the wolf diet. This study also showed anti-apostatic selection towards smaller prey probably formed by the decrease of the wild boar abundance in the past.

**Key words**: wolf diet, selectivity index, Random Encounter Model, anti-apostatic prey selection

## Introduction

In Europe, many studies have been conducted on the wolf’s food preferences. Generally, on the continent, the wolf diet is dominated by medium-sized wild ungulates such as wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*) and chamois (*Rupicapra rupicapra*) (Zlatanova et al. 2014, Newsome et al. 2016). The percentage of the diet consisting of large wild ungulates is also high, including mainly red deer (*Cervus elaphus*) and moose (*Alces alces*); however, their share is dominating in fewer areas than the share of medium-sized wild ungulates. Domestic ungulates are also frequently depredated in southern Europe (Newsome et al. 2016, Petridou et al. 2019), as a significant inverse correlation was found between the occurrence of wild and domestic ungulates in the diet of the wolf (Meriggi & Lovari 1996). Plant matter and even food from anthropogenic sources (garbage dumps) are also taken in varying frequencies especially in lowlands in the vicinity of human settlements (Zlatanova et al. 2014, Newsome et al. 2016). In the most northern parts of its European distribution (Scandinavian Penin-

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sula) as well as in areas of recent recolonizations, the wolf is attacking fewer species and is less prone to variation of the diet (Wikenros 2001, Ansorge et al. 2006, Müller 2006, Wagner et al. 2012, Ståhlberg et al. 2017). In Poland (Białowieża Primeval Forest), unlike some other countries, the food niche of the wolf is wider with five ungulates taking part in its diet – red deer, roe deer, wild boar, moose and European bison (*Bison bonasus*). However, being exposed to more diverse prey choices, the wolf is selecting mainly red and roe deer, driven by ecological, social and anthropogenic factors (Smietana & Klimek 1993, Jedrzejewska et al. 1994, Jędrzejewski et al. 2000, 2002, Mattioli et al. 2011, Nowak et al. 2011).

In Bulgaria, the diet of the wolf is poorly studied. The published studies were conducted in Rila, Pirin, Rhodopi and Osogovo Mtns, with often only local or partial analyses, sometimes based on a low number of samples or collected in one/two seasons (Genov et al. 2008a, 2008b, Georgiev et al. 2008, Serafimov et al. 2008, Obretenov et al. 2014). In Osogovo Mnt, where the wild boar and the roe deer are the only wild ungulate prey present, a previous study was conducted in 2002–2003 for the summer-autumn period (Stancheva 2004). A characteristic feature for most of those studies was that it was not always sufficiently explained how the primary data were obtained or analysed. A more detailed analysis of wolf scats, collected between 2010 and 2016 from Rila, Pirin and Rhodopi, was conducted in 2016 (Aznar & Guyon 2016). Despite the quality and amount of data collected, all the mentioned studies lack attempts to relate the diet to the prey abundance or density data coming from objective and robust methods. Some of these studies (Georgiev et al. 2008, Obretenov et al. 2014) try to relate the prey selection to the prey abundance but this data were taken from the annual census (taxation) of the game species, which according to more recent studies in the region, has often produced an incorrect outcome (Popova et al. 2019a).

All the mentioned studies have one thing in common – they focused mainly on quantifying the wolf preference, rarely discussing whether this was an active choice of the species or being opportunistic, i.e. the wolf was taking the most abundant prey showing *apostatic selection* (Yearsley 2003). The apostatic selection is frequency-dependent and in a predator is influenced by changes in prey abundance. When prey numbers decrease or deplete, a prey switching occurs – the predators switch from primary prey to an alternative food source (Suryan et al. 2000). The optimal diet theory (Stephens & Krebs 1986) states that predators should select for the more profitable prey, balancing between energy gain and energy loss. Thus, the balance between the prey abundance and vulnerability is essential for every predator.

Predators that select for a prey irrespective of its abundance are defined as specialists. So far wolves are considered to be generalists and opportunistic predators, relying on vulnerable prey available in their territory (Mech & Peterson 2003). However, many studies show that wolves often select for a single prey species, even when the preferred prey is less abundant. Thus, to test the hypothesis that the wolf in the Osogovo is selecting its prey opportunistically, with a preference for the most abundant prey, in the present study we combined scat analysis and prey density data derived through camera trapping.

# Materials and Methods

### Study area

The Osogovo is located in southwest Bulgaria as a trans-border mountain shared between Bulgaria and Northern Macedonia. The total area of the mountain is 4223 km$^2$, of which 996 km$^2$ are in Bulgaria. The highest peak is Ruen (2251 m a. s. l). The habitats are mainly forested consisting of beech (*Fagus sylvatica* L.), oak (*Quercus robur* L.) and hornbeam (*Carpinus* sp.). Almost everywhere, the beech outlines the upper border of the forest. The high parts of the mountain (over 1800 m) are covered by mountain pastures with spreads of juniper bushes (*Juniperus* sp.). Totally, 37 species of mammals (except bats) have been registered in the mountain (Zlatanova et al. 2005, 2018), including other two large carnivores – the brown bear (*Ursus arctos* L.) and Eurasian lynx (*Lynx lynx* L.).

Unlike other parts of Bulgaria, the wolf has always been present in the mountain (Genov & Kostova 1993). In 2003, two small (up to 4 individuals each) wolf packs were registered by transects (Zlatanova et al. 2005). Between 2016 and 2018, two packs were also recorded by camera traps in the same region – one of eight and one of four individuals (Popova et al. 2019b), as the larger pack persisted till 2020 and beyond.

In the mountain, there were also herds of horses (*Equus caballus*) extensively grazed and bred in large enclosures with electric fences at an altitude of about 2000 m. No other livestock has been grazed in the study area since 2012.

Because of its location (protected border area), Osogovo has relatively well-preserved habitats and low anthropogenic pressure. On the other hand, the strict border control until the end of the 1980s defined the Osogovo as one of the least studied mountains in Bulgaria. The whole study area lies within the management of the State Hunting Enterprise (SHE) Osogovo, where hunting is all year round, organized on a small scale for individual hunters or small hunting groups.

### Collection and processing of samples

The scat samples were collected during three subsequent years (2018–2020) along transects visited every month from April to November. The scats and the area around were carefully inspected also for footprints; in case of doubt, the samples were not collected. The excrements were placed in a plastic bag with a label for date, GPS location, collector and habitat where they were found. Totally, 127 scats were collected for the whole study period:

- 2018 – $n_{total} = 42$, $n_{spring} = 15$, $n_{summer} = 2$, $n_{autumn} = 25$;
- 2019 – n = 25, $n_{spring} = 12$, $n_{summer} = 2$, $n_{autumn} = 11$;
- 2020 – $n_{total} = 60$, $n_{spring} = 53$, $n_{summer} = 6$, $n_{autumn =}$ 1;

Seasonally the samples were distributed as follows: $n_{spring} = 80$, $n_{summer} = 10$, $n_{autumn} = 37$. The lower number of the summer samples was a consequence of the higher anthropogenic disturbance (tourism, berry and mushroom collection) during this season. According to the camera traps, the wolves stay in the area, but they are less prone to leave scats in open areas or dirt roads.

Due to lack of disturbance in 2020 following the COVID lockdowns, the number of scats collected was almost the same in total as for the both previous years.

The scats were analysed according to the methodology used by Kruuk & Parish (1981). In the lab, each sample was placed in 95% alcohol to avoid contamination with parasites dangerous to humans. Then the samples were washed through a sieve with a mesh width of 3 mm, removing soil, unprocessed leaves/grass and stones. Macrocomponents were divided into three parts – foods of plant origin, animal origin and anthropogenic origin. The microcomponents were identify using a binocular and with the help of external specialists (botanists, herpetologists, ornithologists, entomologists, etc.) if needed.

Each type of food / prey species was presented as a percentage, using the seven-point scale (Kruuk & Parish 1981): 0%, up to 5%, 6-25%, 26-50%, 51-75%, 76-95% and 100%. The data were presented in the results as frequency of occurrence ($F_i$%) determined for each food type – the ratio of the amount of each food type ($n_i$) in percentages to the total number of excrements (N) (Lockie 1959):

$$F_i\% = \frac{n_i}{(N.100)}$$

### Selection of prey

Ivlev selectivity index (Ivlev 1975) was used to determine the wolf preference for its prey:

$$E = \frac{R_I - P_i}{R_i + P_i}$$

where E is the selectivity index, Ri is the percentage of the animal species in the collected scat and Pi is the relative density of the prey species in the study area calculated through the Random Encounter Model (REM) (Rowcliffe et al. 2008). The index varies in the range between -1 and +1, with negative values indicating avoidance or unavailability of prey, zero indicating random selection from the environment and positive values indicating active selection.

Selectivity index for horses could not be developed as their number was controlled by people on irregular, difficult to predict bases. Additionally, the horses were exposed to easy predation being constrained by electric fences, so this limitation put this prey under incomparable to the other prey conditions. Thus, we has conducted selectivity index analyses only for the wild prey.

### Identifying the population density of the wolf, wild boar and roe deer in the mountain

The data were collected for the three years (2018–2020) from 21st of March to 20th of December by 10 camera traps (Scout guard, Keepguard, Cuddeback and Bestguarder) placed along or around the transects (Fig. 1). The camera traps were set up opportunistically at specific sites chosen to maximize animal detection – typically on animal trails, away from attractants (feeding sites or water). The altitude of each camera trap location was measured with a GPS and varied from 737 to 1387 m a.s.l. (average = 1096). All cameras were placed on trees, between 40 and 130 cm above the ground, operating in a continuous 24-hour cycle. The camera traps were set to shoot three photos (5 seconds apart) and a 10-second video to maximize the chances of capture. The next series of photos and a video could be taken one minute after the previous triggering. A standard form was filled for each camera trap location, describing habitat characteristics. The footage was processed in Camera Base v.1.7 (Tobler 2015). Photos and videos of prolonged stay (up to 5 min) of the same individual/individuals in front of the camera trap were considered as only one independent registration to avoid overrepresentation of the species.

The data were collected for 1137 trap days (av. 379 per year), with totally 991 independent registrations of the wild boar, roe deer and wolf (Table 1).

The Random Encounter Model (REM) (Rowcliffe et al. 2008) was used to model the local prey population densities without the need for individual recognition. The independent registrations, camera traps parameters (detection distance and angle of shooting) and animal mobility were used as modelling parameters. The formula below is converting the percentage of independent registrations from the camera traps to the species density D (individuals/km$^2$) by the function of the registration frequency (the number of registrations for a given unit time, y / t), speed of movement (v) and size of the detection zone of the model traps (r and θ):

$$D = \frac{y}{t}\,\frac{\pi}{vr(2+\theta)}$$

where y is total number of independent registrations of the species from the camera traps; t is total residence time of the camera-traps (total number of trap days for all traps); π is the number Pi; r is distance of detection of the object at registration (in km); θ is angle (arc) of registration = angle of view of the camera in radians; v is speed of movement (mobility of the species – distance travelled per day) in km.

The movement speed of the wolf, wild boar and roe deer for similar habitats were taken from published literature with GPS fix frequencies (Hinge 1986, Karamanlidis et al. 2017, Jánoska et al. 2018). For the three species, which often are detected in cohesive groups, a modification of the formula was used – each independent registration was considered as a group registration. In this case, D is obtained by multiplying the initial density in the formula to the mean number of individuals detected for each species.

The density analyses were conducted towards the yearly data (for each of the years 2018, 2019 and 2020) for the wolf, the wild boar and the roe deer and towards the three seasons (spring, summer and autumn combined for all years for the two wild ungulates only). The wolf registrations for each season were not enough to provide for the requirements of the REM model. Winter was not considered in the analyses as no scats were found during this season due to heavy snows in the mountain.

## Results

Only three prey species were found in the scats, i.e. the wild boar, the domestic horse and the roe deer. The wild boar was the most preferred by the wolf

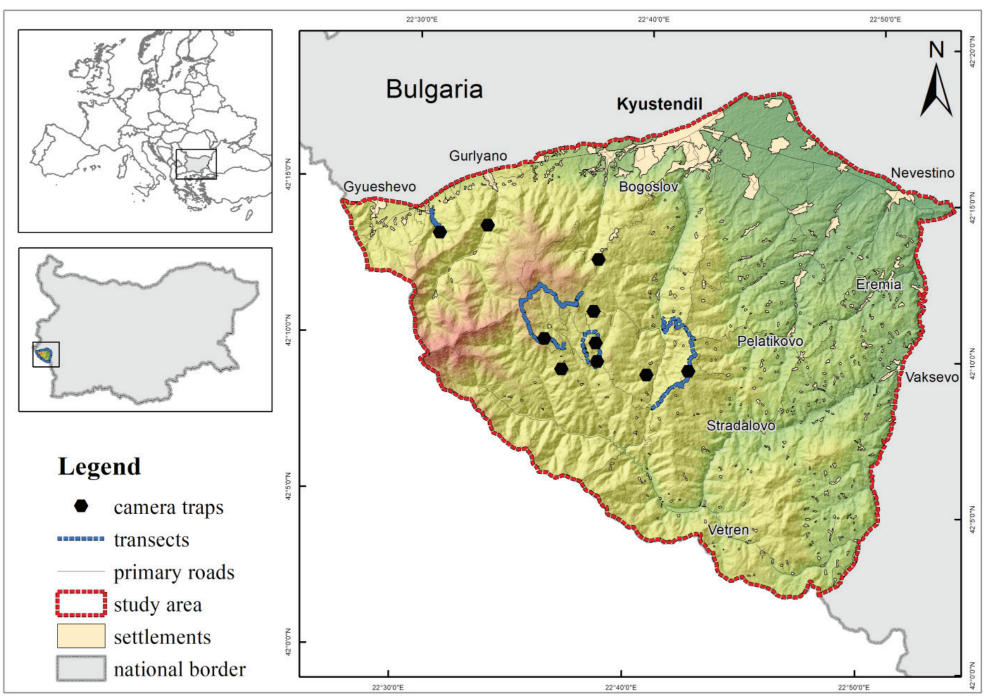


**Fig. 1.** Study area with camera trap sites and location of transects for scat collection

prey in the Osogovo, while the roe deer had a much smaller, even insignificant share (Fig. 2). During the first two years of our study (Fig. 2a), the domestic horse was second in place of importance for the wolf's diet. Due to insufficient care by their owners, the horse herds experienced high vulnerability caused by heavy snows and lack of natural food, making them easy prey for the wolves in the area. Additionally, this neglect of the horses by the owners let to elevated horse mortality and, thus, to an abundance of the carcasses utilized by the wolves. Due to this, most of the free-ranging horses disappeared in 2020; as a result, the roe deer percentage increased significantly.

No plant components, anthropogenic elements or any other food sources were found in the scats.

The wild boar was dominating again throughout the three seasons (Fig. 2b). In summer, the share of the domestic horse and the roe deer increased, while in the autumn the wild boar was prevailing with almost 90 %.

The wolf increased its density three fold the last year (2020), while the wild boar and the roe deer densities showed a gradual decrease (Table 2). The calculated wild boar densities were 10-times smaller than those of roe deer.

Seasonally, an increase was observed in the summer for the two ungulates, most likely due to the birth of the new offspring (Table 3). In the autumn a noticeable decrease was identified in the density of both prey species.

The selectivity index developed for wild prey showed a clear negative value for the wolf's preference for roe deer – yearly and by seasons (Fig. 3) – despite the several times higher density, the roe deer was not preferred by wolves. In the autumn, the preference of the wolf for the wild boar was the highest.

**Table 1.** Number of independent captures per species from the camera traps

| Years | Wolf | Wild boar | Roe deer |
|---|---|---|---|
| 2018 | 3 | 123 | 227 |
| 2019 | 9 | 138 | 195 |
| 2020 | 12 | 142 | 142 |

**Table 2.** Density of the wolf, wild boar and prey by years according to the REM model

| Years | Wolf | Wild boar | Roe deer |
|---|---|---|---|
| 2018 | 0.02 | 1.13 | 8.14 |
| 2019 | 0.02 | 1.10 | 6.83 |
| 2020 | 0.06 | 0.59 | 5.22 |

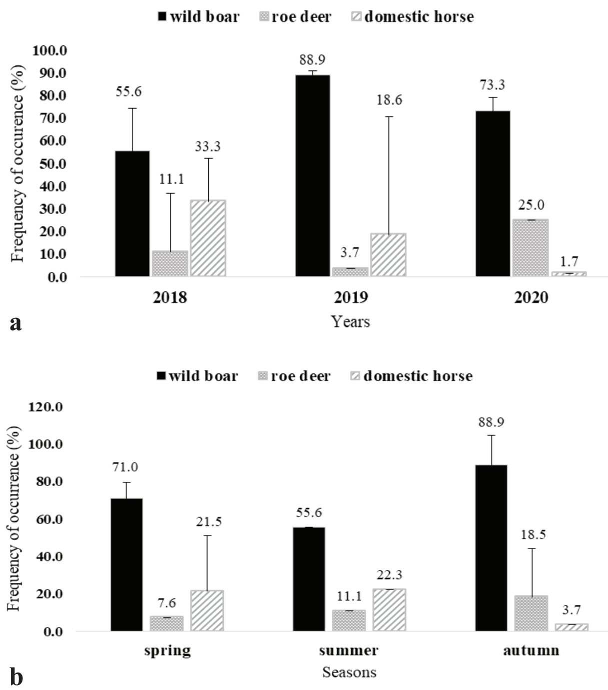


**Fig. 2.** Frequency of occurrence of the prey in the wolf diet in Osogovo Mtn for the period 2018–2020 by year and season. The data are presented in % with standard deviation (whiskers). a. Frequency of occurrence of the prey in the wolf diet by study year. b. Frequency of occurrence of the prey in the wolf diet by season

## Discussion

Analyses for the predator-prey relationship based on objective data is vital for both the conservation of all concerned species and for solving the conflict with hunters. Yet, most of the contemporary surveys usually include only diet studies through scat or stomach content analyses (Zlatanova et al. 2014, Newsome et al. 2016). Although these methods may be robust *per se*, they are too simplified for identifying such a complex relationship if applied separately from abundance or density data. Providing absolute data for the wolf diet (scat or stomach analyses only) is not informative if not compared with abundance or density data obtained robustly from objective methods. Many studies provide proof that there is a discrepancy between the results of scat analyses only and scat and selectivity analyses; e.g., the highest percentage of the red deer in the wolf diet compared to the roe deer and wild boar in Germany (Ansorge et al. 2006) was actually a zero-bounded index in the wolf selectivity (SI = -0.02).

In some studies, where abundance/density data were yet taken into account, it was usually de-

**Table 3.** Density (individuals /km$^2$) of wild boar and roe deer by seasons, according to the REM model

| Years | Spring | | Summer | | Autumn | |
|---|---|---|---|---|---|---|
| | Wild boar | Roe deer | Wild boar | Roe deer | Wild boar | Roe deer |
| 2018 | 0.35 | 7.77 | 2.76 | 15.41 | 0.77 | 3.07 |
| 2019 | 1.56 | 10.63 | 1.46 | 10.49 | 1.43 | 4.5 |
| 2020 | 0.48 | 4.29 | 1.10 | 8.13 | 1.05 | 4.1 |

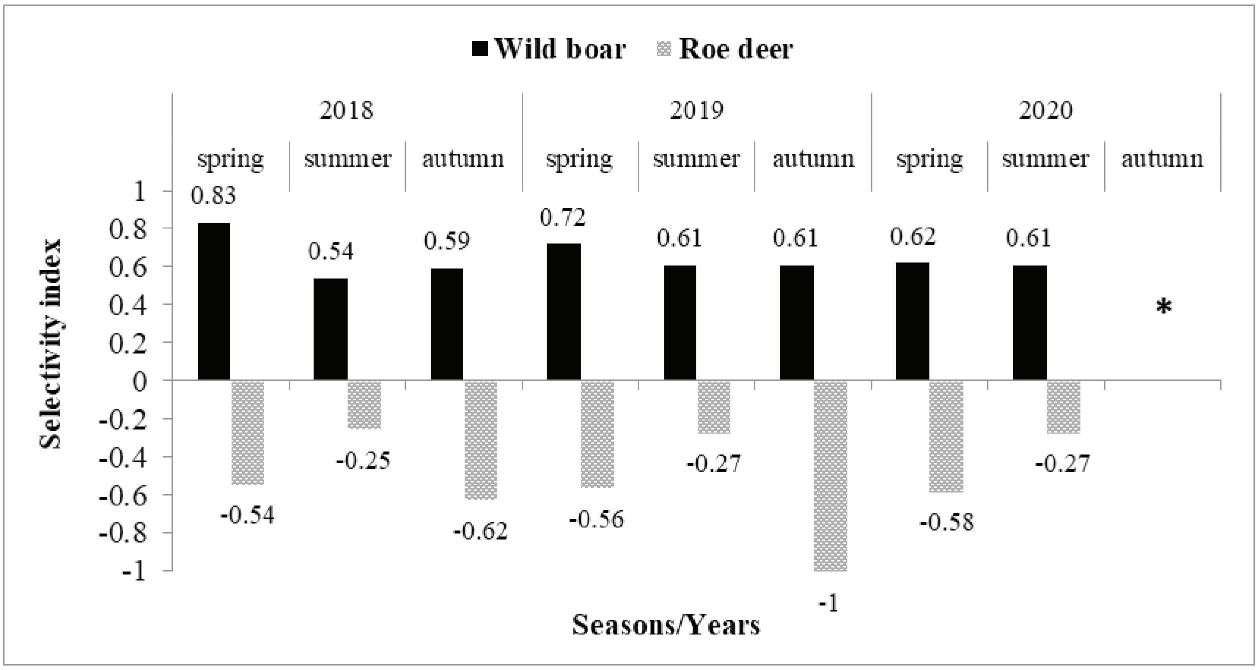


**Fig. 3.** Wolf's prey selection for wild prey presented as selectivity index by year and season. For autumn 2020 (marked by *), the data were not considered due to low sample size (only one scat found). The index varies in the range between -1 and +1, with negative values indicating avoidance or unavailability of prey, zero indicating random selection from the environment and positive values indicating active selection.

rived from hunters/forestry inventories (Okarma 1995, Georgiev et al. 2008, Meriggi et al. 2015, Mengüllüoğlu et al. 2019). As being said before, this approach is highly inaccurate and prone to many biases without a possibility to measure the error or uncertainly in the forest census data. Very few studies were using collection methods based on more objective ungulate abundance data such as, e.g., faecal pellet group counts (Sin et al. 2019). According to our knowledge, there is only one study (Mengüllüoğlu et al. 2019) that has tried to combine partially the diet study from scat analysis with abundance/density from camera-trapping.

The comparison of our results with the published data about the wolf diet in the neighbouring countries showed similarities with Romania (Sin et al. 2019), Turkey (Mengüllüoğlu et al. 2019) and Croatia (Octenjak et al. 2020). In these countries, despite the presence of other prey (red deer, fallow deer and chamois), the wild boar was still dominating (yearly and seasonally) in the wolf diet. In our study, even in the presence of an alternative vulnerable prey with high biomass such as the domestic horses, the wild boar was still the most significant prey. This contradicts the statement of Okarma (1995) that the wild boar was generally avoided by the wolf in Europe. Numerous studies from Southern Europe, not only on the Balkans but also in Italy (Meriggi et al. 2015, Mori et al. 2017, Ståhlberg et al. 2017), pointed out that the wild boar was the most preferred. Additionally, a study in Italy (Mori et al. 2017) found that the number of prey species did not influence the occurrence of wild boar in the wolf diet. The comparison of our results (where the choice was limited to only two species) with those of the adjacent countries with more diverse ungulate prey, and also with areas in Bulgaria where the red deer was present (for example Rhodopi, Rila and Pirin Mtns) confirmed again the absolute dominance of the wild boar in the wolf diet. One of the possible explanations is that the wild boar with its larger number of individuals in herds is much easier to detect by sound and smell (Mori et al. 2017), unlike the deer (red and roe), which move in much smaller groups (Mattioli et al. 2004).

In our study small but a still noticeable decline of wild boar and roe deer density was observed for the period 2018–2020. Possible causes might be poaching, heavy snow or disease-caused mortality. The pressure from the wolf could be excluded as a factor because the wolf density was still within the carrying capacity of the area. In 2020, though a three times higher wolf density was recorded, possibly due to the low disturbance and reduced hunting pressure resulting from COVID-19 lock-down and government restrictions. No African swine fever (ASF) cases were recorded in the mountain yet; the outbreak of ASF might cause a significant change in the wolf diet (Valdmann & Saarma 2020) as already recorded in other countries. This might put more severe pressure on the only alternative wild roe deer and at the same time to diversify the diet with more prey species.

The seasonal densities of the two ungulates vary logically, following the winter mortality or lost fitness of the ungulates due to lack of food (spring), the birth of the new generation (summer) and the natural drop out of the offspring due to predation and diseases (autumn). The highest preference for the wild boar (88.9%) was expressed in autumn when piglets of the same year and yearlings form a bigger share of the wolf's diet (Mattioli et al. 2004, Sin et al. 2019). Still high but a little less was this preference in the spring (71%) when the wolf not only hunted on horses but also feed on carcasses exposed out of the snow after the winter mortality. In the summer, the drop of this preference was complemented with a bigger share of the domestic horse and roe deer, as the latter might be easily hunted during the breeding season (July to mid-August in Osogovo Mtn) due to higher visibility and less alertness of the bucks. In Arezzo, Italy, where the density of wild boar and roe deer populations was similar to the densities in the Osogovo (Mattioli et al. 2004), the wolves did not actively hunt the roe deer but encountered them more frequently in search of wild boar herds when their visibility was higher.

The selectivity analysis was needed to confirm whether the results of our study were an opportunistic trait based on the most abundant species (apostatic selection) or an active selection based on preference to less abundant prey (anti-apostatic selection) (Yearsley 2003). The selectivity indices for the yearly and seasonal preference confirmed the active selection of the wolf for the wild boar. Although the density of the roe deer was significantly higher than that of the wild boar and relatively higher compared to other studies conducted both in Bulgaria (Popova et al. 2019a) and in other European countries (Jędrzejewska et al. 1997, Ansorge et al. 2006, Iannuzzo et al. 2010), it was still not preferred by the wolf.

Our results from scat analyses differed from those of the previous study in 2002–2003 in the same region (Stancheva 2004), where a dominance (71.9%) of the roe deer in the wolf diet was noted. Additionally, the wolf diet then was found to be more diverse, including further the wild boar (9.4%), murid rodents (9.4%), stone marten *Martes foina* (1.5%), brown hare *Lepus europaeus* (1.5%) as well as domestic dog *Canis familiaris* (4.7%), livestock (sheep, goats and calves – 9.3%) and even fruits such as cherry plum (*Prunus cerasifera*) and cornelian cherry (*Cornus mas*) – about 10%. The much more diverse food components in the wolf diet was in accordance with findings from Italy (Meriggi & Lovari 1996) that the diet breadth increased as the presence of large prey in the diet decreased. According to the official census in 2002 and 2003 (no available objective data, e. g. from camera traps or pellet counts for this period was present), the wild boar numbers were twice larger than those of the roe deer (Stancheva 2004) – e.g. again this selection of prey was an anti-apostatic active choice (Yearsley 2003). One of the plausible hypotheses for this preference for the roe deer was the small pack sizes – up to four wolves per pack (Zlatanova et al. 2005) versus a pack of eight wolves in 2018–2020. This hypothesis was built under the assumption supported by many authors that the bigger packs were formed to hunt for larger animals as a larger group facilitates the acquisition of large biomass prey. This assumption was challenged by a study (Schmidt & Mech 1997), which found no evidence that an increased pack size resulted in increased food acquired per wolf. Even more, it made two major conclusions: 1. There was an inverse relationship: less food per wolf was provided as pack size increased; 2. According to many studies, single wolves could kill alone even the largest prey such as moose and bison, and even in large packs, the adult pair made the kill. In larger packs, the adult pairs share with their offspring experience and the surplus food, thus maximizing the survival chances of the new, more numerous generation (kin-selection theory).

The difference in the wolf preference between the two periods may be due to switching to other species because of prey depletion (Yearsley 2003). According to the official census, the numbers of the roe deer in SHE Osogovo had never decreased; even more, they showed a small but constant increase since 2002. The recent study of the wolf diet changes after the outbreak of ASF supported an assumption for a diet shift because of prey decrease (see Valdmann & Saarma 2020); the wolf food niche in 2002–2003 was much broader due to the dominance of prey with less biomass such as the roe deer. This shift might happen already in the 1990s when the mountain was not part of a state hunting structure and thus the game was unprotected to poachers. Due to the rapid political and social changes after 1989, poaching was widespread, affecting predominantly the large-bodied game such as the wild boar. After the establishment of SHE Osogovo in 1996, a gradual but permanent increase of the ungulate numbers was noted, allowing for a more natural selection of prey for the wolf.

The only study in Bulgaria with a similar to our approach combining the wolf diet analysis with selectivity index was conducted in another area – SHE Chepino in Western Rhodopi Mtn (Georgiev et al. 2008). This study was showing a very high density of wolves (0.09 ind. / km$^2$) with a preference for the red deer. It was based on disputable densities of the ungulates coming from the official forestry census, with no clear methodology for data acquisition. The questionable ungulate densities did not allow for direct comparison with our study.

Two other wolf diet studies in Western Rhodopi also used the official census data for density estimation for the wolf and ungulates (Genov et al. 2008b, Serafimov et al. 2008). Both studies also found the prevalence of the wild boar in the wolf diet, despite that the roe deer density was always pointed out as the highest among all ungulate species in the respective study areas.

A comparison of two studies in Poland with ours showed that in indigenous range or long-term established presence (Nowak et al. 2005) the wolf was not selecting the most abundant prey *(*anti-apostatic selection), while in case recolonizing new areas (Nowak et al. 2011) it would prey on the most abundant ungulate *(*apostatic selection), usually the roe deer. Similar results for expressed selection rather opportunistic choice for the most widespread species were obtained in central and southeastern Estonia (Valdmann et al. 1998), Latvia and Estonia (Valdmann et al. 2005), Poland (Jędrzejewski et al. 2000), Germany (Ansorge et al. 2006) and Italy (Mattioli et al. 1995, 2011). The latter two studies for Italy were showing a very clear anti-apostatic selection of the wild boar in the wolf diet, as the selectivity of this species remains paramount despite the fluctuations of its density or even rapid decline. Moreover, in a high-density multi-species ungulate community, where the choice was between four species of prey (some of them, like the fallow deer, of similar biomass), the wild boar was still preferred (Mattioli et al. 2011). Another study (Meriggi et al. 2011) found that the wolf diet, which included livestock depredation, might change as the wolves would switch to wild prey if its abundance increase (apostatic selection of wild prey). This strategy is logical as the wild prey is less risky to hunt compared to the human response to livestock attacks.

# Conclusion

The cross analyses and comparison of our results with published data (local, national and cross-country) justified the rejection of the hypothesis for apostatic selection of prey in Osogovo Mtn. The wolf showed a clear preference for the wild boar, which was present in less density than the roe deer (anti-apostatic selection). The same was observed for the previous study in the same area. Being a complex trait in nature, the prey selection should be studied not only quantitatively but also in a spatially explicit way considering also the pack size territory, habitat components and anthropogenic factors. Thus, the camera traps prove to be a valuable tool for such research and have to be applied in any diet study. In the areas of indigenous and uninterrupted wolf presence, the species shape the populations of its prey, playing a significant role in its selection and populations fitness. The conflict with humans, however, leads to changes in the density and social structure of both predator and prey, re-shaping their populations and may disrupt conservation efforts. Thus, new approaches must be sought (non-invasive and inexpensive) to be applied broadly with a unified approach to answering the constantly raising questions regarding the predator-prey relationship.

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