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A brief study on the Grey wolf (*Canis lupus*) diet on the Northern slopes of Central Stara Planina Mts, Bulgaria

Blagoy Koychev[1*] and Katelina Uzunowa[2]

[1]Department of Forest Ecology, Forest Research Institute, Bulgarian Academy of Sciences, Sofia, 1756, Bulgaria. *E-mail: palaearctica@gmail.com
[2]Department of Animal husbandry – Non-ruminant animals and special branches, Faculty of Agriculture, Trakia University, Stara Zagora, 6000, Bulgaria. E-mail: ky.uzunowa@yahoo.com

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Abstract

The diet of the Grey wolf (*Canis lupus* Linnaeaus, 1758) in the mountainous region of central Bulgaria was studied. Based on 200 excrements collected and analyzed, it was found that among wild ungulates, remains of red deer *Cervus elaphus* were the most frequent (20.9 %), followed by roe deer *Capreolus capreolus* (15.6 %) and wild boar *Sus scrofa* (12.6 %). The most preferable prey for wolf was the horse *Equus caballus* (33.5 %), and domestic ungulates consumption included also cattle (7.28 %). In the studied region, the consumption of horse biomass (34.3 %) was also the greatest, followed by that of roe deer (19.2 %) and red deer (18.0 %). Rodents, sheep, hares and wild cats are considered additional food sources for the species. It can be concluded that the studied near-natural habitat offers the wolf a diverse food base and that it benefits approximately equally from wild and domestic ungulates.

Key words: excrements, food, livestock, predator, victims, wild ungulates.

Introduction

The Grey wolf (*Canis lupus* Linnaeus, 1758) is the second largest predator found in Bulgaria, primarily in mountainous regions, which comprise one-third of the country's territory. Although the species has faced intensive hunting in the past, it has not been severely eradicated due to conflicts with humans (Mihaylov and Stoyanov 2012). According to the IUCN Red List, the Grey wolf is considered Least Concern and can be hunted throughout the year. The study of its feeding behaviour is crucial for understanding its role as a regulator of prey populations and resolving conflicts with gamekeepers and farmers. The wolf primarily attacks domestic animals in areas with developed animal husbandry (Vos 2000, Sidorovich et al. 2003, Migli et al. 2005, Nowak et al. 2005, Russo et al. 2014). This behaviour is often linked to the abundance of its natural prey, such as wild ungulates (Sidorovich et al. 2003, Zlatanova et al. 2014). The availability of food and migra-

tion patterns of its natural prey influences the wolf's behaviour towards livestock (Nelson et al. 2016). The wolf is an opportunistic species that takes advantage of the most available food sources to survive (Meriggi and Lovari 1996). It also relies on carrion from large ungulate game, such as American bison in North America (Jung 2011), cows, and domestic pigs in Europe (Jędrzejewski et al. 2002). The wolf is considered a facultative scavenger occupying the food resource found (Wirsing and Newsome 2021). It is well known that in the specific conditions of Bulgaria, the wolf is hunted by attracting with carrion, especially in the Eastern Rhodopes Mountains (Mts), Strandzha Mountain (Mt) and Sakar Mt.

Its feeding behaviour in Stara Planina Mts is poorly studied. The current study relies on fecal sample analysis, a non-invasive tool in line with modern ecological trends. Information on the wolf's diet in Bulgaria is limited to the Osogovo Mt (Dolapchiev 2019) and the Western Rhodopes Mts (Georgiev et al. 2008).

The aim of the present study was to investigate the feeding behaviour of the Grey wolf (*Canis lupus*) in a near-natural habitat – the central part of Stara Planina Mts, Bulgaria.

Material and Methods

Study area

The study was conducted on the northern slopes of the Central Stara Planina Mts (Fig. 1), centered around N 42°49'59.83'' E 25°00'20.74'', 582 m a.s.l., covering an area of 784 km^2. It included the State

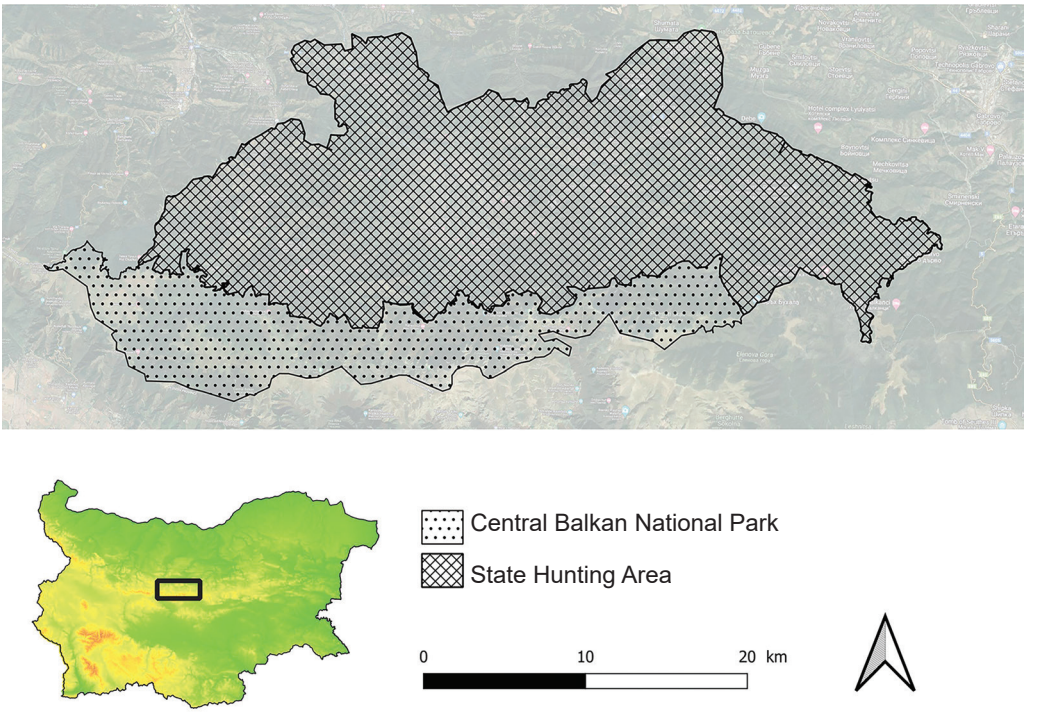

Fig. 1. Study area.

Hunting Enterprises 'Rusalka' and 'Rositsa' to the north and a part of the Central Balkan National Park to the south.

Big game, including red deer (*Cervus elaphus* L.), roe deer (*Caprolus capreolus* L.), wild boar (*Sus scrofa* L.), and in the highest parts, wild goat (*Rupicapra rupicapra* L.) is keeping on the territory. The area above both game preserves and lying on the main mountain ridge constitutes the Central Balkan National Park, where hunting is prohibited and the animals are not disturbed. Most of this area (above 1300 m a.s.l.), consists of meadows used for grazing by cattle (*Bos primigenius taurus* L.), horses (*Equus ferus caballus* L.) and sheep (*Ovis aries* L.) from May to September. The latter are guarded by shepherds and dogs, while some cattle herds are left unguarded by their owners and the horses are completely free-ranging. During spring, when cubs are born and reared, the wolf occupies isolated areas (Mech and Boitani 2003, Spassov 2007, Spiridonov and Spassov 2015). At that time, various activities, such as logging and game management, are carried out in the State Hunting Enterprises. At the beginning of summer, most wild ungulates are concentrated in this so called 'calm zone', around the upper boundary of the forest.

Sample collection and processing

One of the most widely applied non-invasive methods for determining the carnivore's diet is the analysis of undigested plant and animal components in their excrements (Putman 1984). The accuracy of the obtained results for each prey species increases significantly when more than 200 feces are collected as a representative sample for the wolf's diet (Marucco et al. 2008).

A total of 200 wolf excrements were collected between October 2017 and October 2020 along forest roads and animal paths in their habitats. The transects were cleared out of already deposited excrements before the first sampling, in order to start collection of fresh samples after a month. The feces were sampled every month during the study period. The morphology and specific odor of the samples were taken into account to determine species affiliation. Laboratory procedures followed those described by Reynolds and Aebischer (1991) and Ciucci et al. (1996). The samples were heat-treated in autoclave for 90 min, washed under running water through a 2 mm sieve, and then air-dried at room temperature. Electronic scales were used to weigh each food component up to 0.01 g for estimating biomass consumed. Undigested food items were hand separated, as it is widely used in quantitative fecal analysis (Ciucci et. al 2004). Undigested remains of mammalian bones, teeth, hoof, and hairs were identified by referring to collections of specimens from the study area deposited in the Museum of Natural History and Trakia University, Bulgaria. Most of the food items found originated from small number well distinguishable large ungulates by hairs' structure. For this reason a microscopic analysis of hairs wasn't applied. The help of a specialist (E.R.) in hairs' discrimination at a species level was used. The macroscopic hairs' characteristics (thickness, shape and color) were estimated under a 10x lens. Unspecified elements did not exceed 2 % of the total amount and were excluded from the analysis. The relative frequency of occurrence (RFO %) of each food component was calculated by dividing the number of occurrences of a particular food component by the total number of all food components. Components with

RFO values of up to 1 % in the samples were excluded from the analysis. The importance of easily digestible food items however, may be underestimated by this method (Klare et al. 2011). To complement this method (Okawara et al. 2018), the weight ratio of food components was also calculated, using the following regression equation: $y = 0.439 + 0.008x$, where y is the air-dry weight of prey remains in each excrement sample and x is the sought ingested and digested biomass (kg), as described by Weaver (1993).

It was possible to distinguish between young individuals (juveniles) and those over 1 year old of roe deer by the size of hooves found in the samples (Fig. 2).

Results and Discussion

Losses of game, livestock or crops could be of great economic value. Revealing feeding behaviour of medium-sized and large carnivores is useful for understanding their 'economic food niche' (Litvaitis 2000).

A total of 194 samples wolf's feces (97 %) contained a single component and 6 samples (3 %) contained 2 components. Of all two-component samples, only one contained traces of a third species (hedgehog fur), which was most likely ingested with the stomach contents of a first-order victim, and was thus excluded from the analysis. This is consistent with the trend found by Wagner et al. (2012). Smaller animals are often swallowed whole by predators (Jędrzejewski et al. 2002), thus untypical food components could be ingested.

Horses (RFO = 33.5 %) were the primary food source for wolves in the Stara Planina Mts, followed by red deer (RFO = 20.9 %), roe deer (RFO = 15.6 %), and wild boar (RFO = 12.6 %). Cattle, rodents and sheep represented an additional food source (Fig. 3). The wolf consumed hares and wild cats as an exception.

When dividing the wolf's food into

a) **b)**

Fig. 2. Remains of Roe deer: juvenile (a) and adult (b) found in wolf excrements in the Central Stara Planina Mts, Bulgaria.

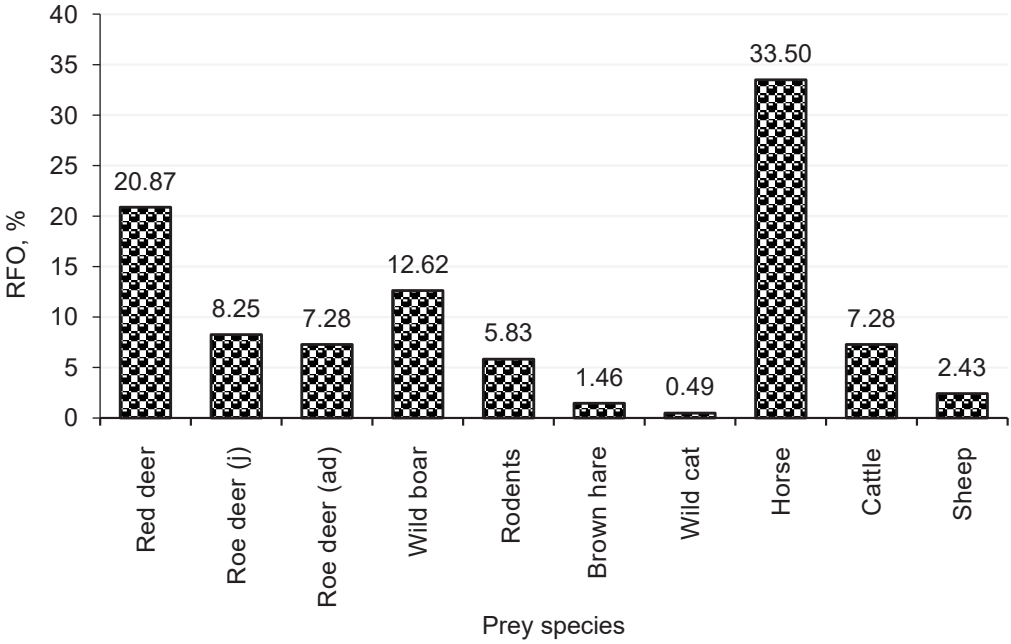

Fig. 3. Relative frequency of occurrence of prey species detected in the excrements of wolves in the Central Stara Planina Mts, Bulgaria.

natural and anthropogenic sources, the following ratio was obtained: 56.9 % natural and 43.1 % anthropogenic (mainly livestock). In southern Europe, red deer consumption is similar to that of roe deer and wild boar in the wolf's diet, when all three species are numerous (Meriggi et al. 2011, 2015). If the wild boar population is reduced due to African swine fever (ASF), the wolf switches to cervids (Klich et al. 2021). In Sikhote-Alin, the wolf's diet primarily consists of wild ungulates, mainly *Cervus elaphus xanthopygos* (Gromov 1979).

Roe deer were found in lower relative frequency of occurrence (15.6 %) in the wolf's diet compared to red deer, with juveniles predominance (Fig. 3), a trend already described for cervids by Wagner et al. (2012). In the Western Rhodopes Mts, the wolf preys on roe deer as red deer are scarce, (Genov et al. 2008, Georgiev et al. 2008). Similar feeding strategy has been reported for the Osogovo Mt (FO = 72 %; Stancheva 2004). In other Bulgarian mountains, roe deer consumption is significantly lower: in the Pirin Mt – 18.4 % (Dutsov et al. 2022), in the Kraishte Mt – 11 % (Dutsov et al. 2004), and in the Western Rhodopes Mts – 38.5 % (Georgiev et al. 2008, Genov 2015). In central and western Poland, the species occurs in the wolf's diet at a high rate, 42.8 % (Nowak et al. 2011), reaching 56 % in southeastern Estonia (Valdmann et al. 1998). In this research, the yearlings' remains were prevalent (RFO = 8.3 %) among those of roe deer (RFO = 7.3 %) found in the wolf's diet. A similar trend for both roe deer and red deer was described by Wagner et al. (2012).

The wild boar was the third most common wild ungulate found in the samples (RFO = 12.6 %; Fig. 3). This is probably

due to the wolf's preference for sufficiently large victim at lower risk, such as young roe deer and red deer. Wild boar and red deer are of different importance in the food of the wolf in Italy depending on a particular year (Marucco et al. 2008). Wild boar was the main food resource for the wolf in the Bulgarian part of the Osogovo Mt located in the western Bulgaria (Dolapchiev et al. 2022). The wild boar forms noisy herds, which are easily detectable by the wolf. It is the main food for the wolf in Italy (Mori et al. 2017), in Anatolia, Turkey (Mengüllüoğlu et al. 2019) and in other places where it is abundant. In Spain, the boar consumed biomass was found to vary greatly – 3–31 %, with offspring being the predominant prey. However, the wolf's contribution to reducing the number of this problematic ungulate species is considered insignificant compared to hunting (Nores et al. 2008). Predation by the wolf is thought to mitigate human-wild boar conflict (Mengüllüoğlu et al. 2019). The less frequent consumption of wild boar in the study area is likely due to the outbreak of African swine fever during the sampling period. The origin of the wild boar remains found in the wolf feces in Bulgaria is equivocal, as it could have come from active predation or scavenging. It is common for remains from hunter harvests to be left in Bulgarian nature.

The horses were found to be the most prevalent prey in the wolf diet in the Central Stara Planina Mts, both in terms of occurrence and ingested biomass (figs 3 and 4). Newborns and foals make up the majority of the predator's food during the snow-free period of the year, due to their availability (as per B. Koychev's personal observation). Wolves tend to be attracted to horses when the two species coexist. In northern Portugal wolves feed primarily on horses when herds graze freely in the mountains (Vos 2000). Similarly, in central Asia (Altai), horses are consumed more frequently than cows (Bondarev 1985), as seen in Mongolia (Hovens and Tungalaktuja 2005, Nakazawa et al. 2008, van Duyne et al. 2009), consistent with the findings in this study.

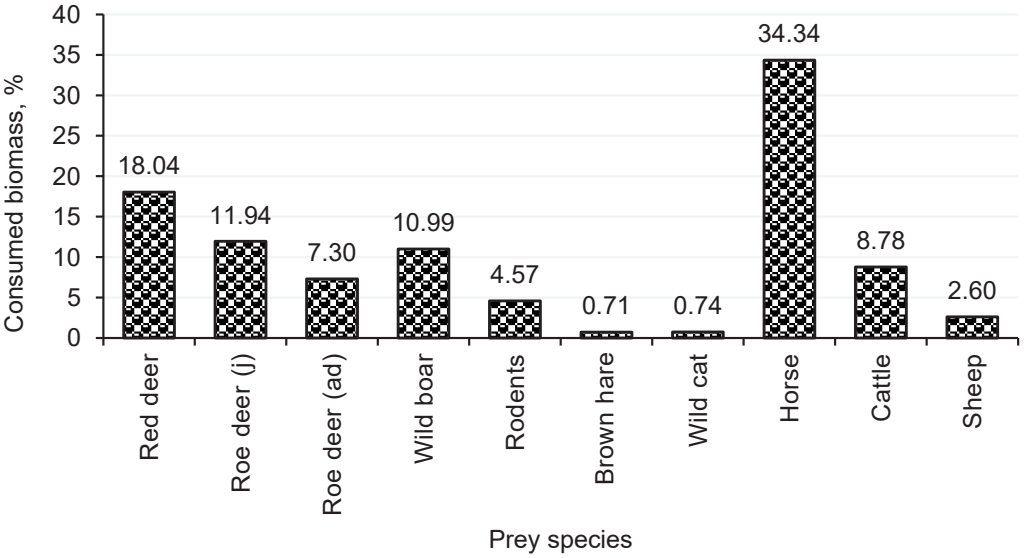

Fig. 4. Relative proportion of wolf's prey according to biomass consumed.

Cattle were reported to be attacked less frequently and mostly served as a buffer prey, along with medium-sized mammals (Sidordvich et al. 2003, Velázquez et al. 2022), consistent with our results (figs 3 and 4). In the study area, cattle are herded to farms at the foot of the mountain for the winter, making them a buffer food resource with temporary access. However, in cases of year-round pasturing, their occurrence in the predator's diet increases (Merkle et al. 2009). Sheep are scarce in the study area, as they are traditionally bred in the lowlands. Medium-sized mammals such as hares, wild cats, and rodents, are not of a particular nutritional value for the wolf and were rarely found in excrements (Fig. 3) with the lowest biomass ingested (Fig. 4). In the Western Rhodopes Mts, the wolf mainly feeds on wild ungulates, both in terms of frequency of occurrence and ingested biomass (Georgiev et al. 2008).

The wolf's diet in our study consisted of more than 40 % livestock (Fig. 5). The predator attacks primarily the freely grazing foals on the highland meadows, while rarely calves. Sheep are accidental prey for the wolf as herds are accompanied by shepherds and dogs during the day, and herded into pens at night. This foraging strategy has been described in previous studies in Bulgaria (Spassov et al. 1999, Spassov 2007). In comparison, wolves in Kazakhstan consumed 79.3 % livestock (Grachev 1979), and in Mongolia, 70 % (Hovens and Tungalaktuja 2005, Nakazawa et al. 2008, van Duyne et al. 2009). In our country, however, the farm animals' consumption is not always a result of ac-

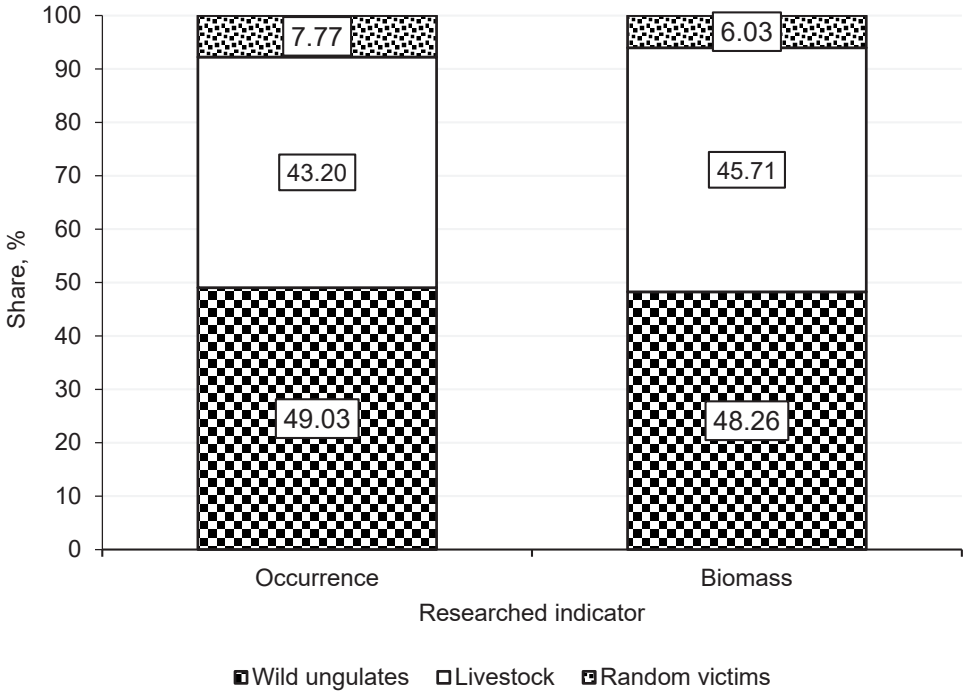

Fig. 5. Main food groups ratio in the wolf's diet in Central Stara Planina Mts, Bulgaria.

tive predation. Commonly, hunters attract wolves for shooting by setting livestock leftovers or whole animal carcasses. Thus, the damage caused by wolves on livestock is difficult to determine through their feces. In North America, cattle make up more than 22 % of the wolf's diet, in places with carcass discarded (Petroelje et al. 2019). It is assumed that the presence of livestock in the wolf's diet in Central Stara Planina Mts is due to the large number of grazing animals in the 'Central Balkan' National Park and the presence of hunting farms nearby. Unlike in North America, where wild prey provides for the wolves' nutritional needs, with waste and domestic animals being consumed only in isolated areas (Peterson and Ciucci 2003), in North Caucasus, domestic animals were found in 94.5 % of samples (Bibikov 1985). In Portugal, 84.7 % of the ingested volume was made up of livestock (Roque et al. 2001) occurrence.

Wild ungulates made up the other half of the wolf's diet in the study area, both in terms of occurrence (49.0 %; Fig. 5) and ingested biomass (48.3 %; Fig. 5). Wolves in Lithuania specialize in preying on wild ungulates (Špinkytė-Bačkaitienė and Pėtelis 2012), and in Italy, the use of this food source by wolves increased from 1976 to 2004, when it became a preferred prey over livestock when it was plentiful (Meriggi et al. 2011). The reason for this may be that wolves try to avoid confrontation with humans and remain unnoticed. In Alpine, Apennine and Mediterranean ecosystems the consumption of wild ungulates reaches 89.4–95.1 % (Capitani et al. 2004). The additional food groups were found at low frequencies and quantities, representing 7.8 % and 6.0 % respectively (Fig. 5). No remains of domestic ungulates were found in the wolf's diet in near-natural habitat in Mongolia. Such habitats are believed to limit predation on livestock due to the presence of diverse wild fauna (Tiralla et al. 2021).

Conclusion

The near-natural character of the Central Stara Planina Mts habitat determines the approximately equal consumption of wild and domestic ungulates by the wolf, known as typical large hypercarnivore mammal.

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