Mammalian Biology
Zeitschrift für Säugetierkunde
www.elsevier.de/mambio

Original investigation

Seasonal fluctuations of the wolf diet in the Hustai National Park (Mongolia)

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Receipt of Ms. 22.3.2004
Acceptance of Ms. 20.12.2004

Abstract

Seasonal fluctuations in the wolf diet in the Hustai National Park (Mongolia) were determined by analysing wolf scats that were collected from 1994–1997. Except for July, August and September, at least 50% of the frequency of occurrence of prey items in wolf scats consisted of livestock. The frequency of occurrence of wild ungulates ranged from 8–43%, and wild ungulates were most often consumed in July, August and October, but seldom in June. Our study suggested that most seasonal changes in the wolf diet were effected by the life history of red deer. The occurrence of wild ungulates in the wolf diet coincided with the availability and vulnerability of calves. To reduce livestock losses and poaching of wolves we recommend more wolf research, protection and monitoring of both wild prey populations and wolves, and the reintroduction of livestock guarding dogs and year-round guarding of domestic horses.

Key words: *Canis lupus*, *Cervus elaphus*, horses, diet, Mongolia

Introduction

Wolves are well known to predate on domestic ungulates (Bibikov 1982; Boitani 1982; Cuesta et al. 1991; Papageorgiou et al. 1994; Meriggi et al. 1996) and wild ungulates (Potvin et al., 1988; Jhala 1993; Larter et al. 1994; Smietana and Klimek 1993; Mattioli et al. 1995; Okarma 1995; Kohira and Rexstad 1997; Spaulding et al. 1998; Kunkel et al. 1999; Gade-Jorgensen and Stagegaard 2000; Arjo et al. 2002; Jedrzejewski et al. 2002). Although in areas inhabited by both domestic as well as wild ungulates, wolves usually prefer to predate the latter (Meriggi et al. 1996; Meriggi and Lovari 1996; Capitani et al. 2004). Among wild ungulates wolves generally prefer red deer (Carbyn 1983; Jedrzejewski et al. 1993, 2000; Smietana and Klimek 1993; Okarma 1995). Under certain circumstances, wolves substantially contribute to the total natural mortality of red deer (Okarma et al. 1995; Jedrzejewski et al. 1993, 2002) and other wild ungulates (Gasaway et al. 1983), although they normally do not exterminate this prey (Mech 1977). During this study in the Hustain Nuruu Steppe Reserve in Mongolia (since 2000 called the Hustai National Park, HNP), circumstances were not completely natural. Based on interview data wolves, predated up to 2.1% of all livestock in the research area on a yearly

1616-5047/$ - see front matter
doi:10.1016/j.mambio.2004.12.003

basis (Hovens et al. 2000), and wolves were therefore often poached in the HNP by local herdsmen (Hovens unpublished data). Related to availability wolves predated more red deer than livestock, but depended on the latter. Because livestock was abundant around the park, wolves remained at a high population, even when the red deer and other ungulate populations were low. The wolf impact on red deer was therefore high and the red deer population depended on immigration from the neighbouring areas to survive (Hovens et al. 2000).

To reduce conflicts between wolves and livestock and red deer, a better understanding of the relations between wolves and their main prey is needed. The main objective of this study was to determine seasonal fluctuations in the wolf diet and to evaluate by which factors these fluctuations might have been caused.

Material and methods

The Hustain Nuruu Mountain Steppe Reserve Biodiversity Project

The HNP was created by the Mongolian government in 1990 and managed by MACNE (Mongolian Association for the Conservation of Nature and Environment). In 1992, MACNE and the Dutch FPPP (Foundation for the Preservation and the Protection of the Przewalski horse) started the Hustain Nuruu Mountain Steppe Reserve Biodiversity Project. The aim of this project was to restore the natural steppe ecosystem, including the reintroduction of Przewalski horses in 1994 (Bouman 1998). Besides studies on the reintroduced Przewalski horses (*Equus przewalski*) several other biological studies have been initiated and executed. Initially, some concern existed about the potential impact of wolf predation on the reintroduced Przewalski horses. While wolves sometimes killed Przewalski horses (especially foals), the Przewalski horses normally withstood wolf attacks and more births than deaths occurred since the reintroduction project began (Dr. Bandi, Director of the HNP, pers. comm. 2003).

The research area

The research area (120,000 ha) is situated 100 km southwest of Ulan Bator, the capital of Mongolia, and encompasses the HNP and its direct surroundings. The HNP is 50,000 ha, and part of a mountain chain that runs northeast southwest. Its mountains are mainly covered with steppe and some small (in total 4168 ha) patches of forest, which consist of birch (*Betula fruticosa*, *B. fusca*, *B. platyphylla*) and poplar (*Populus pilosa*). The reserve's elevation is 1340 m and its highest mountain is 1841 m. A description of the vegetation is given by Wallis de Vries et al. (1996) and a list of the mammals by Todgerel (2002). The agricultural area north west of the reserve and the Tuul valley in the southeast are used by nomads to tend their livestock. The agricultural area north west of the reserve is also used for growing crops, primarily grain. Due to a lack of permanent water no wild and few domestic ungulates inhabited this area. The Tuul valley is covered with steppe grasses and some riverine forests. The climate is continental, characterized by cold winters with only a few cm of snow. Apart from wolves, the only other large predator in the research area was lynx (*Felis lynx*), which occurred in very low densities within the reserve and was rarely seen.

Numbers of wild and domestic ungulates and wolf packs in the research area

We monitored wild ungulates by weekly transect counts that were conducted from 1993 to 1997 (Hovens et al. 2000). Red deer were the most abundant wild ungulate in the reserve and were concentrated in and around the largest forested area. Red deer varied from 198 to 421. A population of 70–76 Mongolian gazelles (*Gazella gutterosa*) irregularly inhabited a part of the Tuul valley on the border of the research area. From the end of September until the beginning of May they moved together in one herd, that irregularly visited the Tuul valley. A majority of the time this herd was more than 60 km from the research area, and from September 1996 until May 1997, we did not locate this herd (Hovens et al. 2000). From the beginning of May until the end of September the Mongolian gazelles lived in small groups and maximally 15 Mongolian gazelles inhabited the Tuul Valley.

Numbers of livestock were monitored twice a year (Hovens et al. 2000). Between 16,270 and 27,857 livestock (sheep, goats, cows and horses) lived near the reserve. Wolf den observations indicate there were 2–3 wolf packs in the research area.

Wolf scat analysis

Wolf scats were collected in the HNP from 1994–1997. Prey remains in scats were identified

using the laboratory's hair, bone and claw reference collection. Hairs were identified by microscopic observation using glycerol slides. The presence of various prey remains per scat was used to calculate the frequency of occurrence of prey items in all wolf scats, and from this, the percentage of occurrence was derived. Hairs of red deer and Mongolian gazelles were not distinguishable from each other; neither were the hairs of cows and goats. Therefore the following four ungulate groups were identified: (1) sheep; (2) cows and goats; (3) wild ungulates (red deer and Mongolian gazelles); and (4) horses.

The frequency of occurrence of prey species in wolf scats underestimates the number of small prey actually consumed but for prey of approximately the same size, the frequency of occurrence in scats will represent their relative occurrence in the diet (Floyd et al. 1978; Weaver 1993). However, factors like carcass use and attendant scavengers strongly influence the relation between the frequency of occurrence and the number of prey actually consumed (Weaver 1993), most carcasses in or near the HNP were usually fed on by cinereous vultures (*Aegypius monachus*). Because outside the reserve wolf kills were sometimes watched over by herdsmen in order to shoot the wolves, wolves rarely returned to eat from a prey a second time. Therefore small and large ungulates, after being killed by wolves, probably resulted in similar amounts of wolf scats.

The older a wolf scat is, the more difficult is to determine its age. Scats with an estimated age of 2 weeks may in reality be 1 or 2 weeks older, while scats with an estimated age of 6 months may be several months older. Scats that have been frozen and covered with snow for several months remain fresh for a longer period. Therefore, it is especially difficult to estimate the age of old scats that are found during spring.

The percentage of marmots in the wolf diet was used as a criterion to determine the maximum age at which a reliable estimation of a wolf scat's age can be made. From the end of September to the end of February marmots in the HNP hibernate under a few meters of frozen ground and predictably wolf scats that are produced during the hibernation period of marmots, may contain almost no marmot remains. However, it is possible that they feed on the remains of previously killed and hidden marmots during this period. If only scats with a maximum estimated age of 3 months were included in our analysis no marmots were eaten in the hibernation period. If scats with an estimated age of more than 3 months were also included, marmots appeared to occur in the wolf diet during the hibernation period of marmots. Therefore, only wolf scats with a maximum estimated age of 3 months were used for this study.

Results and discussion

A total of 250 wolf scats were analyzed to determine the frequency of occurrence of prey items. Out of 41 wolf scats that contained marmot remains, 40 were produced between March and September. Only one scat with marmot remains was produced during the hibernation period of marmots: this scat was found on 20 November and was approximately 2 weeks old.

Table 1 gives the percentage of prey items in wolf scats per month. The number of wolf scats per month is too small to determine the precise wolf diet per month. From February to November the number of scats is large enough to determine the major changes in the composition of the wolf diet per month.

Marmots

Most marmots in the HNP closed their winter burrows (a tunnel that runs vertically) in the last 2 weeks of September to start hibernating. The presence of marmot remains in one wolf scat in November, probably involved a marmot that was killed and cached. A possible explanation for the decrease of marmots in the wolf diet in April (Table 1) is the peak of 'natural' livestock death before the start of the growth season in May. The increase in September is possibly caused by the fact that marmots are very fat and thereby slow, shortly before they start to hibernate. On several occasions we observed single wolves attempting to catch marmots by surprise, though we never noticed a successful kill.

Wild ungulates

We found many wolf kills among red deer and no wolf kills among Mongolian gazelles. Five months a year maximally 15 Mongolian gazelles inhabited the research area and the red deer number was 13–28 times higher than the number of Mongolian gazelles. During the other 7 months, Mongolian gazelles were

Table 1. Percentage of occurrence of prey items per month. The numbers of wolf scats in November ($n = 5$), December ($n = 5$) and January ($n = 7$) were too small, and therefore were combined in the winter period.

	Feb	Mar*	Apr*	May*	Jun*	Jul	Aug*	Sep*	Oct*	Nov–Jan
N scats	14	31	50	45	29	10	16	15	23	17
N prey items	19	36	64	50	37	19	19	20	28	20
Horse	26	22	38	30	46	11	11	10	14	25
Cow/goat	21	11	11	22	8	11	11	15	11	30
Sheep	16	17	11	6	14	11	26	20	25	15
Total livestock	63	50	60	58	68	33	48	45	50	70
Wild ungulate	21	17	20	16	8	37	32	20	43	20
Marmot	—	19	8	20	16	21	16	25	—	5
Hare	—	—	8	4	3	5	—	10	4	5
Small rodents	—	3	3	2	5	—	5	—	4	—
Badger	5	6		—	—	—	—	—	—	—
Bird	5	—	2	—	—	—	—	—	—	—
Wild boar	5	—	—	—	—	—	—	—	—	—
Suslik	—	6	—	—	—	—	—	—	—	—
Hedgehog	—	—	—	—	—	5	—	—	—	—

*In this month, one scat contained the remains of a grasshopper. Additionally, one scat in March contained the remains of a dung beetle. Since these scats mainly consisted of the remains of other prey species, insects were not included to determine the frequency of occurrence. *N* = number of scats/prey items.

mostly far away from the research area, but, when they were present, red deer were still 2.6–6 times more numerous and therefore most wild ungulate remains in wolf scats are probably from red deer.

The decrease in wild ungulates in the wolf diet in June (Table 1) coincides with the calving period of red deer in early June. Hinds usually move away from their herds to give birth, and the majority of them become solitary after calving and do not live in their usual range. For the first 2–3 weeks of life a calf is kept in a secluded spot and visited by the mother 2–4 times daily (Clutton-Brock and Guiness 1975). During the first few days of life a calf freezes when disturbed and, for approximately the first 2 weeks, its urine and faeces are consumed by the mother (Youngson 1970; Arman 1974). Therefore wolves may not find hinds and calves in June. This is demonstrated by our wildlife count data: during the weekly wildlife counts from 1994 until 1998, the lowest number of red deer was always found in June. Through or wildlife counts, we found that red deer were not concentrated on calving grounds, but were widely dispersed throughout the reserve in June, in both forested and open habitats. We assume this is the classic ungulate response to avoid predation as has been documented in red deer, elk, moose, etc.

The sudden increase in wild ungulates in the wolf diet in July and August (Table 1) is possibly due to the fact that most red deer calves joined a herd from the end of June to early July. After a calf has joined a herd, it is fairly easy for wolves to find and kill it. The first dates when calves were seen in a herd were: June 17th (1994), June 21st (1995), July 19th (1996) and June 18th (1997). Andersone (1998) already demonstrated that wolves kill many red deer calves and Hovens et al. (2000) demonstrated this for the HNP. Calves rapidly become faster and more agile, and the percentage of wild ungulates in the wolf diet in September is similar to that from November to June.

The increase in wild ungulates in the wolf diet in October (Table 1) is probably caused by the decreased alertness of red deer during rutting season, making them more vulnerable to attack. The climax of the rutting season

usually falls in the first week of October in the HNP, and at this time the authors were able to stalk the herds to within a distance of five m. Huggard (1993) demonstrated that high snow conditions during the winter can increase red deer predation by wolves. During the research period no high snow conditions occurred in the HNP, and we did not observe a high winter mortality of red deer.

Domestic ungulates

Except for July, August and September, at least 50% of the frequency of occurrence of prey items in wolf scats consisted of livestock, suggesting that livestock was an important part of the wolf diet (Table 1) either through scavenging or predation. Among livestock, wolves relatively kill a lot of domestic horses (Fig. 1) (Hovens et al. 2000). This is likely an effect of husbandry practices. Mongolian horses are sometimes not seen by their owners for weeks, whereas sheep and goats are herded during the daytime. Moreover cows, goats and sheep spend the night near their owner's ger (Mongolian tent). The increase in horses in the wolf diet in April is likely due to carcass use. The area around the reserve was overgrazed and at the end of the Mongolian winter a lot of livestock (especially horses) always died from starvation. The increase in horses in the wolf diet in June coincides with the aforementioned decrease in red deer in the wolf diet. The decrease in horses in the wolf diet from July to October is likely a result of the fact that Mongolians keep foals and mares near their ger to milk the mares from late June until late October. The decrease in livestock in the wolf diet in July (Table 1) is a likely result of the sudden availability of red deer calves. After October, when red deer have become more alert after the rutting season, wolves mainly prey on livestock. Our observations coincide with those of Jedrzejewski et al. (2000), in finding that the amount of other ungulates in the wolf diet depends on the density of red deer in the region. Although the number of livestock was always 39–140 times higher than the number of red deer, seasonal changes in the wolf diet could mainly be explained by the life cycle of red deer. This coincides with the fact that, related to availability, wolves in HNP predated more red deer than livestock (Fig. 2) (Hovens et al. 2000).

Fig. 1. Domestic horse that survived a wolf attack.

Fig. 2. Red deer stag killed by wolves.

Management recommendations

During the Soviet period (before 1990) a national wolf hunt was organised every first weekend of February and wolves became extinct in large parts of Mongolia. According to several Mongolian biologists and herdsmen (pers. comm.), the wolf number in Mongolia has increased since 1990 and Hovens et al. (2000) demonstrated that the wolf density in the research area has increased since the summer of 1994. In the research area the co-existence of livestock, wolves and red deer resulted in a conflict: from August 1994 until September 1997 wolves killed 1139 head of livestock (Hovens et al. 2000), local people shot at least 20 adult wolves and dug out at least 3 wolf dens (unpublished data, based on extensive interviews with local people and personal observations) and wolves partly caused the decline of the red deer population (Hovens et al. 2000). Return to extensive wolf hunting is not a good solution for these problems. To allow co-existence of wolves, livestock and wild prey populations we recommend to reintroduce the following traditional Mongolian methods that were abolished when wolf numbers in Mongolia were low:

1. manage for abundant populations of native prey,
2. introduction of the Mongolian breed of livestock guarding dogs in combination with a livestock guarding dog program, and
3. carry out year round guarding of domestic horses.

These measures will increase natural forage for wolves and decrease the availability of livestock for wolves, which may result in fewer problems for local herders and a more natural ecosystem, in which the wolf population depends on and responds to the fluctuations of wild prey populations.

Acknowledgements

The Dutch Foundation for the Preservation and the Protection of the Przewalski horse and the Mongolian Association for the Conservation of Nature and Environment supported this research. We thank Dr. P.J.H. van Bree for motivating us and for his comments on the first draft of this manuscript. We also thank Inge Bouman, R. Henkens, S. Joshua, Grietje Hovens and

L. Hurlstone who also commented on the first draft of this article. We thank Dr. T. Rijkers and E. Bangs for their comments on the second draft of this article. We thank rangers Myagmar, D., Oinbajer, Sh., Dorsjpurev, U., Chulunbaatar, D. and Sanjimettav, Ts. and biologists T. Todgeril, D. Batdorj, B. Munkhtsog and U. Aybeck for helping us with wildlife counts and collecting wolf scats. Finally, we thank all staff members and local people for their cooperation.

Zusammenfassung

Saisonale Fluktuationen von Wolfsnahrung im Hustai Nationalpark (Mongolei)

Anhand von Kotproben von Wölfen, die von 1994 bis 1997 gesammelt wurden, konnten saisonale Fluktuationen der Wolfsdiät im Nationalpark Hustai (Mongolei) festgestellt werden. Mit Ausnahme der Monate Juli, August und September bestand mindestens 50% der im Wolfskot vorgefundenen Beutereste aus Nutztieren. Wildungulat–traten in 8 bis 43% der Proben auf und wurden am häufigsten in den Monaten Juli, August und Oktober genutzt, jedoch kaum im Juni. Diese Untersuchung deutet darauf hin, dass saisonale Veränderungen der Wolfsdiät wahrscheinlich von der Biologie der Rothirsche beeinflusst werden, da die Abnahme von Wildungulaten in der Wolfnahrumg in den Zeitraum der Kälbergeburten fiel, während die Zunahme von Wildungulaten mit jener Periode koinzidierte, in der sich neu geborene Kälber den Herden anschlossen und die Brunftzeit stattfand. Um sowohl den Verlust von Nutzvieh als auch das Wildern auf Wölfe zu vermindern, empfehlen wir die Wolfsforschung zu verstärken, das Monitoring und den Schutz von Wolfs- und Wildbeutepopulationen zu verbessern, die Wiedereinführung von Hütehunden sowie die ganzjährige Überwachung von Nutzpferden.

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