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Winter habitat selection and feeding habits of polecats (*Mustela putorius*) in the Białowieża National Park, Poland

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Abstract

Polecats (*Mustela putorius*), that inhabited the pristine mature forests, were studied by means of snowtracking on 11.2 km^2 during 5 winters (1985/86–88/89 and 1990/91). They preferred wet habitats: riverside ash-alder forests and bog alderwoods. Drier forests (oak-linden-hornbeam and spruce-pine stands) were used by polecats less frequently than would have been expected from their occurrence in the study area. The intensity of polecats' use of habitats changed with winter weather. On relatively warm days (0 to −5 °C) polecat tracks were recorded twice as often in wet forests as in the dry ones. At temperatures from −6 to −10 °C, this ratio approached 1 : 1, and below −10 °C, when most of the running and stagnant waters were frozen, polecat tracks were found in drier forests twice as frequently as in wet forests. The diet of polecats was studied by an analysis of 222 scats collected during 5 winters (1986/87–1990/91). Anurans (mainly *Rana temporaria*) comprised 70 to 98 % of the biomass consumed by polecats and were found in 60 to 95 % of scats. Forest rodents (*Apodemus flavicollis* and *Clethrionomys glareolus*) constituted from 1 to 29 % of the biomass eaten by polecats. The consumption of rodents grew with decreasing winter temperature and increasing numbers of rodents. Snowtracking of individual polecats showed that in wet forests, the polecats moved in close proximity to water courses and searched for anurans, whereas in the drier forests, they hunted rodents, mainly by digging.

Introduction

Polecats were often described as predators inhabiting a variety of habitats (Blandford 1987) and showing a generalistic feeding habit (Rzebik-Kowalska 1972; Brugge 1977; Mermod et al. 1983; Lode 1988, 1990). However, the recent studies by Weber (1989a, b) and Jędrzejewski et al. (1989) showed a high specialization of the polecat in capturing anurans. Earlier, Schaff (1911) observed that a relatively high contribution of amphibians to the polecat diet resulted from its living in wet habitats. The later studies of Danilov and Rusakov (1969), Jensen and Jensen (1972), and Lode (1988) confirmed that polecats often live close to water.

In our studies undertaken in the Białowieża National Park, the autumn-winter diet of polecats and their habitat preferences were investigated in the primeval forest. We endeavoured to explain the relationship between the polecat's diet and its habitat selection. We studied the influence of winter weather and the availability of forest rodents on the polecats' utilization of habitats and food resources. The project covered six winters (1985/86–1990/91) and was part of a long-term research project on predator-prey relationships in the pristine forests of the Białowieża National Park (e.g. Jędrzejewski et al. 1989; Brzeziński et al. 1992).

Study area

The Białowieża National Park (eastern Poland, 23° 55′ E, 52° 45′ N) of 47.5 km^2 is located in the center of the Białowieża Primeval Forest (1,250 km^2). The forest extends on both sides of the Polish-Belarussian border and preserves the remnants of the European temperate lowland forests of boreal

Table 1. Characteristics of weather conditions during 6 cold seasons (15 Nov.–15 Apr.) and indices of rodent (*C. g.* – *Clethrionomys glareolus* and *A. f.* – *Apodemus flavicollis*) numbers in autumn in Białowieża Primeval Forest, eastern Poland

Year	Mean daily temperature (°C)	Mean daily snow cover (cm)	Rodent numbers in autumn (N/100 trap-nights)	
			C. g.	*A. f.*
1985/86	−2.5	19	2.1	6.2
1986/87	−3.6	20	1.8	1.9
1987/88	0.2	8	3.8	3.1
1988/89	2.2	2	3.4	1.0
1989/90	2.5	2	0.8	1.3
1990/91	0.6	4	5.8	8.6

nemoral type. It contains the pristine deciduous, mixed, and coniferous stands composed of oak *Quercus robur*, hornbeam *Carpinus betulus*, linden *Tilia cordata*, maple *Acer platanoides*, pine *Pinus sylvestris*, spruce *Picea abies* and other tree species. Along the small forest rivers grow riverside flood-plain forests (composed of ash *Fraxinus excelsior* and black alder *Alnus glutinosa*, with admixture of elm *Ulmus* spp.). Bogs with stagnant water are covered with alderwoods including black alder and admixtures of spruce. Riverside ash-alderwoods and bog alderwoods cover 14.5 % of the National Park area. More information on the vegetation is given by Falinski (1986). In the Park, hunting and timber exploitation are not allowed; tourism is restricted to a few pedestrian paths. A small stream, the Orłówka (about 5.5 km long, up to 4 m wide and 1.5 m deep), flows through the Park. The northern and western borders of the Park are delimited by two rivers (the Narewka and the Hwoźna) which flow in the open marshy valleys. The water level in the rivers and in the stream varies seasonally, reaching its maximum in spring. The Orłówka often dries up in summer. In winter, the Orłówka freezes, however, unfrozen air-holes can still be found in its middle and lower course, at temperatures below −15 °C. The upper part of the stream freezes completely at about −5 °C.

The density of polecats in the study area was 4–5 adult individuals/10 km^2 in winter (Jędrzejewski and Jędrzejewska 1993).

Białowieża National Park lies in the temperate subcontinental climatic zone (Olszewski 1986). An average daily minimum temperature below 0 °C is recorded from November until the end of March. The average minimum temperature in January is −4.3 °C. The mean snow cover is 18 cm. The snow cover is present for an average of 92 days per year. During the study period (1985/86–1990/91), the winter weather was highly variable (Tab. 1).

Material and methods

Habitat selection

In the winters of 1985/86–88/89 and 90/91, habitat preferences of polecats were studied by snowtracking (the winter of 1989/90 was mostly snowless). Tracking was done on 11.2 km^2, on a grid of transects, totalling 59,250 m. All transects were divided into 50-m sections. During the tracking, conducted 1–2 days after the snowfall, the tracks of polecats crossing the transects were recorded. Altogether, 918.7 km of tracking transects were walked and polecat tracks were found in 245 of 18,374 50-m sections. The habitat description of each 50-m section was made on the basis of a forest community map and was verified in the field. The map represents the forest inventory map which distinguished four different habitats: 1. oak-linden-hornbeam forest (rich deciduous stands on brown soils), 2. spruce-pine forest (coniferous and mixed coniferous stands on drier, sandy soil), 3. ash-alder forest (riverside flood plain forests), and 4. bog alderwood (bog forests in places with stagnant waters).

Diet composition and foraging habits

The study of polecat diet was based on the analysis of 222 scats collected during 5 cold seasons (15 Nov.–15 Apr. 1986/87–90/91). Scats were collected at polecat dens, in known polecat territories on the banks of the Orłówka, during radiotracking, on polecat trails during snowtracking, and from livetraps (information on livetrapping and radiotracking is given in Brzeziński et al. 1992). Scats were analyzed following the standard procedure of Lockie (1959). Prey items were identified by bones, hair, feathers and exoskeletons according to the keys of Pucek (1981), Debrot (1982), März (1987)

and comparative skeletal material. The contribution of various prey groups to the polecat diet was shown as percent occurrence (% O) in all analysed scats and percent of mean biomass (% B) consumed per one scat. For the biomass estimation, the following coefficients of digestibility were used (data on polecats, if not stated otherwise): rodents – 17.8 (Roger et al. 1991), insectivores – 15.2 (averaged from Roger et al. 1991; Lode 1990), carcasses of cervids – 15 (Jędrzejewski and Jędrzejewska 1992; for *Vulpes vulpes*), fish – 25 (Fairley et al. 1987; for *Mustela vison*), birds – 12.4 and anurans – 41.3 (Roger et al. 1991), insects – 5 (Lockie 1961; for *Martes martes*). For each winter, food niche breadth was calculated ($B = 1/\Sigma p_i^2$, where p_i = percent biomass of a particular prey group consumed, after Levins 1968).

Data on foraging by polecats were obtained by snowtracking individual animals. During tracking, an observer noted the characteristics of the forest type and all activities of an animal that could be inferred from the traces in the snow. The length of a trail was estimated by pacing; 10,970 m of trail were followed.

Climatic data came from the Białowieża meteorological station. The data on autumn numbers of the forest rodents, *Apodemus flavicollis* and *Clethrionomys glareolus* in the years 1985–90, were kindly granted by Dr. Z. Pucek (from his long-term trapping of forest rodents in Białowieża National Park).

Results

Winter habitat selection of polecats

The general pattern of habitat selection of polecats is shown in figure 1. The most preferred sites were the wet habitats, riverside ash-alder forest and bog alderwood. Drier forest associations (oak-linden-hornbeam forest and spruce-pine forest) were used less frequently than could have been expected from their occurrence in the study area.

The intensity of utilization of particular habitats by polecats changed with weather conditions. Polecat tracks were recorded on 118 sections (each 50 m long) of tracking transects in oak-linden-hornbeam and spruce-pine forests and on 127 sections in riverside

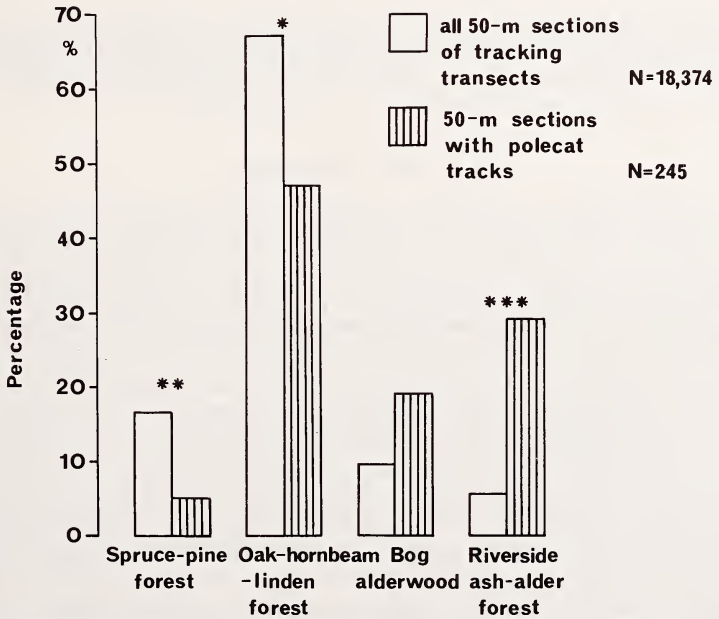

Fig. 1. Winter habitat selection by polecats *Mustela putorius* in the Białowieża National Park, as studied by snowtracking (data pooled for 5 winters, 1985/86–88/89 and 1990/91). * $p < 0.05$, $G = 4.06$; ** $p < 0.01$, $G = 6.72$; *** $p < 0.001$, $G = 17.98$, G-test)

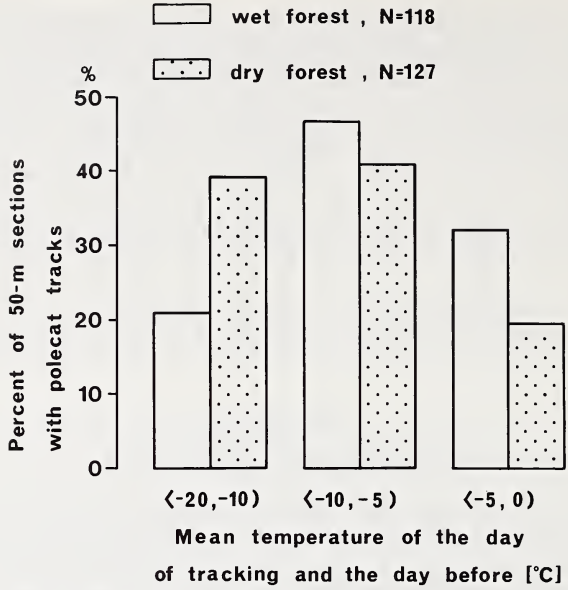

Fig. 2. Use of forest habitats by polecats in winter in relation to temperature as studied by snowtracking. N – number of 50-m sections of tracking transects with polecat tracks recorded. Wet forests – riverside ash-alder forest and bog alderwood, dry forests – oak-hornbeam-linden forest and spruce-pine forest. Frequency distributions statistically different ($p < 0.01$, $t = 2.956$, Wilcoxon test)

and bog forests. At warm temperatures (0 to −5 °C) polecat tracks were recorded twice as often in bog and riverside forests as in the dry forests (Fig. 2). At temperatures from −6 °C to −10 °C, this ratio approached 1:1, and below −10 °C, dry forests were utilized twice as often as the completely frozen riverside and bog forests (Fig. 2).

Polecat diet and foraging

In winter, the staple food of polecats was anurans, which comprised 70 to 98 % of the total consumed biomass (Tab. 2). The common frog *Rana temporaria* was most frequently consumed. Rodents, insectivores and ungulate carrion were supplementary foods. The consistently high contribution of anurans to the polecat diet caused the food niche breadth of this predator to be very narrow (1–1.7) with not much variability between winters (Tab. 2).

The lowest contribution of anurans to the polecat diet occurred in 1990/91, when forest rodents were very abundant (see Tab. 1). The share of rodents in the polecat diet increased in years of high rodent densities and during harsh winters. As shown by multiple regression, two variables, average daily temperature in winter (Tw) and index of autumn abundance of forest rodents (Ra), explained 95 % of the variation in the percent occurrence (% O) of rodents in polecat diet in the cold season ($\%\ O = 8.38 + 1.79Ra - 2.64Tw$, $n = 5$, $F = 18.262$, $R^2 = 0.948$, $p = 0.05$). Variation in rodent abundance contributed more to R^2 than variation in temperature ($sr^2_{Ra} = 60\ \%$, $sr^2_{Tw} = 33\ \%$). The same relationship (although statistically not significant) was recorded for another assessment of the rodent share in polecat diet, percent biomass ($\%\ B = -6.31 + 2.28Ra - 0.27Tw$, $n = 5$, $F = 6.97$, $R^2 = 0.875$, $p = 0.125$).

Foraging modes of polecats differed among habitats (Tab. 3). In wet forests, polecats

Table 2. **Diet composition (in percent occurrence – % O, and percent biomass – % B) of polecats in the Białowieża National Park in 5 cold seasons (15 Nov.–15 Apr.)**

N – number of scats, B – niche breadth according to Levins (1968), + – traces of food, . – biomass not estimated

Item	1986/87 N = 27		1987/88 N = 19		1988/89 N = 95		1989/90 N = 43		1990/91 N = 38	
	% O	% B	% O	% B	% O	% B	% O	% B	% O	% B
Apodemus flavicollis	18.5	3.2	–	–	7.4	1.3	4.7	1.0	23.7	21.1
Clethrionomys glareolus	–	–	15.8	2.8	3.2	0.2	2.3	0.4	10.5	8.0
Other rodents	1.4	1.9	–	–	–	–	–	–	–	–
Total rodents	25.9	5.1	15.8	2.8	10.5	1.5	7.0	1.4	34.2	29.1
Neomys fodiens	3.7	0.5	–	–	1.1	+	–	–	–	–
Sorex araneus	–	–	–	–	1.1	+	–	–	–	–
Sorex or *Neomys*	–	–	5.3	1.5	1.1	+	7.0	1.1	5.3	1.1
Talpa europaea	3.7	0.6	–	–	1.1	+	–	–	–	–
Total insectivores	7.4	1.1	5.3	1.5	4.2	0.2	7.0	1.1	5.3	1.0
Cervidae carcass	3.7	5.6	–	–	2.1	0.1	–	–	–	–
Birds	–	–	5.3	+	1.1	+	2.3	0.1	–	–
Rana temporaria	26.9	.	–	–	25.3	.	16.3	.	7.9	.
Rana arvalis	–	–	–	–	3.2	.	–	–	–	–
Rana spp.	25.9	.	36.8	.	25.3	.	39.5	.	6.3	.
Anura undetermined	33.3	.	57.9	.	51.6	.	39.5	.	52.6	.
Total anurans	81.5	87.9	94.7	95.4	93.7	98.1	90.7	97.4	65.8	69.9
Fish	7.4	0.3	5.3	0.3	–	–	2.3	+	–	–
Dytiscus spp.	–	–	–	–	9.5	0.1	2.3	+	–	–
Mean biomass consumed per 1 scat (g)	38.6		18.6		28.2		29.5		11.9	
Food niche breadth B	1.3		1.1		1.0		1.0		1.7	

moved in close proximity to water courses, which suggested searching for anurans. In dry forests, where water courses were scarce, the most common polecat foraging activity was hunting rodents, predominantly by digging for them (Tab. 3).

Discussion

Polecats have been classified as unspecialized predators (Erlinge 1986) because most studies done in Europe, in many different habitats, including human settlements (review in Blandford 1987), showed that polecats fed on rodents, birds, rabbits, rats, and eggs (Kratochvil 1952; Danilov and Rusakov 1969; Rzebik-Kowalska 1972; Brugge 1977; Walton 1977; Herrenschmidt 1982; Lode 1990). In the pristine broadleaf forests of Białowieża National Park, polecats proved to be food and habitat specialists. They lived near running and stagnant waters and fed predominantly on anurans. This positive association between polecats and water was reported by Danilov and Rusakov (1969), Jensen and Jensen (1972), and Lode (1988). Some previous studies showed the presence of amphibians in the polecat diet (Kratochvil 1952; Danilov and Rusakov 1969; Rzebik-Kowalska 1972; Brugge 1977; Walton 1977; Lode 1988, 1990), but only few proved amphibians to be the main prey (Weber 1989 a, b), and none have documented that anurans comprise up to 98 % of biomass consumed by polecats as found in the present study.

In rich oldgrowth forests, the community of mammalian predators and raptors is composed of 23 species (Jędrzejewski and Jędrzejewska 1993). The polecat's niche (considering both habitat and food) as a semiaquatic predator is quite different from all other terrestrial predators (Jędrzejewski et al. 1989). Its food niche is similar to that of the

Table 3. **Differentiated foraging activities of polecat in wet forests (bog alderwood and riverside ash-alder forest) and dry forests (oak-linden-hornbeam forest and spruce-pine forest) during snow period**

Data of snowtracking from the winters of 1986/87, 1987/88, and 1990/91. Total length of snowtracking in wet forests – 6775 m, in dry forests – 4195 m. Differences between habitats: * $p < 0.025$, $G = 5.21$, $df = 1$; *** $p < 0.001$, $G = 60.85$, $df = 1$ (G-test)

Activity	Number or length (m) per 1 km of trail	
	Bog alderwoods and riverside ash-alder forest	Oak-linden-hornbeam forest and spruce-pine forest
Foraging on stream[1]:		
– wading in water or walking on ice	11.1	2.6
– length of moving on ice	325.2 m	21.0 m
– looking under banks	10.0	1.7
Hunting rodents:		
– all attacks on rodents	4.9	14.8*
– attacks by digging	2.9	12.2
Intensity of area searching:		
– following own trail	51.5 m	9.3 m***

[1] differences in polecat foraging on stream in the two habitats were obviously the result of scarcity of water sources in dry forests.

river otter *Lutra lutra*. The otters, however, live on larger rivers in the Park (Narewka and Hwoźna) and do not inhabit small forest streams, the main polecat habitat (Brzeziński et al. 1993). The American mink *Mustela vison*, a newcomer to the community, may have a similar food and habitat niche as that of the polecat. However, the studies performed on mink in other parts of northeastern Poland showed that it is a generalistic predator, not specializing in anurans (Brzeziński and Zurowski 1992). In the Swiss mountain forest, rodents were more numerous than frogs, but frogs were eaten more frequently by polecats (Weber 1989b). In our study area, polecats extensively utilized forest rodents only in a year of high rodent numbers (1990) following a year of heavy mast production (acorn and hornbeam seeds).

Polecats are well adapted for capturing anurans. Weber (1989b), found on the basis of enclosure experiments, that frogs were more easily captured by polecats than were rodents. Polecats were able to locate and excavate frogs from 30 cm of soil, even when snow cover was up to 1 m thick. Polecats also eat toads (Weber 1989a; Lode 1990) which are inedible for most mammalian predators. In the temperate climates, common frogs *Rana temporaria* (the polecats' main prey) hibernate from the second half of October through early March (Juszczyk 1987). During mild winters, when the temperature is above 0 °C, frogs often become active (Savage 1961). Active frogs were observed at the Orłówka stream in January and February (personal observation). This species hibernates in the mud at the bottom of small water courses or under roots in the river banks (Savage 1961; Juszczyk 1987). Polecats are able to excavate frogs from the mud (Rzebik-Kowalska 1972; Lode 1988; Weber 1989b). High consumption of amphibians during winter can also be explained by the fact that polecats, like other small mustelids (see Jędrzejewska and Jędrzejewski 1989), store excess prey captured under favourable conditions and exploit the stores when conditions become too harsh for hunting. Rusakov (1962), Danilov and Rusakov (1969), and Lode (1989) found a few to several dozen dead animals (mainly frogs, rodents and birds) stored in polecat dens. Danilov and Rusakov (1969) reported that, during extremely cold periods, polecats did not leave their dens. This is possible if stored food supplies are utilized.

Preference for wet habitats and specialization in anurans have, however, one disadvantage in the temperate zone. In severe winters, streams and bogs freeze deeply, depriving polecats of anuran resources for prolonged periods. Under those conditions, polecats may abandon their well defined, nearly linear, territories along the stream (Brzeziński et al. 1992) and disperse over drier forest habitats, trying to survive by hunting rodents and scavenging. Many of them end up in human settlements. In the Białowieża Primeval Forest, the dry forests were utilized more during frosty weather, and in the village of Białowieża, highest numbers of polecats raiding domestic animals were captured by farmers in January and February, the coldest months of the year (Brzeziński et al. 1992).

In hunting rodents, polecats dig them up much the same as they dig for amphibians. Digging, effective even in winter, seems to be a general behaviour of the *Putorius* subgenus of mustelids; *Mustela putorius* digs for anurans and rodents, *M. eversmanni* digs up susliks *Citellus* spp. and other rodents (Kydyrbaev 1988), and *Mustela nigripes* digs up prairie dogs *Cynomys* spp. (Campbell et al. 1987; Richardson et al. 1987).

Observations reported here and results from other studies suggest the following generalisations:

1. In its pristine forest habitat, *Mustela putorius* is a specialized hunter for anurans and lives near small streams and bogs.
2. Regular seasonal freezing of water sources resulted in evolution of an alternate adaptation; under natural conditions this facultative "buffer" adaptation is hunting forest rodents (by digging them up) and by scavenging on ungulate carcasses.
3. In the man-made landscape, particularly with drainage and land reclamation projects that degraded polecat habitat throughout Europe, these predators had to rely on what used to be their facultative adaptation in order to survive.

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Zusammenfassung

Selektive Nutzung des Lebensraumes im Winter durch Iltisse (Mustela putorius) und ihre Nahrung im Nationalpark Białowieża, Polen

Bevorzugte Lebensräume von Iltissen (*Mustela putorius*) wurden im Białowieża Nationalpark auf einer Fläche von 11,2 km^2 in 5 Wintern (1985/86–88/89 und 1990/91) über Häufigkeiten von Fährten im Schnee ermittelt. Danach waren Iltisse vornehmlich in feuchten Habitaten (am Fluß gelegene Erlen-Esche- und Erlenbruchwälder) anzutreffen. Trockene Regionen (Eiche-Linde-Hainbuche und Fichte-Kiefer-Einstände) wurden seltener aufgesucht. Die Intensität der Lebensraumnutzung änderte sich jedoch mit dem winterlichen Wetter. An relativ milden Tagen (0 bis −5 °C) wurden Iltisspuren doppelt so häufig in feuchten Waldungen gefunden wie in trockenen, bei Temperaturen zwischen −6 und −10 °C näherte sich dieses Verhältnis 1 : 1, und bei Temperaturen unter −10 °C, als die meisten fließenden und stehenden Gewässer gefroren waren, konnten in den trockenen Waldregionen doppelt so viele Iltisspuren festgestellt werden wie in den feuchten. Nahrungsanalysen an 222 Kotproben von Iltissen aus 5 Wintern (1986/87–1990/91) ergaben, daß Anuren (hauptsächlich *Rana temporaria*) in 60–95 % der Kotproben 70–98 % der Biomasse ausmachten. Auf Nagetiere (hauptsächlich *Apodemus flavicollis* und *Clethrionomys glareolus*) entfielen nur 1–29 % der konsumierten Biomasse. Der Nagetieranteil nahm mit abnehmender Wintertemperatur zu, aber auch mit zunehmender Abundanz der Nager. Verfolgungen von Spuren einzelner Individuen zeigte, daß sich die Tiere in den feuchten Waldregionen in der Nähe der Gewässer bewegten und Anuren suchten. In den trockenen Standorten erbeuteten sie Nagetiere hauptsächlich durch Ausgraben.

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