

Chapter 8

Food Habits of the Asian Badger in the Urals and Western Siberia

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Abstract – Food habits of the Asian badger (*Meles leucurus*) in continental Asia are poorly known. Here, we present information on the composition of this species' diet at 5 sites situated in the Urals and Western Siberia. We analyze the importance of various types of prey and discuss geographical variation in food habits in the genus *Meles*. The specific feature of the diet of the Asian badger in Urals and Western Siberia is the low consumption of earthworms, which may be due to weather, habitat structure and abundance of other prey items. Our data do not support the hypothesis that the proportion of animal food in the diet of *Meles* increases with latitude, although this may be related to the restricted gradient of latitudes (55–61 °N) included in our study. In the Urals and Western Siberia, feeding on plant material was the highest in northern sites, while animal prey (both vertebrates and invertebrates) were most intensively consumed in the southern areas. We suggest that the feeding habits of *Meles* are more affected by availability of different food at a given location, than by major environmental gradients.

INTRODUCTION

Badgers of the genus *Meles* (Carnivora, Mustelidae) are distributed throughout most of the Palearctic region (Proulx *et al.*, Chapter 2, this volume). The genus *Meles* currently comprises 4 species: European badger (*M. meles* L., 1758), Asian badger (*M. leucurus* Hodgson, 1847), Southwest Asian badger (*M. canescens* Blanford, 1875) and Japanese badger (*M. anakuma* Temminck, 1844) (Del Cerro *et al.* 2010; Abramov and Puzachenko 2013; Sato, Chapter 1, this

volume). Due to their burrowing activity and diverse trophic relationships, Eurasian badgers (*Meles* spp.) are important components of natural communities. In some countries, they are considered as game species and their fat is used in traditional medicine. Both European and Asian badgers can function as habitat engineers (e.g. Dvornikov and Chaschin 2008; Kurek *et al.* 2014) and seed dispersers (e.g. Pigozzi 1992; Peredo *et al.* 2013). In some regions, the European badger is of conservation concern (Griffiths and Thomas 1993; Sidorovich *et al.* 2011). It can also be an agricultural pest (Schley 2000) and has a potential role in the transmission of bovine tuberculosis to cattle in certain parts of Europe (for a review see Delahay *et al.* 2000).

The biology of Eurasian badgers, but particularly that of *M. meles*, has been well studied in the western part of their geographical range. Much attention has been given to geographical variations in feeding habits. It was shown that *M. meles* diet and feeding strategies at the southern edge of its geographical range, in Spain, are different from those in central Europe and the British Isles (e.g., Shepherdson *et al.* 1990; da Silva *et al.* 1993; Kowalczyk *et al.* 2004; Macdonald *et al.* 2004; Fischer *et al.* 2005; Barea-Azcón *et al.* 2010). Goszczyński *et al.* (2000) reported a positive correlation between geographical latitude and the proportion of animal food in the diet of *M. meles* in Europe. Similar results were reported for several omnivorous mammals (Vulla *et al.* 2009). However, other authors showed that the proportion of plant and animal food in the diet of this species could be affected by season, local habitat structure and temporal dynamics of prey abundance (Virgós *et al.* 2004; Fischer *et al.* 2005; Loureiro *et al.* 2009; Mysłajek *et al.* 2013). Melis *et al.* (2002) indicated that badgers' diet can be described as unimodal, bimodal, or trimodal according to the number of categories dominant in volume. Some researchers treat *M. meles* as a true generalist (Marassi and Biancardi 2002; Melis *et al.* 2002), while others report specialization on single prey, like earthworms in Scotland (Kruuk and Parish 1981), olives in Italy (Kruuk and de Kock 1981), or wild rabbits in the south of Spain (Martin *et al.* 1995; Fedriani *et al.* 1998).

In comparison, the diet of the Asian badger has been poorly studied. Data on diet composition were presented for Kyrgyzstan (Yanushevich 1969), Buryatia (Russia) (Smirnov and Noskov 1977), Karakalpakiya (Uzbekistan) (Reimov 1972), Kazakhstan (Afanasyev 1982) and Krasnoyarsk kray (Russia) (Minakov 2004). Most of these publications are not available for wide scientific audience, cover short periods of data collection – 1 or 2 year(s) – and report only main prey categories and their frequencies of occurrence. Reviews of this species' biology in the Urals and Western Siberia (Kirikov 1952; Laptov 1958; Marvin 1969) included only information on the types of food consumed by Asian badger without any quantitative data. Recent publications present analyses of Asian badger diet in the forest–steppe zone of Urals region (Markov *et al.* 2005) and in the middle taiga of Western Siberia (Zagainova and Markov 2011).

Existing data on the diet of Asian badger suggest that species' trophic relationships in natural communities of northern Asia are different from those in Western Europe mainly due to the short period of animals' activity. In most parts of northern Asia, Asian badgers sleep from the second half of October until the end March or the beginning of April (Heptner *et al.* 1967). Such seasonality is especially expressed in the taiga zone, close to the northern limit of badger's geographical range. Thus, analyses of the feeding habits of the Asian badger at the northern periphery of its geographical range are important to understand how this species adapted to various environments.

In this study we present information on food habits of the Asian badger at several sites situated in various natural zones, from the mountains of the Southern Urals and the forest–steppe in the south, to the middle taiga of the West-Siberian Plain in the north. We also analyze the importance

of various prey types based on quantitative assessments of the number of prey remains, and discuss geographical variation in Eurasian badgers' feeding habits.

STUDY AREAS

This study was conducted in the region of Urals and adjacent parts of Western Siberia (Figure 1). The range of Asian badger within this region expands from about 51 °N to approximately 62 °N, covering the following main natural zones: taiga zone, which is subdivided into northern, middle and southern taiga subzones; forest–steppe; and steppe zones. Specific natural communities are

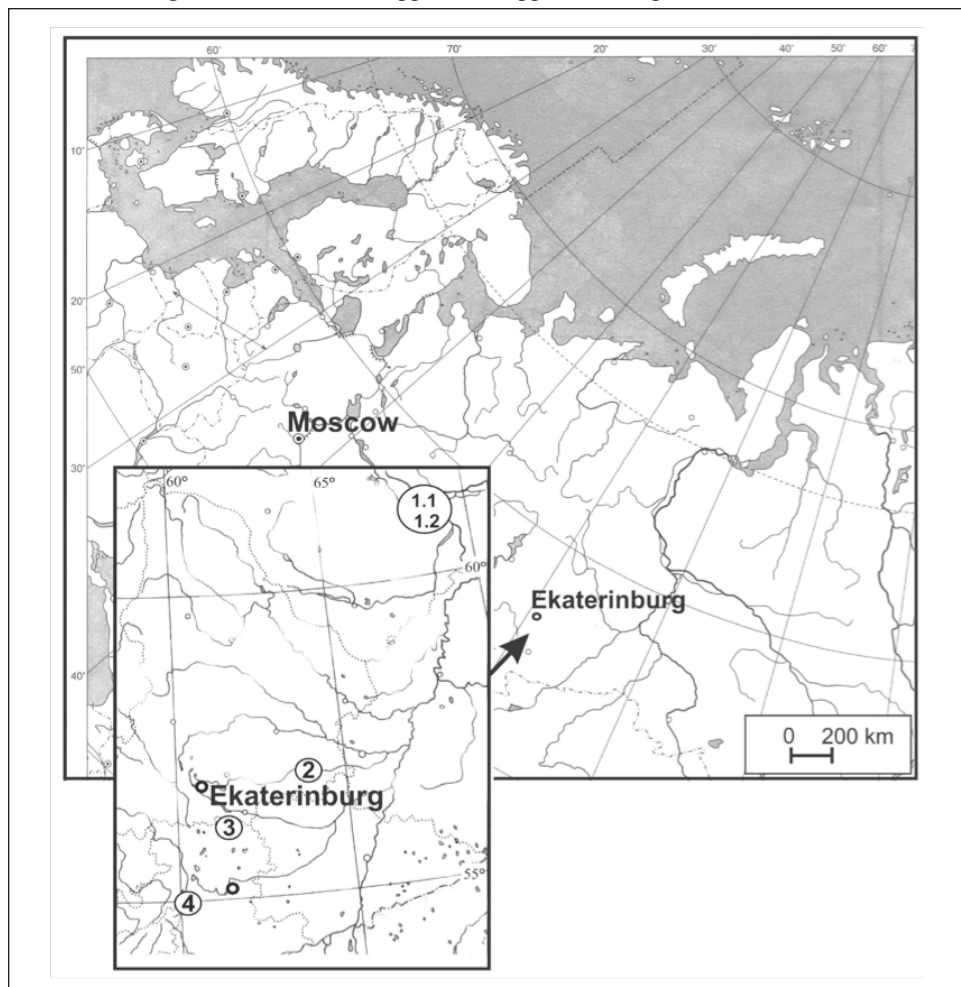


Figure 1. Geographical position of the study area and experimental sites. Sites (north to south): 1.1 – Coniferous forests, middle taiga of Western Siberia; 1.2 – Mixed deciduous forests, middle taiga of Western Siberia; 2 – Southern taiga of Western Siberia; 3 – Northern forest–steppe; 4 – Pine woods in the mountains of the Southern Urals.

represented in the mountains, which are covered with Norway spruce (*Picea abies*) in the north and pine (*Pinus* sp.) woods in the south. Data have been collected at 5 experimental sites.

Site 1.1 – Coniferous forest in the middle taiga of Western Siberia

The island Bolshoy (Big) Chukhtinsky (area 865 ha) is situated in the bottomland of the river Ob at about 61°13' N and 69°4' E. Average temperatures (and extremes) are -19.8 °C (-49.5 °C) for January and +17.5 °C (+34.5 °C) for July. Annual precipitation is 553 mm. Average altitude is 45 m a.s.l. (range = 30–60 m a.s.l.). Forests are mainly coniferous; tree stands are dominated by fir (*Abies* spp.) and spruce (*Picea* spp.). Siberian pine (*Pinus sibirica*) is present in more than 50% of the forested area. About 38% of the area is covered by deciduous forest. Other habitat types are small meadows and marsh. Herbaceous layer is dominated by blackberry (*Vaccinium myrtillus*), cowberry (*Vaccinium vitis-idaea*) and green mosses. Forty-three badger setts (burrows) were previously found on this island; 13 of them with more than 3 entrances were treated as breeding or “main” setts (Markov 2009). The territory of the island is part of a nature reserve; human impact on natural communities is negligible.

Site 1.2 – Mixed deciduous forest in the middle taiga of Western Siberia

This 364-ha site is situated on the island Maly (Small) Chukhtinsky, 1 km north of Site 1.1; both sites are separated by the river and swamped bottomland. Climatic parameters are the same as for Site 1.1, except the average altitude that is 40 m a.s.l. (range = 30–50 m a.s.l.); 70% of the area is deciduous, and the proportion of stands with Siberian pine does not exceed 10%. Twenty badger setts have been found on this island; 8 of them were categorized as main setts. The territory of the island is part of a nature reserve, and human impact on natural communities is negligible.

Site 2 – Southern taiga of Western Siberia

This site is situated at about 56°98' N, 63°78' E; the studied area is about 1,166 ha. Average temperatures (and extremes) are -18.0 °C (-46.0 °C) in January and +19.4 °C (+39.5 °C) in July. Annual precipitation is 375 mm. Average altitude is 100 m a.s.l. (range = 90–120 m a.s.l.). Forests are dominated by Scots pine (*Pinus silvestris*), birch (*Betula* sp.) and aspen (*Populus tremula*). In the understory, main species are raspberry (*Rubus idaeus*) and briar (*Rosa* spp.), while those in the herbaceous layer are graminoids (*Graminea* spp.) and bracken (*Pteridium aquilinum*). Scats were collected in the surroundings of 5 main setts. The site is within a nature reserve, with negligible human impact on natural communities.

Site 3 - Northern forest–steppe

Site 3 is located at approximately 56°21' N, 61°28' E. The sampled area is about 1,700 ha. Average temperatures (and extremes) are -16.0° C (-46.0° C) in January and +19.0 °C (+39.0 °C) in July. Annual precipitation is 375 mm. Average altitude is 220 m a.s.l. (range = 206–230 m a.s.l.). Meadows are the main habitat type. Wet meadows are dominated by *Filipendula* plants and sedges (*Carex* sp.), while graminoids are most common on the dry meadows. Only about 25–30% of this area is covered by deciduous and mixed forests dominated by birch, aspen and Scots pine. Marshes cover about 10–15% of the study site. Human impact on natural communities is haymaking and cultivation of crops. Scats were collected around 4 main badger setts.

Site 4 – Pine woods of the Southern Urals

This 600-ha site is situated approximately 55°00' N, 60°09' E, in the surroundings of lake Bolshoye (Big) Miassovo, Ilmensky State Nature reserve. Average temperatures (and extremes) are -16.4 °C (-36.6 °C) in January and +19.5 °C (+37.0 °C) in July. Annual precipitation is 580–680 mm. Average altitude is 300 m a.s.l. (range = 292–358 m a.s.l.). Nearly 99% of the mountainous area consists of forests that are dominated by Scots pine; birch is present as a secondary forest type. Also, 3 small marshes and a dry meadow are present at this site. There were 3 main and about 11 secondary badger setts. The site is part of a strictly protected area, and human impact on natural communities is negligible.

MATERIALS AND METHODS

Scat collection

Asian badger diet was determined on the basis of undigested remains in scats (faeces). Scats were collected from “latrines” situated close to badger paths in the surroundings of known setts. Field work was performed at seasons when all types of food were available for badgers. This approach was used to obtain data on badger food habits when they are not affected by seasonal changes in prey availability. At Site 1.1, food availability changed significantly with season (the abundance of plant food, particularly berries and Siberian pine nuts, increased in August–September), thus it was not possible to collect data during 1 season with high availability of all types of food. For this reason, scats were collected in spring (end of May to beginning of June) and fall (within the first 20 days of August in 2006–2008 and the last 10 days of September in 2009) and data for these 2 seasons were averaged and used in future analyses as 1 dataset. At Site 1.2, where Siberian pine was not so abundant, scats were collected in July and August 2006 and 2007. At Sites 2, 3 and 4, field work took place between approximately 20 June and 10 July in a specific year. The number of scats collected at each site is shown in Table 1. Prior to data collection, old scats were removed from latrines, thus the data we obtained characterized exactly the diet of badgers during the time period when the field work was carried out. Latrines were checked for scats every 2 days. Whole scats (in a majority of cases) or random parts of a pit content (when a very high volume of excrements was present and individual scats were “merged” and could not be distinguished) were collected and placed in separate plastic bags. Using several random parts of “merged” fecal samples did not significantly affect the percentage of occurrence of food items, but could lead to mistakes when estimating the amount of consumed food. For this reason, only data from whole scats were used to analyze the amount of consumed food. Each sample was first rinsed through sieves with mesh sizes from 1 to 0.25 mm and a sample of sediment was collected in 1.5-ml plastic tubes for microscopic examination of the presence of earthworm chaetae. After the preliminary processing, scats were dried and stored at -20 °C (when possible) or in a cool place at a temperature below or close to 0 °C.

In the laboratory, scats were soaked in water and again washed through the sieves. All recognizable prey parts were separated and identified using specialized literature (Medvedev 1982; Mayakov and Shepel 1987; Gromov and Yerbaeva 1995; Borodin 2009) and by comparing with reference collections. Plant remains were identified by green material, seeds and nutshells; invertebrates by chaetae and elements of exoskeleton; vertebrates by bones, teeth and hair. Scale remains were used for identification of fish and reptiles. Consumption of birds was also identified

Table 1. Sampling years and periods, and number of Asian badger (*Meles leucurus*) scats collected at study sites.

Site	Characteristics	Year	Sampling period	Sample size
1.1	Coniferous forest in the middle taiga of Western Siberia	2006	May, August	50
		2007	May, August	63
		2008	May, August	49
		2009	May, September	42
1.2	Mixed deciduous forest in the middle taiga of Western Siberia	2006	July – August	10
		2007	July – August	15
2	Southern taiga of Western Siberia	2004	20 June – 10 July	18
		2009	20 June – 10 July	24
		2010	20 June – 10 July	34
3	Northern forest-steppe	1999	20 June – 10 July	16
		2000	20 June – 10 July	35
		2001	20 June – 10 July	29
		2003	20 June – 10 July	23
		2004	20 June – 10 July	51
		2005	20 June – 10 July	19
4	Pine woods of the Southern Urals	1998	20 June – 10 July	51
		2006	20 June – 10 July	51
		2009	20 June – 10 July	19

by presence of feathers and egg shells. When possible, remains of plants, insects, mollusks, amphibians, reptiles and mammals were identified to species or genus; earthworms, to family; birds, to order; and fish, to class level.

Assessment of the amount of consumed food

Quantitative assessment of the number of remains in scats was made for all food categories except mollusks and birds. Amount of plant food was estimated by the remains of fruits, namely seeds of grains and berries and shell of Siberian pine nuts; green parts were found in a few samples in very small amounts and were not included in the analysis. Seeds and nutshells were weighed on an electronic balance scale with an accuracy of 0.1 g, and were given a rank according to the obtained value. For berries, ranks were: 0: no remains, 1: <0.1 g, 2: 0.1–1 g, 3: 1.1–5 g, 4: 5.1–10 g, 5: >10 g. For Siberian pine nutshells, ranks were: 0: no remains, 1: ≤15 g, 2: 15.1–30 g, 3: 30.1–45 g, 4: 45.1–60 g, 5: >60 g.

The number of earthworm chaetae in samples was assessed for Site 1.1 for the period 2006–2009; Site 1.2, for 2006–2007; Site 2, for 2009–2010; and Site 3, for 2004–2005. For Site 4, we used samples collected in 2009 and also literature data by Dvornikov and Chaschin (2008) for the same territory. Counts of chaetae were made following methods described in Kruuk and Parish (1981): chaetae were counted in 10 1-cm² squares, and the average number of chaetae per cm² was calculated.

We did not use methods of visual estimation of the volume of food consumed, as done in previous studies (e.g., Kruuk and Parish 1981; Goszczyński *et al.* 2000; Marassi and Biancardi 2002). The main reason for this was that remains of food could be represented by “outer coverings” (e.g., chitinous remains of insects or nutshells). The volume of such remains is closely related to the total volume of consumed prey. On the other hand, the number of bones of

vertebrates is only indirectly related to the mass or volume of prey. Thus, different categories of food cannot be compared based only on the volume of remains. Instead of a visual estimation of volume, we counted the “minimum number of individuals”: insects were counted by elytra, heads and pronotums; mammals, amphibians and reptiles by bones and teeth. When scats only contained mammalian hair (i.e., bones were absent), the number of consumed individuals was taken equal to 1 (following the rule of the “minimum number of the individuals”). Such approach is used in fish diet studies (e.g., García-Berthou and Moreno-Amich 2000), herpetological research (e.g., Strüssmann *et al.* 1984), but also in carnivore food habit studies (e.g., Jones and Barmuta 1998; Mukherjee *et al.* 2004). This method is accurate, results are reproducible, and it does not underestimate the importance of prey whose remains could be in small volume (e.g., bones of amphibians or juveniles). The disadvantage of this method is that results could not be directly compared to a number of other studies where percentage of volume had been used as main indicator of prey’s contribution to badgers’ diet. However, both the number of individuals and percentage of volume (correctly measured) could in future be recalculated to the volume of consumed biomass using reliable coefficients of digestion and data on prey mass (e.g., Jones and Barmuta 1998).

Contribution of each food category to Asian badger diet (for each site) was expressed in 2 ways. 1. *Percentage of occurrence* (PO) of food in the given year (i.e., scats with a given prey found as percentage of all analyzed scats) and mean value for the whole multiple-year period of observations. It is important to emphasize that the unit of observation was the dataset for a given year. Since scats were collected in different years, the number of samples with prey was related to the number of scats collected in a given year, and the mean value and the error of the mean thus reflected the variation of PO as caused by inter-annual variations in weather conditions, food availability, or other factors. If the prey was observed during only 1 year, PO was calculated just for the year of observation. An alternative way of calculating PO would be to pool all the data for the given site, but such approach does not allow estimation of annual variation of PO. In 3 cases, when prey was observed in only 1 year, PO was potentially overestimated. We specially indicated these cases in Table 2. 2. *Average amount of consumed food per scat (pooled data for the whole period of observation)*, which corresponded to the average rank for plant food, the average number of earthworm chaetae per cm², and the average number of insect and vertebrate (excluding birds) individuals.

For mammals we also calculated the *proportion of individuals of the given species/genus* (i.e., the number of individuals of the given species/genus to the total number of individuals of all mammals in the whole sample) for the given site. For insects, we calculated the *contribution of orders* as the number of species/genera of the given order related to the total number of species/genera in the whole sample for the given site.

Pairwise comparison of sites was performed using non-parametric statistics (Mann–Whitney test). The null-hypothesis about the lack of differences was unambiguously rejected for $p < 0.05$, though differences were treated as significant for $p < 0.1$. Statistical analysis was performed using STATISTICA 8.0 (StatSoft, Inc. 2007).

RESULTS

The diet of Asian badgers included 9 food categories: plants (berries and nuts), earthworms, insects,

mollusks, fish, amphibians, reptiles, birds and mammals. Data on the percentage of occurrence of these food categories at the 5 sampling sites are shown in Table 2.

Table 2. Percentage of occurrence (%; mean \pm SE; min / max) of the food categories in the diet of Asian badgers in Urals and Western Siberia.

Food categories	Site (total number of scats)				
	1.1 (n = 204)	1.2 (n = 25)	2 (n = 76)	3 (n = 173)	4 (n = 121)
Plants	99.4 \pm 0.6; 97.6 / 100.0	95.0 \pm 5.0; 90.0 / 100.0	65.3 \pm 20.5; 29.2 / 100.0	64.0 \pm 11.6; 31.3 / 100.0	52.2 \pm 10.8; 33.3 / 70.6
Earthworms	67.4 \pm 13.9; 28.6 / 93.7	81.7 \pm 8.3; 73.3 / 90.0	45.5 \pm 16.3; 29.2 / 61.8	14.6 \pm 10.3 4.3 / 25.0	100.0 \pm 0.0; 100.0 / 100.0
Insects	83.3 \pm 3.8; 76.0 / 90.5	95.0 \pm 5.0; 90.0 / 100.0	100.0 \pm 0.0; 100.0 / 100.0	96.0 \pm 1.7; 89.7 / 100.0	100.0 \pm 0.0; 100.0 / 100.0
Mollusks	0.0	0.0	52.1 \pm 9.4; 41.2 / 70.8	32.5 \pm 11; 2.9 / 78.9	10.7 \pm 0.6; 9.8 / 11.8
Fish	7.4 \pm 4.1 0.0 / 18.0	0.0	0.0	0.0	33.3*
Amphibians	17.6 \pm 4.1; 9.5 / 28.6	46.7 \pm 6.7; 40.0 / 53.3	96.3 \pm 3.7; 88.9 / 100.0	84.4 \pm 7.6; 51.7 / 100.0	29.5 \pm 13.7; 15.7 / 56.9
Reptiles	1.0 \pm 0.6; 0.0 / 2.0	0.0	56.5 \pm 10.9; 38.9 / 76.5	65.8 \pm 12.9; 20.0 / 100.0	11.6 \pm 7; 3.9 / 25.5
Birds	14.3 \pm 4; 6.1 / 24.0	50.0*	15.0 \pm 6.4; 8.3 / 27.8	41.3 \pm 5.7; 24.1 / 57.9	20.3 \pm 7.7; 9.8 / 35.3
Mammals	33.7 \pm 10.8; 4.8 / 57.1	20.0*	51.0 \pm 21.7; 29.4 / 94.4	89.4 \pm 3.3; 75.0 / 98.0	10.5 \pm 7.7; 0.0 / 25.5

*Food category found during a single year at the corresponding sampling site

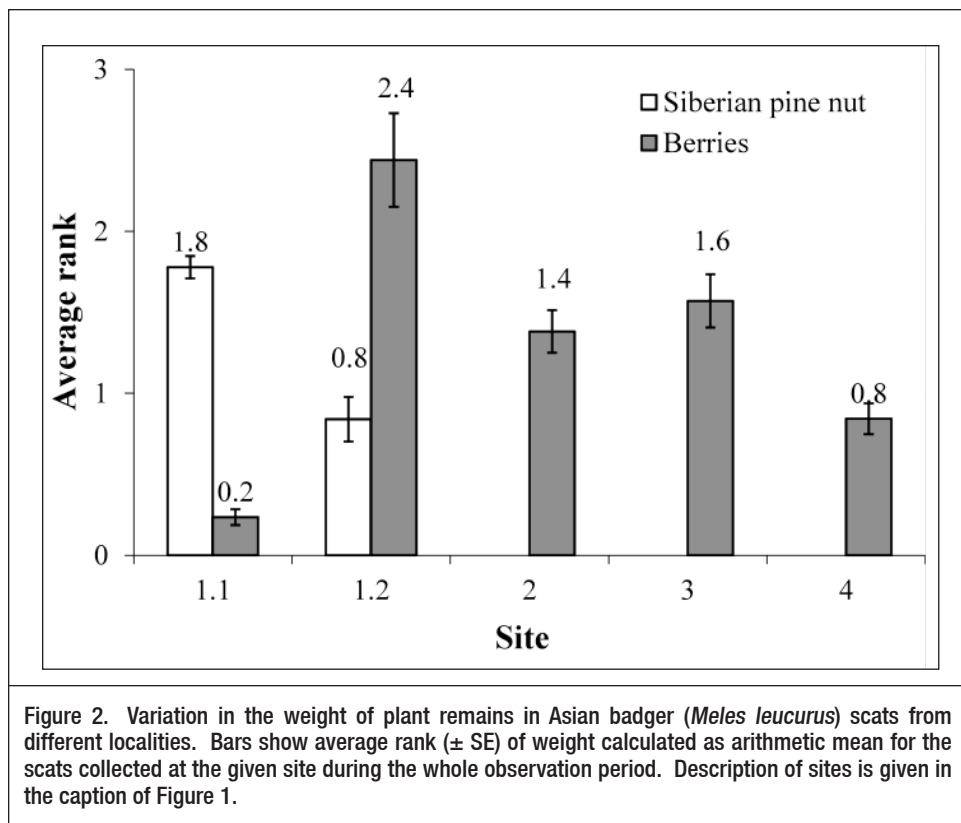
Plants

The main type of plant food in the diet of badgers inhabiting Site 1.1 was Siberian pine nuts with a PO of 99.4% (we found only 1 scat that did not contain nutshells). In Site 1.2, its PO equaled $65 \pm 5\%$, despite the fact that the proportion of forests with Siberian pine was much lower. In all areas, badgers consumed wild berries. In middle taiga (Sites 1.1 and 1.2), the most frequently consumed berry was blackberry, while in forest-steppe and southern taiga, the highest PO was observed for strawberry (*Fragaria* sp.).

The highest PO of plant remains was observed at the most northern sites, situated in the middle taiga of Western Siberia. The PO was similar (50–65%) in Sites 2, 3 and 4. The mass of Siberian pine nuts remains in scats from Site 1.1 varied from 0.05 to 87 g per scat, and the average rank was 1.8 ± 0.1 (thus remains did not exceed 30 g per scat); at Site 1.2, it was lower with an average rank of 0.2 ± 0.1 (up to 15 g per scat). The mass of berry remains varied from less than 0.1 g (single seeds) to 25 g. The highest average rank for berries was observed in scats from Site 1.2 (2.4 ± 0.4 ; up to 5 g per scat), while at most sites the rank did not exceed 1.0 (less than 0.1 g per scat) (Figure 2). Differences in average ranks of berries were statistically significant ($p < 0.001$) for all pairs of sites, with the exception of Sites 3 and 4 (Mann-Whitney test, $U = 10,442, p = 0.97$).

Earthworms

The highest PO of earthworms (Lumbricidae) was observed in scats from Site 4 (100%); the

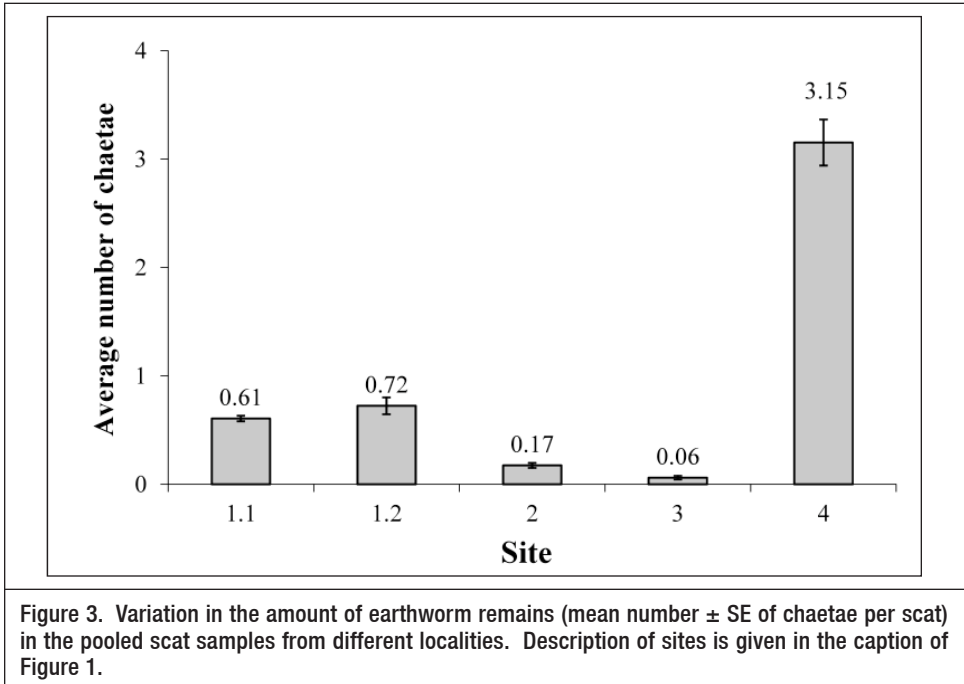


lowest PO was for Site 3 scats (14.6%). The average number of earthworm chaetae also was the highest at Site 4, in the pine woods of Southern Urals; values for Sites 1.1 and 1.2 were much lower. The lowest number of earthworm remains was found in scats from southern taiga and northern forest–steppe (Figure 3). Differences between pairs of sites were statistically significant ($p < 0.01$), except for Sites 1.1 and 1.2.

Insects

Most insects consumed by Asian badgers belonged to the order Coleoptera; proportions of other orders were much lower (Table 3). In Sites 1.1 and 1.2, badgers most frequently consumed ground beetles (*Pelophila borealis*, *Carabus aeruginosus*), carrion beetles (various species of Silphidae), diving beetles (*Rhantus* sp.), bumblebees (*Bombus* sp.) and wasps (various species of Vespidae). In Sites 2 and 3, insect remains were dominated by dungbeetles (*Anoplotrupes stercorosus* = *Geotrupes stercorosus*), carrion beetles (various species of Silphidae), ground beetles (various species of *Carabus*, *Pterostichus*, *Amara* and others), bumblebees (*Bombus* sp.) and wasps (various species of Vespidae).

Insects had a high PO (more than 75%) at all sites. The number of individuals per scat was the highest at Site 2 (Figure 4) due to the presence of ants (families Formicidae and Myrmicidae). The number of ants per scat varied from single individuals to hundreds of them. Comparisons



of the number of insects per scat between pairs of sites showed that in all cases, except for Sites 1.2 and 4, differences were statistically significant ($p < 0.001$). Thus, along the gradient of the contribution of insects to the species diet, study sites were situated (in ascending order) as follows: coniferous forests of middle taiga (Site 1.1) – deciduous forests of middle taiga (Site 1.2) and pine woods of Southern Urals (Site 4) – northern forest–steppe (Site 3) – southern taiga of Western Siberia (Site 2).

Amphibians and reptiles

At all sites, Asian badgers ate frogs (*Rana* sp.). Species specific for certain sites were common toad (*Bufo bufo*) (Site 2; PO = 55.6–79.9% in different years) and common newt (*Lissotriton vulgaris*) (Site 3, found in 2003–2005; PO = 17.5–26.3%). Reptiles were represented by lizards (Lacertidae); at Site 4 we also found the remains of anguine lizard (*Anguis fragilis*) and grass snake (*Natrix natrix*). The highest PO of amphibians and reptiles was observed in Sites 2 and 3; PO was much lower in Sites 1.1, 1.2 and 4. The maximum average number of amphibians per sample was also observed at Site 2 (Figure 5). Pairwise differences in the average number of amphibians between sites were statistically significant ($p < 0.001$), except for Sites 1.2 and 4.

The average number of individuals did not exceed 0.1 in scats from Sites 1.1 and 1.2; differences between groups were not statistically significant ($p > 0.05$). In contrast, in scats from Sites 2 and 3, the average number of individuals was 3.2, a value 30 times higher than that of scats from other sites. Differences between groups, as well as differences between sites 2 and 3 were statistically significant ($p < 0.001$).

Table 3. Taxonomic composition of insects in the diet of Asian badgers (proportion of the number of species/genera of the given order to the total number of species/genera of insects found in pooled scat samples $\times 100$).

Order	Site				
	1.1	1.2	2	3	4
Coleoptera	86.3	81.0	89.7	89.0	90.0
Hemiptera	3.1	1.7	3.2	3.5	3.3
Orthoptera	1.1		0.7	0.9	
Hymenoptera	7.3	13.8	5.3	5.7	6.7
Mecoptera				0.3	
Homoptera		1.7	0.7	0.3	
Odonata	1.1	1.7			
Lepidoptera	1.1		0.4	0.3	

Mammals

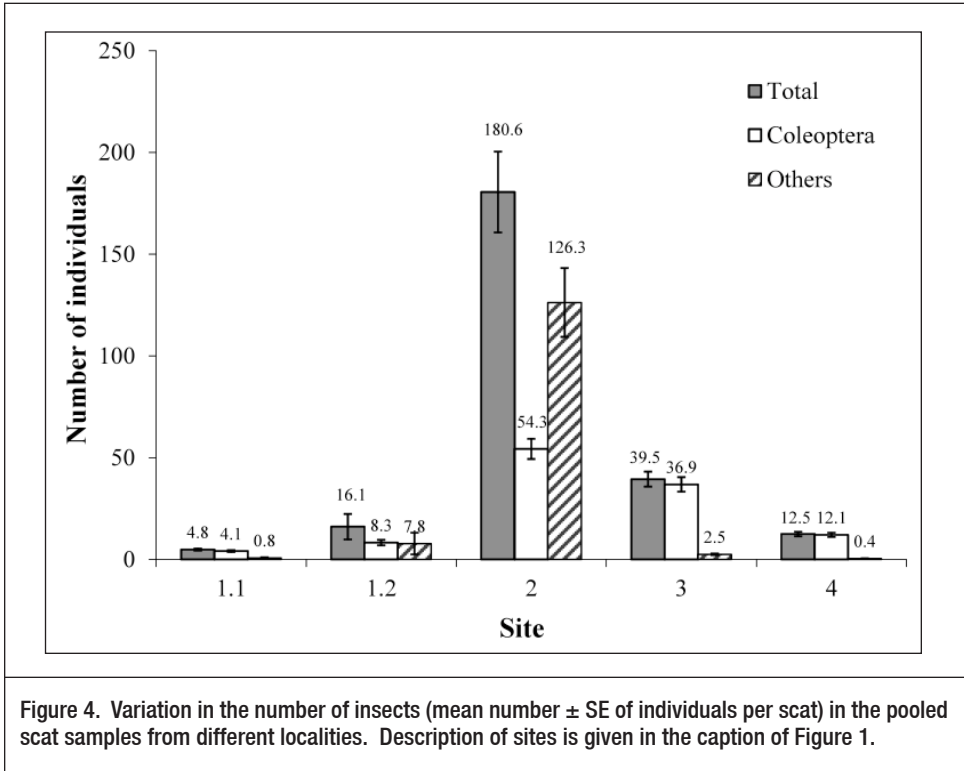
Mammals were represented by rodents and insectivores (Table 4). Rodents were dominated by voles. At Site 1.1, PO of *Microtus* and *Clethrionomys* was generally similar (23.1% and 30.8%, respectively), accounting for annual variation. At Site 1.2, remains of mammals (genus *Clethrionomys*) were found in only 1 sample. At Sites 2 and 3, common voles (*Microtus*) were consumed most frequently (PO = 67.5% and 91.9%, respectively), while remains of representatives of the genus *Clethrionomys* were only rarely found (PO = 12.6% and 7.8%, respectively). At Site 4, remains of voles that allowed taxonomic identification were found in only 1 scat; at this site we had the highest number of scats with undetermined remains.

The highest PO of mammal remains and the lowest annual variation of this index were observed in scats from Site 3. In scats from other sites, annual variation was high. The lowest values were observed in Site 4: PO equaled 25% in 1998, 5% in 2006, whilst in 2009 we found no remains of mammals in the scats.

The average number of mammals per sample also was the highest at Site 3; pairwise differences with all other sites were statistically significant at $p < 0.001$. Values of this index in the middle taiga (Sites 1.1 and 1.2) were low (Figure 5), but the difference between both sites was statistically significant ($p = 0.049$), indicating that badger ate more mammals at Site 1.1. There was no statistically significant difference between Sites 1.2 and 4 ($p = 0.73$), as for both of them the average number of individuals per scat for the pooled sample did not exceed 0.1.

Other food categories

Remains of mollusks were split into 2 categories. The first category included mollusks that were regarded as “purposely eaten by badger”. These were relatively big mollusks (shell size > 5 mm), whose shells were severely damaged, supposedly by chewing. The second category included small mollusks (shell size ≤ 5 mm) whose shells were found intact and we treated them as being ingested unintentionally. Remains of “big” mollusks were found only at Sites 2, 3 and 4. Fish was only rarely eaten by badgers; remains were found in scats from Sites 1.1 and 4, but the PO was low. Remains of birds were found at all sites and in all cases they represented the order Passeriformes. The highest PO of birds (41.3%) was observed at Site 3; PO was much lower at all other sites (Table 2).



DISCUSSION

Our data allow to compare the diet composition of Asian and European badgers, and also to estimate the variation in the contribution of different food categories in natural zones, stretched in latitudinal direction. The gradient of latitudes covered in this study corresponds to northern Europe and this partly limits the possibility of comparing our data with those from central and southern Europe. However, specific features of the Urals region, particularly the high diversity of climatic conditions and natural communities, allowed us using data from southern Europe to discuss possible reasons to the observed trends.

The diet of Asian badgers in Urals and Western Siberia is characterized by a relatively low consumption of earthworms; although the PO of earthworm chaetae was similar to that reported for European badger populations, the number of chaetae was very low at most sites, indicating that badgers did not consume a high biomass of earthworms. This is what distinguishes our results from data presented for many regions of Northern and Central Europe, and British Isles, where authors consider earthworms as the key resource for the European badger (e.g., Kruuk and Parish 1981; Seiler *et al.* 1995; Goszczyński *et al.* 2000). In our study, earthworms had a high PO and were eaten in large amounts only in 1 site, namely in the mountainous pine woods of Southern Urals (Site 4). In other study sites, the contribution of this prey to the overall diet was relatively low. This concerns both northern areas (Sites 1.1 and 1.2) and sites situated in southern taiga

Table 4. Taxonomic composition and proportions of mammal species in the diet of Asian badgers (number of individuals of the given species related to the number of individuals of all mammals in pooled scat samples $\times 100$).

Taxa	1.1	1.2	Site 2	3	4
Rodentia					
Genus <i>Microtus</i>, including:	33.8		76.0	86.6	50.0
<i>M. arvalis</i> sensu lato			26.5	25.0	
<i>M. agrestis</i>			3.3	5.0	
<i>M. ex gr. arvalis-agrestis</i>			20.5	6.2	
<i>M. gregalis</i>			3.3	11.1	
<i>M. oeconomus</i>	33.8		0.6	4.2	50.0
<i>Microtus</i> sp.			21.8	35.1	
Genus <i>Clethrionomys</i>, including:	38.5	33.3	4.6	1.6	
<i>C. rutilus</i>	38.5		0.7	0.2	
<i>Clethrionomys</i> sp.			3.9	1.4	
<i>Arvicola terrestris</i>			0.6	2.4	
<i>Ondatra zibethicus</i>				0.4	
Undetermined vole <i>Arvicolinae</i>	3.1				14.3
<i>Apodemus agrarius</i>			0.7		
<i>Apodemus</i> sp.			0.7	1.8	
<i>Sylvaemus uralensis</i>			0.7		
<i>Micromys minutus</i>	3.1		0.7		
<i>Sicista</i> sp.			0.7	0.2	
Insectivora					
<i>Sorex</i> sp.	21.5	66.7	14.6	7.0	14.3
<i>Erinaceus</i> sp.			0.7		
<i>Talpa europaea</i>					21.4

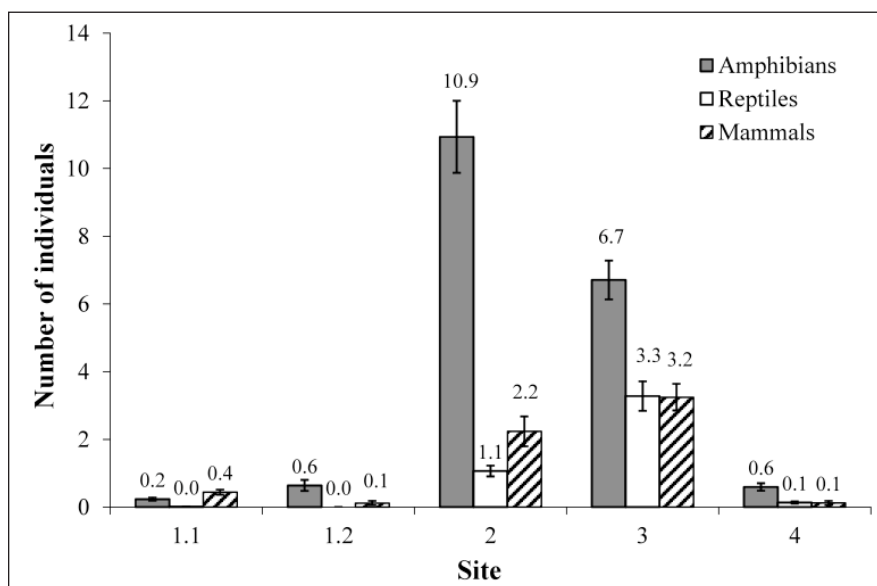


Figure 5. Variation in the number of vertebrates (mean number \pm SE of individuals per scat) in the pooled scat samples from different localities. Description of sites is given in the caption of Figure 1.

and forest–steppe. Observed differences in the contribution of earthworms to Eurasian badgers' diet could result from seasonal differences in earthworm abundance. Many authors noted that in Western and Central Europe, the contribution of earthworms to European badger diet is the highest in winter and spring (Hofmann 1999; Lanszki 2004; Fischer *et al.* 2005). In summer, they are consumed in smaller amounts due to hot weather and, as a consequence, to the migration of earthworms well below the soil surface (Rodriguez and Delibes 1992; Marassi and Biancardi 2002). According to these observations, the amount and biomass of earthworms ingested should be the lowest at Sites 2, 3, and 4 where scats were collected in the hottest period of the year, i.e., June and July. However, high PO and large numbers of earthworm chaetae in scats from Site 4 do not allow accepting this hypothesis unambiguously. Another possible reason for the low consumption of earthworms in most of our study areas could be habitat structure. In Western Europe, earthworms are mainly consumed in pastures and agriculture fields. In the study sites under consideration, the proportion of these habitat types was extremely low or nil. Data on abundance of earthworms in natural communities of Urals and Western Siberia are presented in several publications. According to literature, the abundance of earthworms in the pine woods of Southern Urals is up to 42 individuals/m² (Nagumanova 2006). Plant associations of Sites 2 and 3 were characterized by a relatively low abundance of this type of prey, namely 2.4–5.6 individuals/m². However, values are even lower for middle taiga (0.8–2.4 individuals/m²; Striganova and Poryadina 2005) and this does not explain the higher consumption of earthworms in the middle taiga in comparison with the northern forest–steppe and southern taiga sites in Western Siberia. A third reason that could explain the differential contribution of this food category is the availability of other prey. Recently, Li *et al.* (2013) analyzed Eurasian badgers' diet in 22 localities over the range of the genus *Meles* and reported the frequency of occurrence of earthworms being negatively correlated with that of insects and mammals. In our case, a strong negative correlation (Spearman's rank correlation test, $r_s = -0.82$, $p = 0.13$) was found between the average number of food types and the average number of earthworm chaetae per scat at each site (Zaiganova and Markov, unpublished data). Although not statistically significant, probably due to very small sample size ($n = 5$), this unpublished result still demonstrates the high probability of correlation between the diversity of food items eaten by Eurasian badgers and the number of earthworm chaetae. A fourth and last reason could be related to the difference in earthworm species composition between Urals and Western Europe, and also between our study sites. In Western Europe, *M. meles* eats mainly earthworms of the genus *Lumbricus* (*L. terrestris*, *L. rubellus*), which are most abundant in natural communities and in agriculture fields (Kruuk and Parish 1981; Goszczyński *et al.* 2000). In the middle taiga (Sites 1.1 and 1.2), *Eisenia nordenskioldi* is a dominant species, while *L. rubellus* is more abundant in southern taiga and forest–steppe (Striganova and Poryadina 2005). The relatively low consumption of earthworms at Sites 1.1 and 1.2 could be explained by the smaller size of *E. nordenskioldi*, which could make it a less attractive prey than bigger earthworms of the genus *Lumbricus*, but the same explanation could not be applied to Sites 2, 3 and 4. In Poland, Goszczyński *et al.* (2000) reported a quite intensive consumption of *L. rubellus*, but we did not make similar observations in the areas where this species is supposed to be abundant according to literature data (Striganova and Poryadina 2005). Existing data do not allow us to determine which hypothesis is more valid, and we consider the consumption of earthworms in our study areas as being affected cumulatively by weather conditions, habitat structure and abundance of other prey items. It is worth noting that a low contribution of earthworms to European badger diet has been

reported for several regions in Europe, mainly in Southern Europe – in Italy (Pigozzi 1991), Spain (Rodriguez and Delibes 1992) and Portugal (Rosalino *et al.* 2005) – but also in Central Europe (Hungary; Lanszki 2004) and Northern Europe, notably in Finland (Kauhala *et al.* 1998) and Belarus (Sidorovich *et al.* 2011).

Generally the diet of Asian badgers in Urals and Western Siberia is similar to that of the European badgers. Common feature of all studied sites is the frequent consumption of insects. Many authors noted that, despite the high PO, the contribution of insects to the diet of badgers is low in terms of biomass. In our data, this was the case at Site 1.1 where the average number of insect individuals per scat was only 4.8. At the other sites, scats contained, on average, the remains of more than 10 imagoes; at Sites 2 and 3, these were respectively 180.6 and 28.5 imagoes. Thus, we consider insects to be an important part of Asian badgers' diet at most of our study sites.

The contribution of plant food to the species' diet was the highest in the middle taiga. Previously we already discussed the importance of such resource as Siberian pine nuts (Zagainova and Markov 2011). Here we show that at the other study site in middle taiga characterized by a lower availability of nuts, plants were still one of the most important food categories. We found that blackberry was the most consumed berry in Sites 1.1 and 1.2. Interestingly, we did not find cowberry remnants in scats from middle taiga, although this resource was highly available at both sites. Amphibians were the most intensively eaten prey among vertebrates, and this was the case at all study sites.

The PO and abundance of mammals in the Asian badger diet was higher in southern taiga and forest–steppe as compared to middle taiga and mountainous pine woods. We suggest that the contribution of mammals to badgers' diet depends on the availability of rodents living in colonies and aggregations. In the case of the Urals and Western Siberia, these are voles of the genus *Microtus* inhabiting open and semi-open landscapes. Our data suggest a possible correlation between the abundance of rodent remains in badger scats and the proportion of open landscapes in the study area. Indeed, the contribution of voles was the highest in the northern forest–steppe where the proportion of forest did not exceed 25%, and was the lowest at highly forested sites, situated in pine woods of Southern Urals and middle taiga of Western Siberia.

Overall, our data do not support the hypothesis that animal food increases at higher latitudes (see Goszczyński *et al.* 2000; Vulla *et al.* 2008; Li *et al.* 2013). In our case, the contribution of plant food was the highest in the northern sites, while that for invertebrates, particularly earthworms, reached its maximum at the most southern site, i.e. in the pine woods of Southern Urals. The disagreement between our data and comparisons made at continental scale may result from the relatively low gradient of latitudes in our study. Comparison of North vs. South data (with the limit between “North” and “South” situated at 50 °N) highlighted significant differences in the frequency of occurrence of mammals and amphibians in the diet of both European and Asian badgers – these types of prey were consumed more frequently in the North than in the South (Markov and Zagainova 2014). That said, in most articles discussing this subject (e.g., Goszczyński *et al.* 2000; Vulla *et al.* 2008), geographical latitude is treated as a continuous variable and authors use it as a predictor in quantitative analyses of the variation of diet composition. Our dataset suggests that in the Urals region, in the gradient of latitudes from 55–61 °N, geographical latitude itself is not a good predictor of the contribution of animal food to badgers' diet. We suggest that, at least within our study area, the diet of Asian badgers is more affected by food availability at the local scale than by major environmental gradients. This suggestion is in agreement with the hypothesis of local

“specialization” discussed for European badgers by Revilla and Palomares (2002). These authors mentioned that “use of short-term studies without considering temporal variability can lead to a false impression of local specialization” (p. 92). Based on our data, obtained during several years of observations, we conclude that Asian badgers demonstrated generalist food habits in 3 of 5 study areas, but clearly used Siberian pine nuts and earthworms as key resources in the coniferous forests of middle taiga and pine woods of Southern Urals, respectively.

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