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Short communication

Diets of the Eurasian least shrew (*Sorex minutissimus*) from various localities in Hokkaido, Japan

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The Eurasian least shrew (*Sorex minutissimus* Zimmermann, 1780) is a rare species in spite of its wide range in Eurasia (Ohdachi et al. 2006). In Japan, it is currently recorded from northern, eastern, and Tokachi regions of Hokkaido (Abe et al. 2005). Ecological information including food habits of this species, especially in Hokkaido, is scarce.

In Hokkaido, there are four *Sorex* species; *S. unguiculatus* Dobson, 1890, *S. caecutiens* Laxmann, 1788, *S. gracillimus* Thomas, 1907, and *S. minutissimus*. Food habits of the former three species were investigated in several studies (e.g., Abe 1968; Inoue and Maekawa 1990; Ohdachi 1995). Diets of *S. minutissimus* in Russia were investigated by direct observation in captivity (Okhotina 1974) and digestive tract contents analysis (Churchfield and Sheftel 1994; Churchfield et al. 1999). However, there is no report on food habit of *S. minutissimus* in Hokkaido. Therefore, study for food habit of *S. minutissimus* is necessary to investigate interspecific relationships among sympatric *Sorex* species in Hokkaido. In this paper, we reported diets of *S. minutissimus* from digestive tract contents of 38 individuals collected from seven localities in Hokkaido from 1988 to 2007.

Materials and methods

Shrews were collected from seven localities in Hokkaido (Fig. 1) from 1988 to 2007. Habitat type and collection month and year for each locality are as follows (numbers correspond with those of Fig. 1). (1) Sarobetsu Moor (Horonobe-cho): developed peat lands or hills in wet lands; six samples collected in September, 1991, one sample in September, 1994, one sample in October, 2002 and nine samples in October, 2004. (2) Teshio Experimental Forest, Hokkaido Univ. (Horonobe-cho): *Picea glehnii* forest with *Sasa kurilensis* floor; one sample collected in July, 1988. (3) Asajino (Sarufutsu-mura): coastal sand dune with graminoids, herbs, and *Rosa rugosa*; one sample collected in October, 2006. (4) Mt. Nishi-nupukaushi (Kamishihoro-cho): the mixed forest of broad-leafed and coniferous trees with *Sasa kurilensis* floor; one samples collected in August, 2007. (5) Kamishihoro-cho: stony site in a wind-shelter belt; one sample collected in February and one in December, 1992, and one sample in July, 1993. (6) Koitoi (Shiranuka-cho): coastal sand dune with coastal graminoids and herbs; eleven samples collected in July, 2006. (7) Fureshima coast (Nemuro-shi): coastal sand dune with graminoids, herbs, and *Rosa rugosa*; four samples collected in September, 2005. The Japanese law of wildlife conservation and hunting regulation revised in 2002 prohibits a researcher to capture *S. minutissimus* without a permission. The shrews after 2002 were accidentally collected in the surveys for other small mammal species. After capturing, shrew specimens were preserved in 70% ethanol until analysis. Now, all shrew samples examined

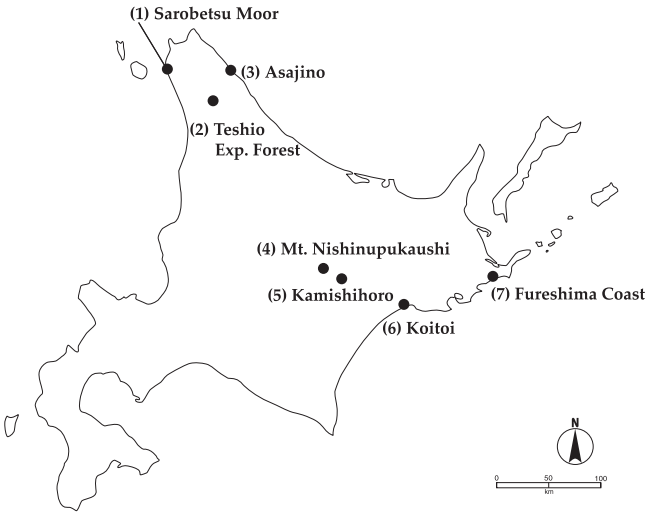

Fig. 1. Locations of seven study areas in Hokkaido.

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Table 1. Percent frequency of occurrence and percent volume index of digestive tract contents of *Sorex minutissimus* in Hokkaido

Location	N	Chiropoda		Araneae		Opiliones		Coleoptera adult		Collembola		Lepidoptera larva		Hymenoptera		Diptera larva		Diptera adult		Isopoda		Amphipoda		Acari		Unid. Item		Soil	
		F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%	F%	V%
(1) Sarobetsu Moor	17	35.3	3.5	47.1	4.9	0.0	0.0	41.2	9.9	5.9	0.1	5.9	11.7	5.9	0.3	0.0	0.0	0.0	0.0	11.8	9.8	0.0	0.0	0.0	0.0	29.4	52.2	11.8	7.6
(2) Teshio Exp. Forest	1	0.0	0.0	100	10.3	100	0.8	100	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	87.5	0.0	0.0
(3) Asajino	1	0.0	0.0	100	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(4) Mt. Nishinupukaushi	1	0.0	0.0	100	87.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.9	0.0	0.0	100	11.2
(5) Kamishihoro	3	0.0	0.0	100	40.8	66.7	2.0	33.3	54.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	3.1	0.0	0.0
(6) Koitoi	11	9.1	17.8	81.8	41.6	0.0	0.0	36.4	14.8	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.3	9.1	1.0	0.0	0.0	9.1	1.2	0.0	0.0	9.1	23.4	0.0	0.0
(7) Fureshima Coast	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	100	0.0	0.0	0.0	0.0	0.0	0.0
total	38	5.9	12.1	60.5	15.4	7.9	0.1	34.2	11.1	2.6	0.1	2.6	8.4	2.6	0.2	2.6	0.1	2.6	0.2	5.3	0.4	7.9	7.1	2.6	0.1	21.1	45.2	7.9	5.9

Location numbers correspond with those of Fig. 1.

here are stored at Natural History Museum of Botanical Garden, Hokkaido University, Sapporo.

Digestive tract contents were analyzed following Ohdachi (1995). Entire digestive tracts, from stomach to rectum, were removed from each individual. Each digestive tract was dissected in a glass vessel and all contents were extracted, which were sieved with water through a 100 × 100 μm mesh, and all remains were placed into another vessel. The contents items were identified with a binocular microscope. These items were compared with reference specimens of invertebrates, referring Aoki (1999). Then, the number of unit squares of the ocular lens ruler (1 × 1 cm square with 20 × 20 unit squares) which a specific item occupied was counted under ×7 magnification.

Each food item was quantified by two indices, percent frequency of occurrence (*F*%) and percent volume occurrence (*V*%), which were calculated following Ohdachi (1995).

The number of food items per individual was compared between *S. minutissimus* and the other three *Sorex* species in Hokkaido, and the differences were statistically tested by Kruskal-Wallis test and multiple comparing Steel-Dwass test. In this analysis, soil and unidentified items were excluded.

The similarity of food consumption between *S. minutissimus* and the other three species in Hokkaido was calculated with percent overlap index (Schoener 1970):

$$C_{kh} = 1 - 1/2\sum_{j}^{S}|(V\%_{kj} - V\%_{hj})/100|,$$

where C_{kh} = the similarity of food consumption between species *k* and *h*, $V\%_{kj}$ = the volume index percentage for food item *j* of species *k*, and $V\%_{hj}$ = that of species *h*. Note that C_{kh} is zero when species *k* and *h* share no food items and 1.0 when they have identical food consumption.

The data of digestive tract contents of *S. unguiculatus*, *S. gracillimus*, and *S. caecutiens* were based on diet study in northern Hokkaido by Ohdachi (1995) and food items were re-categorized to be the same as in the present paper. All statistical analyses were conducted using *R* Version 2.7.2 (R Development Core Team 2008).

Results and discussion

Fourteen categories of digestive tract contents were classified (Table 1). Among the content items except

soil were considered to be prey items for shrews. Spiders (Araneae), adult coleopterans, and centipedes (Chiropoda) were major prey items of *S. minutissimus* in Hokkaido. Especially, spiders were the most major food item.

Okhotina (1974) carried out food choice test for *S. minutissimus* in Far East Russia, and showed that this species preferred centipedes (Chiropoda) and also ate spiders, ant pupae (Hymenoptera; Formicidae), and small earthworms (Haploxida; Lumbricidae). Churchfield and Sheftel (1994) and Churchfield et al. (1999) found that major stomach and gut contents of *S. minutissimus* in Siberia were spiders, adult and larval coleopterans, cabbage bugs (Heteroptera), moth larvae (Lepidoptera), centipedes (Chiropoda), harvestmen (Opiliones), and mites (Acari). Therefore, Russian population and Hokkaido population of *S. minutissimus* share similar food items.

Lepidopteran larvae were scarcely appeared in the present study (F% = 2.6, Table 1), although they are a major food item for the other three *Sorex* species in Hokkaido (Ohdachi 1995). In addition, Churchfield and Sheftel (1994) and Churchfield et al. (1999) showed that *S. minutissimus* in Siberia largely ate lepidopteran larvae. The reason of the less use of lepidopteran larvae in Hokkaido was unknown. Differences in habitat type and sampling season might be potential causes.

In coastal sand dune (Koitoi), *S. minutissimus* ate terrestrial amphipods, most of which could be identified as sand hoppers (Amphipoda; Talitridae) (Table 1). Sand hoppers were not recorded for the other three *Sorex* species in Hokkaido (Abe 1968; Inoue and Maekawa 1990; Ohdachi 1995). They are abundant small arthropods in coastal habitats. Hence, sand hoppers are an appropriate food resource for *S. minutissimus* in coastal habitats.

Comparing to the other three *Sorex* species in Hokkaido (Ohdachi 1995), the number of occurrence of food items per individual was significantly lower in *S. minutissimus* (1.76 ± 0.19, mean ± *SE*) than any other three species in Hokkaido; 4.42 ± 0.10 for *S. unguiculatus*, 4.18 ± 0.24 for *S. caecutiens*, and 4.08 ± 0.14 for *S. gracillimus* (Kruskal Wallis test, $P < 0.05$. Multiple comparing Steel-Dwass test against each of the three species, $P < 0.05$). The extremely small body size of *S. minutissimus* (Abe et al. 2005) might have limited the number of food items per unit time.

The similarity of food consumption (C_{kh}) of *S. minutissimus* was higher between *S. gracillimus* (0.45) than between the other two species, *S. unguiculatus* (0.26) and *S. caecutiens* (0.32). Body size is also most similar between *S. minutissimus* (ca. 1.8–2.5 g) and *S. gracillimus* (ca. 3.0–5.0 g) in Hokkaido (S. D. Ohdachi, unpublished data). Thus, *S. gracillimus* seems to be a potential severe competitor for *S. minutissimus* because the two species are ecologically similar to each other.

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