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Temporal changes in the population density and diet of brown bears in eastern Hokkaido, Japan

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Abstract. In eastern Hokkaido, Japan, occurrences of human-brown bear (*Ursus arctos yesoensis*) conflict have increased during the last decade. Locals speculate that these conflicts have been caused by an increase in the bear population and/or changes in bear ecology, although no evidence is available to support either hypothesis. We compared scat densities and the diets of bears for the years 1978 and 1998–2000 in Urahoro, eastern Hokkaido. The scat density in 2000 tended to be lower than in 1978, suggesting that bear density has not increased over the last two decades. In 1978, herbaceous plants were the dominant early and late summer foods of bears. Berries, including *Rubus* spp. and *Actinidia kolomicta*, were dominant late summer foods. In contrast, sika deer (*Cervus nippon yesoens*is) meat appeared frequently in bear scats in all seasons in 1998–2000, at a much higher percentage than in 1978. Crops, including sugar beet and corn, also increased in early and late summer. These results suggest that the diet of bears has changed over the last two decades, and that bears have become more dependent on deer and on crops. We conclude that the increase in human-bear conflicts is not because of an increase in the bear population, but because of the increased dependence of bears on deer and crops as food sources.

Key words: *Cervus nippon yesoensis*, crop damage, food habit, scat density, *Ursus arctos yesoensis*.

The distribution of the Hokkaido brown bear (*Ursus arctos yesoensis*) decreased from an area covering approximately 47,000 km^2, or 60% of the island, in 1978 to roughly 40,000 km^2 (50%) in 1991 (Mano and Moll 1999). As a result of human activities and lowland development, bear populations are now fragmented into five regional subpopulations (Hokkaido Institute of Environmental Sciences [HIES] 2000). Based on interviews with hunters, the Hokkaido brown bear population was estimated as being between 1,771 and 3,628 animals in the 1990s (HIES 2000). Some studies have indicated a decreasing population trend (Hokkaido Government Nature Preservation Division 1986; Aoi 1990; Mano and Moll 1999).

Nevertheless, Hokkaido brown bears are killed throughout the year because of frequent human-bear conflicts involving agricultural damage, village invasions, and attacks on people. Sport hunting using firearms is permitted between 1 October and 31 January. The average annual harvest from 1991–1998 was 236.2 bears, which is equivalent to approximately 10% of the population (HIES 2000).

People living near bear habitats report that human-bear conflicts have increased during the last decade (HIES 1995, 1996, 2000). They speculate that these conflicts have increased because of an increased bear population and/or because of changes in bear ecology, due to the deterioration of the habitat (HIES 1995, 1996, 2000).

While it is clear that human-bear conflicts should be minimized, population control should be carried out on the basis of solid evidence. However, there is no evidence to prove an increase in the bear population, or

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changes in bear ecology. The objectives of this study were, therefore, to identify population trends and the ecology of the bears in this region in relation to agricultural damage and habitat changes.

Urahoro, eastern Hokkaido, is a typical town in which the number of human-bear conflicts has increased during the last decade. The Urahoro Town Office contains long-term records of bear kills, starting from 1966. The annual mean number of bear kills shows a declining trend prior to 1995, with 4.9 ± 2.6 *SD* during 1972–1983 but only 2.3 ± 1.2 *SD* to 1984–1995, followed by an abrupt increase for 1996–2001 (6.0 ± 2.8 *SD*), in reaction to an increase in human-bear conflicts (Sato 2003). If the number of bear kills is a reflection of changes in the bear population, it would suggest that the population increased during the late 1990s. However, it is unrealistic to suppose that a bear population, whose reproductive rate is low, could rapidly recover under heavy hunting pressure (Bunnel and Tait 1981). Rather, it is more probable that the increased number of bear kills reflects an increase in human-bear conflicts. We hypothesized that the recent increase in the occurrence of human-bear conflicts in Urahoro has been caused, not by an increase in the bear population, but by changes in their food habits.

Study area

Urahoro is located at the foot of Shiranuka Hill (100–700 m), in eastern Hokkaido, Japan (N 42'48, E 143'39). The mean annual temperature is 6.3°C and the mean annual precipitation is 13053 mm. The area covers 730 km^2, of which 74% is forested (44% natural forest and 30% plantations). Deciduous broadleaved trees like *Quercus crispula*, *Acer mono*, and *Tilia japonica* dominate the natural forests (Sato 1988), and *Larix leptolepsis* is dominant in the plantations. In the 1990s, the sika deer population increased (HIES 1997). Major forms of land use are crop fields and pastures, and the human population is about 7,000 people.

The most serious human-bear conflicts in Urahoro involve the factors of crop damage and a latent fear of attacks. Bear attacks on people have not occurred since 1975, when a bear injured a woman (Hokkaido Government 2000). Since 1993, damaged crop fields, mainly sugar beet and corn, have fluctuated between 20 and 100 ha (Urahoro Agricultural Cooperative unpublished data). There are no records before 1993, because damage was negligible. Lethal control has mainly been initiated in response to bear damage.

Materials and methods

Surveys in 1978

In July and August 1978, in cooperation with members of the Hokkaido University Brown Bear Research Group, we searched for bear signs along forest roads in an Urahoro district forest, belonging to the Hokkaido government. From 11–16 July, 1978, five parties explored streams and paths throughout the forest for a total distance of 33.5 km. From 26–29 August, 1978, four parties walked 32.3 km. Bear scats were collected and their numbers and locations were recorded.

Surveys in 2000

The same surveys were repeated in 2000, in cooperation with members of the Urahoro Brown Bear Research Group and the Hokkaido University Brown Bear Research Group. Surveys covering 58 km were conducted by eight parties in July, August, and October, and the same kinds of data were recorded. The area surveyed covered all of the census routes that were surveyed in July and August of 1978. We collected bear scats from May to November 1998–2000. Only fresh scats were collected.

Quantitative analyses of scats

The 34 bear scats collected in 1978 were quantitatively analyzed. About 30 g of material from each scat were sampled, and these samples were separated into individual food categories, oven-dried for 24 hours at 60°C, and weighed. Each category is presented by percent frequency of occurrence and percent dry weight.

All 117 scats collected in 1998–2000 were analyzed by the point-frame method (Sato et al. 2000). We washed the contents with tap water, on a sieve (2.0-mm mesh aperture). We then spread 500 g of the material remaining on the sieve onto an enamel tray (38 × 33 cm). The tray was marked with a 1 × 1-cm grid on the bottom, and the points of intersection were regarded as point frames. Over 400 points were counted. Sato et al. (2000) has confirmed that the point-frame method can reflect dry weight.

Animal materials are generally underestimated because they are more digestible than plant materials. We therefore recalculated the values for the volumes of six major categories (herbs, berries, acorns and nuts, deer, ants, and crops) using the correction factors proposed by Hewitt and Robbins (1996). Correction factors were 0.25 for herbs, 1.2 for berries, 1.5 for acorns and nuts, 3.0 for deer, 1.1 for ants, and 1.0 for crops. We divided

Table 1. Scat densities of brown bears along routine census routes in Urahoro, Hokkaido, July, August 1978, and July, August, October 2000.

Year	July			August			October		
	Explored distance (km)	Number of scats	Number of scats/km	Explored distance (km)	Number of scats	Number of scats/km	Explored distance (km)	Number of scats	Number of scats/km
1978	33.5	16	0.477	32.5	46	1.415	–	–	–
2000	33.5	1	0.030	32.5	1	0.031	–	–	–
	58*	2	0.034	58*	2	0.034	58*	5	0.086

*This includes the whole of census routes that explored in July and August 1978.

the 1978 samples into two seasons and the 1998–2000 samples into four seasons based on plant phenology, *e.g.*, spring (March–May), early summer (June–July), late summer (August–September), and fall (October–January). Based on the corrected volumes for the six major food categories, we compared the diets of 1978 and of 1998–2000 with a Pearson chi-square test for equality, using a statistical software package (SPSS Base ver. 11.5J and SPSS Exact test).

Results

Comparison of scat densities

We compared scat densities for 1978 and 2000 (Table 1). The scat density in July and August 2000 tended to be lower than in 1978. These summer months correspond to the period of crop damage by bears (Urata 2003). We therefore also surveyed scat densities in October, after crop damage had ceased, to compare with those in July and August. The scat density in October 2000 was almost the same as in July and August. Thus, the decrease in scat density suggests that bear density was lower in 2000 than in 1978.

Comparison of diets

In 1978, herbaceous plants were dominant in the bear scats in early and late summer (Table 2). In early summer, they were exclusively dominant in the scats, although their volume decreased in late summer. Berries in the scats increased markedly both in frequency and volume in late summer and consisted mainly of *Rubus* spp. and *Actinidia kolomikta.* In terms of animal material, only ants (Formicidae) occurred at high frequency in early and late summer, although their volume was low. We found no evidence of crop consumption.

In 1998–2000, herbaceous plants were common and dominant in spring, early summer, and late summer, as in 1978 (Table 3). In all seasons, the percentage of sika deer in scats was high, both in frequency and volume, which was not the case in 1978. In spring, herbaceous plants and sika deer were dominant, and together comprised as much as 98.4% of volume. In early summer, insects, mainly Formicidae, and crops, mainly sugar beet with a small amount of wheat, increased. In two cases, we found the hooves and teeth of sika fawns in the scats. The composition in late summer was similar to that in early summer, while the frequency of occurrence of

Table 2. Percent frequency of occurrence (F) and percent volume (V) for each diet category in the brown bear scats collected in Urahoro, Hokkaido, 1978.

	July (N = 16)		August (N = 18)	
	F	V	F	V
Plant materials				
Herbaceous plants	100.0	73.5	77.8	42.3
Petesites japonicus	93.8	69.8	77.8	42.1
Other forbs	18.8	2.6	5.6	0.0
Graminoids	6.3	1.1	5.6	0.2
Berries	–	–	94.4	35.6
Rubus spp.	–	–	66.7	16.6
Actinidia arguta	–	–	16.7	1.0
Actinidia kolomikta	–	–	50.0	12.5
Aralia cordata	–	–	16.7	0.4
Prunus ssiori	–	–	11.1	4.7
Vitis coignetiae	–	–	5.6	0.3
Seeds	–	–	16.7	0.0
Fallen leaves and twigs	56.3	15.2	22.2	5.2
Unknown	12.5	4.3	33.3	4.6
Animal materials				
Insects	68.8	4.4	50.0	1.0
Formicidae	68.8	3.1	44.4	0.8
Vespula flaviceps lewisii	–	–	5.6	0.0
Lucanidae	6.3	1.0	16.7	0.1
Unknown	12.5	0.2	5.6	0.0
Cambaroides japonicus	–	–	11.1	0.1
Others				
Soil and pebbles	31.3	1.2	72.2	11.3
Hair of *Ursus arctos*	12.5	0.0	–	–
Unknown	6.3	1.5	–	–

Table 3. Percent frequency of occurrence (F) and percent volume (V) for each diet category in the brown bear scats collected in Urahoro, Hokkaido, 1998–2000.

	May (N = 12)		Jun–Jul (N = 30)		Aug–Sep (N = 42)		Oct–Nov (N = 33)	
	F	V	F	V	F	V	F	V
Plant materials								
Herbaceous plants	83.3	66.6	70.0	40.4	73.8	27.2	39.4	7.6
Petesites japonicus	25.0	10.1	36.7	27.3	16.7	13.3	–	–
Other forbs	75.0	55.6	13.3	9.8	28.6	3.4	36.4	7.5
Graminoids	16.7	0.9	3.3	3.3	42.9	10.5	3.0	0.2
Berries	–	–	3.3	3.3	26.2	3.5	75.8	55.5
Actinidia arguta	–	–	–	–	7.1	0.5	54.6	39.0
Aralia cordata	–	–	–	–	2.4	0.0	23.2	1.4
Prunus ssiori	–	–	3.3	3.3	7.1	2.9	–	–
Sorbus commixta	–	–	–		–	–	3.0	–
Vitis coignetiae	–	–	–	–	2.4	0.0	36.4	15.2
Others	–	–	–	–	7.1	0.0	3.0	–
Acorns and nuts	–	–	–	–	16.7	2.5	27.3	17.6
Quercus crispula	–	–	–	–	2.4	0.6	15.2	10.1
Juglans mandshurica	–	–	–	–	7.1	1.8	9.1	7.4
Pinaceae	–	–	–	–	7.1	0.1	3.0	0.1
Seeds	8.3	–	16.7	0.7	2.4	0.1	3.0	0.1
Fallen leaves and twigs	50.0	1.0	56.7	2.5	45.2	5.3	27.3	1.5
Mosses	8.3	–	–	–	4.8	0.0	–	–
Unknown	–	–	3.3	0.1	–	–	–	–
Animal materials								
Cervus nippon	50.0	31.8	46.7	15.5	33.3	14.1	42.4	16.4
Insects	16.7	0.1	63.3	12.2	61.9	15.8	21.2	1.0
Formicidae	16.7	0.1	53.3	9.5	38.1	14.8	15.2	0.8
Vespula flaviceps lewisii	–	–	13.3	2.3	2.4	–	–	–
Lucanidae	–	–	3.3	0.0	9.5	0.2	–	–
Maggots	–	–	3.3	0.0	16.7	0.6	6.1	0.1
Unknown	–	–	16.7	0.2	23.8	0.2	9.1	0.1
Crops	–	–	23.3	19.0	31.0	25.4	–	–
Corn	–	–	–	–	11.9	8.0	–	–
Sugar beets	–	–	20.0	18.7	16.7	12.6	–	–
Wheats	–	–	3.3	0.3	–	–		
Meadows	–	–	–	–	4.8	4.7	–	–
Others								
Soil and pebbles	8.3	0.5	20.0	6.4	21.4	6.2	3.0	0.3

berries increased. Crops included sugar beet, corn, and small amounts of meadow grasses. In fall, berries, mainly *Actinidia arguta* and *Vitis coignetiae*, were dominant, and acorns and nuts increased while herbaceous plants decreased.

The corrected scat compositions indicated that the contribution of sika deer to the brown bear diet in 1998–2000 was large, particularly in spring: 85% in spring, 52% in early summer, 43% in late summer, and 34% in fall (Fig. 1). The contribution of herbaceous plants was smaller in 1998–2000 than in 1978. The corrected diet compositions of the six major categories in early and late summer differed between 1978 and 1998–2000 (early summer: $d.f. = 4$, $\chi^2 = 53.44$, $P < 0.0001$, late summer: $d.f. = 5$, $\chi^2 = 115.32$, $P < 0.0001$).

Discussion

Comparison of scat densities

We used the scat density of brown bears as an index

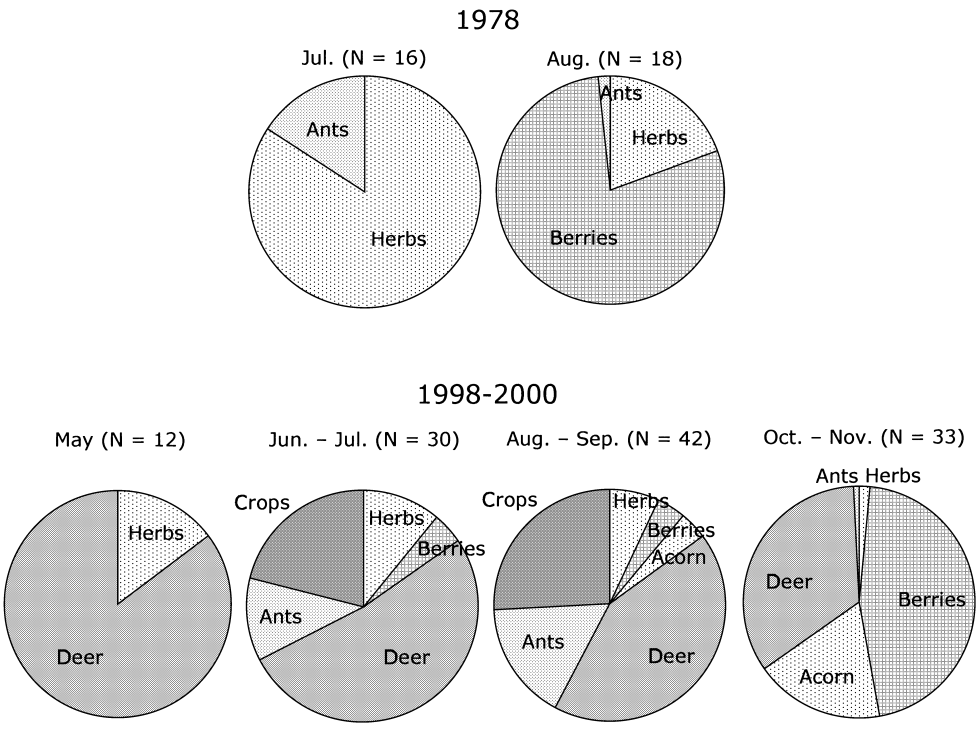

Fig. 1. Scat composition in percent volumes for major categories of brown bears collected in Urahoro Town, Hokkaido, in 1978 (top) and 1998–2000 (below). Data was corrected by the correction factor (Hewitt and Robbins 1996).

of population density. The results indicated that bear density was lower in 1998–2000 than in 1978. In 1995–1998, extensive surveys of bear scat densities were conducted throughout Hokkaido (HIES 2000). In the Akan-Shiranuka region, to which Urahoro belongs, mean density was 3.1 ± 3.4 (*SD*) bears per 100 km, which corresponded well with scat density in 2000. Information from the 1980s is limited, although members of the Obihiro University of Agriculture and the Veterinary Sciences Brown Bear Research Group conducted surveys in our study area between May and October of 1983–1985 (Osa, personal communication). The scat density was as low as <1 scat per 100 km. The number of bear kills in Urahoro also decreased rapidly in the mid 1980s (Sato 2003). This suggests that the brown bear population was already decreasing in the early 1980s. It is therefore likely that the current increase in human-bear conflicts is not the result of an increase in the bear population.

Comparison of diets

The sizeable presence of herbaceous plants in the early summer of 1978, and from spring to early summer of 1998–2000, corroborates earlier studies of Hokkaido brown bears (Aoi 1985; Ohdachi and Aoi 1987; Yamanaka and Aoi 1988; Sato 2002) and those of other regions of the world (Cicnjak et al. 1987; Mattson et al. 1991; Clevenger et al. 1992; Elgmork and Kaasa 1992; McLellan and Hovey 1995; Persson et al. 2001).

The large contribution of berries, particularly *Rubus* spp., to the diet during the late summer of 1978 was greater than the berry proportions reported in most other studies investigating the food habits of brown bears. The dominance of *Rubus* in the diet of Urahoro brown bears seems unique: brown bears in other alpine habitats forage on *Vaccinium* spp. in late summer (Canada: Hamer and Herrero 1987; Hamer et al. 1991; McLellan and Hovey 1995, Alaska: Stelmock and Dean 1986, Spain: Clevenger et al. 1992, France: Berducou et al. 1983, Norway: Elgmork and Kaasa 1992). Some *Rubus* species are typical pioneer plants that rapidly invade forest gaps and cleared areas (Amor 1974; Suzuki and Maeda 1981; Suzuki 1987). As the forests in the study area were logged on a large scale in the early 1970s (Miura 1999), it is plausible that *Rubus* species invaded the clearings and spread. Slopes in these logged areas were covered with *Rubus* in 1978. However, these plants disappeared suddenly when the forest canopy closed (Suzuki 1989, 1990), and are now rarely found, only in sunny patches along forest paths in Urahoro.

In 1998–2000, sika deer composed a large proportion of the diet throughout the year. This was not the case in the 1980s in Hokkaido, when deer evidence was rarely found in bear diets (Aoi 1985; Ohdachi and Aoi 1987; Yamanaka and Aoi 1988). It is therefore most likely that bears began to eat sika deer more frequently, probably in the 1990s. This change was probably caused by a marked deer population increase after the 1990s (HIES 1997; Kaji et al. 2000). Footprints of sika deer were less numerous than those of brown bears in 1978, whereas deer footprints were found everywhere in 1998–2000. The number of sika deer found during spotlight censuses has increased since 1991, when the censuses began (Sato 2002).

As agricultural damage by deer increased, lethal control and hunting in Urahoro increased abruptly during the late 1990s (Sato 2002), and the number of lethal control after 1997 was approximately 2000 (Sato 2002). Lethal control are carried out throughout the year, except during hunting season. As a result, many deer carcasses are left in the fields and become available to bears throughout the year. Signs of feeding on deer carcasses are common near crop fields and in forests. Leaving a deer carcass near a crop fields or a forest path would cause a bear to stay on to eat the carcass. This situation increases the possibility of human-bear encounters.

Crop damage by bears was quite limited in 1978, and from 1983–1985 (Osa, personal communication). During the summers of 1998–2000, the proportion of crop material found in bear diets increased greatly, and was significantly greater than in 1978. Crop use by brown bears is widespread in Hokkaido (Sato 2002), and is a cause of human-bear conflicts (HIES 2000). Corn is usually the most important crop for bears in Hokkaido, but in Urahoro sugar beet is the most important and corn is the second most important crop. In Urahoro and in other areas of eastern Hokkaido, sugar beet is widely cultivated, and bears consume sugar beet over a long period because the rootstock is available throughout the growing season. In contrast, ripened corn is available only from late August to early September. The large amount of berries, acorns, and nuts in the bear diets in the fall of 1998–2000 corresponds with other areas of Hokkaido (Aoi 1985; Ohdachi and Aoi 1987; Yamanaka and Aoi 1988; Sato 2002), as well as with other areas of the world (Cicnjak et al. 1987; Mattson et al. 1991; Clevenger et al. 1992; Elgmork and Kaasa 1992; McLellan and Hovey 1995).

In summary, during the last two decades, deer and crops have increased in the diets of bears in Urahoro, while herbaceous plants and berries have decreased. These temporal changes in food habits could explain why human-bear conflicts have increased recently, in spite of a decrease in the bear population.

Management implications

It is apparent that bears have become more dependent on deer and, ironically, intensified deer control has increased the occurrence of people encountering bears. This is because many deer carcasses are left in fields. It is known that when a brown bear takes possession of high quality and large food, such as deer meat, it often behaves in such a way as to try to monopolize the area (Herrero 1985; Swenson et al. 1999), which could result in attacks on humans. Therefore, deer carcasses should not be left in fields but should be properly processed, as recommended by the Government of Hokkaido.

Lethal control of bears seems to be the only option for reducing crop damage and attacks on humans. However, human-bear conflicts are caused not by the whole bear population but only by a limited number of "problem bears"; the first priority should therefore be to eliminate these "problem bears". In addition, to prevent bears from invading crop fields, non-lethal methods of prevention, such as electric fences, should be implemented.

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