POPULATION CHARACTERISTICS OF BROWN BEARS ON OSHIMA PENINSULA, HOKKAIDO

TSUTOMU MANO, Institute of Applied Zoology, Faculty of Agriculture, Hokkaido University, Sapporo, 060 Japan

Abstract: Population characteristics of brown bears (*Ursus arctos yesoensis*) on Oshima Peninsula, Hokkaido, Japan were studied from January 1983 to May 1985. Although the sex ratio of bears greater than 2 years of age did not differ from 50:50, the younger age classes of males constituted a significantly ($P < 0.05$) larger portion of the kill than those of females. Within the study area, the age and sex structure of harvested bears did not differ by locality and did not change between the periods 1972–75 and 1981–84. There was no consistent trend in harvest from 1969 to 1984. Assuming the population was stationary, the average annual mortality rate was calculated from the age distribution of harvested bears as 20.5%, 14.2%, and 16.9% for males, females, and sexes combined, respectively. The differential vulnerability to hunting among the sexes may be 1 of the causes of these differing mortality rates.

Int. Conf. Bear Res. and Manage. 7:69–73

Brown bears are the largest terrestrial animals in Japan; they occurred throughout the island of Hokkaido before modern development began in the mid-1800s. For the last 100–120 years, however, the bears have been killed indiscriminately, and their distribution is now confined to mountain ranges on the island (Abe 1980, Kaji 1982). Until recently, little management information on Hokkaido's brown bears was available; additional data on the population dynamics of this species are needed for proper management.

Because of the lack of data and public attitudes toward bears, I initiated a study of an isolated brown bear population in the Oshima Peninsula, Hokkaido, during 1983. The purpose of this paper is to report some characteristics of harvested bears and demographic parameters of a heavily hunted brown bear population.

I am grateful to every bear hunter and taxidermist who cooperated with this study. H. Kudo and the members of the Hiyama Exp. For. of Hokkaido Univ. provided field assistance. I also thank N. Ohtaishi and N. Hachiya for advice on age determination and T. Aoi, K. Kaji, and T. Koizumi for encouragement and helpful suggestions. The members of the Brown Bear Research Group of Hokkaido Univ. also provided help during this study. H. Abe and M. Kawata reviewed the manuscript and offered many suggestions. This study was partially funded by the Nature Preservation Division of the Hokkaido Government.

STUDY AREA

The Oshima Penisula is in the southwestern part of Hokkaido, Japan. The Kuromatsunai Depression, located at the base of the peninsula, is the northern boundary of the study area (Fig. 1). The brown bear population in the study area is separated from bear populations in the northeastern range by intensive agricultural development in this depression (Abe 1980, Kaji 1982). Elevation varies from sea level to 1,520 m and the area is characterized by steep mountain ranges.

The temperate maritime climate has a mean annual temperature of 8 C and average annual precipitation of 120 cm. Snow depth ranges from 70 cm in lowlands to 300 cm in the mountains. Snow cover persists from mid-December to early April at low elevations and to mid-May in the higher mountain ranges.

Forest occupies about 80% (5,600 km^2) of the area. Farmland occurs on 18% of the study area and is generally located along the coast and diluvial plain.

The brown bear hunting season extends from 1 October to 31 January each year. Depredation kills (i.e., of bears that become nuisances) are permitted throughout the year. A "prophylactic" kill season (part of a depredation control program) occurs 15 March-31 May each year. When snow remains relatively late in the season, many hunters kill denning bears as well as bears just emerging from dens. There are no legal restrictions on the number, sex, and age of bears that may be harvested.

MATERIALS AND METHODS

Age Determination

Data on harvested bears were collected from January 1983 to May 1985. I asked every hunter to report to the Hiyama Experiment Forest of Hokkaido University when he took a bear. When notified of a bear kill, I interviewed hunters and borrowed the skull to determine the bear's age. Hunters always reported their bears to the town office to receive a bounty; thus I was able to obtain information on all bear kills. A taxidermist saved the skull if it was obtained from a hunter.

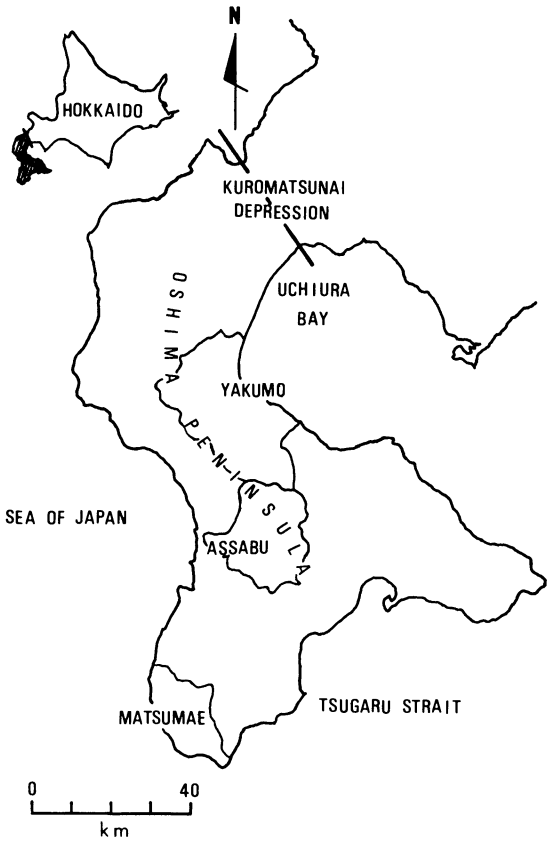

Fig. 1. The study area on Oshima Peninsula, Hokkaido. The brown bear population in the peninsula is isolated from the population in the northeastern ranges by Kuromatsunai Depression.

After cleaning the skull, I extracted the upper canine teeth and measured the maximum width and thickness of the root to determine sex (Yoneda and Abe 1976). Age was determined by counting cementum annuli of a sectioned canine tooth (Craighead et al. 1970, Yoneda 1976). The age of cubs and yearlings was determined from skull morphology and size.

Harvest Statistics

I obtained information on brown bear harvest for 1969–84 from the Nature Preservation Division of the Hokkaido Government, Nature Preservation Section of Oshima, Hiyama, and Shiribeshi Subprefectural Offices of the Hokkaido Government and from the Forest Unit of each city, town, and village office in the study area. Date and location of kill, sex, and age reported by hunters were recorded for all bears killed in the entire study area, especially from 1972 to 1975 and 1981 to 1984. Of the available data, I examined only abundance, age structure, and sex structure.

To assess local differences between age and sex structure, I compared information on harvested bears from 3 town areas (Fig. 1) where hunting patterns differed. Harvest statistics (unpubl. data from the forest unit of the town office) were collected for the periods of 1976–84, 1968–84 (except 1975–76) and 1975–84 for Yakumo, Assabu, and Matsumae town areas, respectively.

RESULTS AND DISCUSSION

Population Abundance and Structure

Total annual harvest averaged 98.4 bears. This harvest fluctuated from year to year, but no consistent trend from 1969 to 1984 was detected (Fig. 2). I assumed that the hunting effort was constant. Table 1 shows sex ratio, age structures, and proportion of females with cubs or yearlings in the periods 1972–75 and 1981–84. There were no significant differences in sex ratios (chi-square test, $\chi^2 = 0.07$, df = 1, $P > 0.05$), age structures ($\chi^2 = 0.95$, df = 1, $P > 0.05$), and females with cubs or yearlings ($\chi^2 = 0.02$, df = 1, $P > 0.05$) between the 2 periods. Thus, I assume that the population was stable during the study period.

Local Differences in Harvest Structure

A hunter may kill bears to control depredations in the district where he lives (city, town, or village). During the sport hunting season, when there is no

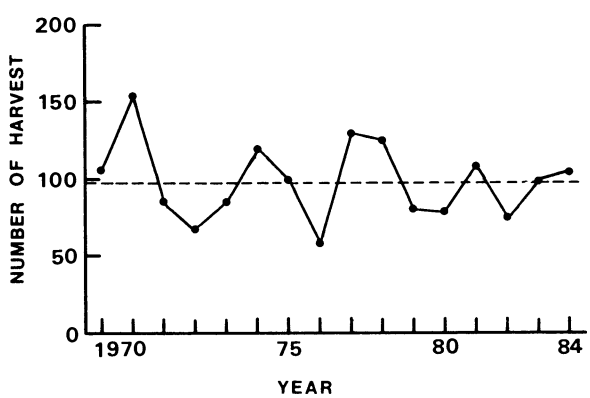

Fig. 2. Annual harvest of brown bears in Oshima Peninsula, Hokkaido 1969–84. The dashed line indicates an average annual harvest of 98.4 bears. Data are from the Nature Preservation Division of the Hokkaido Government and the Nature Preservation Section of Oshima, Hiyama, and Shiribeshi Subprefectual Offices of the Hokkaido Government.

Table 1. A comparison of sex ratios, age structures, and percentages of females with cubs between the periods of 1972–75 and 1981–84 in Oshima Peninsula.

	1972–75					1981–84				
				Total					Total	
	Male	Female	Unkn.	*N*	%	Male	Female	Unkn.	*N*	%
Cubs	45	35	2	82	22	48	32	0	80	22
Subadults	45	44	0	89	24	42	35	0	77	21
Adults[a]	108	88	0	196	53	108	95	0	203	57
Females w/cubs	—	33	—	33	9	—	33	—	33	9
Unknown	2	3	0	5	1	0	0	1	1	0
Total	200	170	2	372		198	162	1	361	
(Sex ratio)	(54)	(46)				(55)	(45)			

[a] Adults include females with cubs.

restriction on hunting area, hunters rarely kill an animal out of their district. From January 1983 to May 1985, 2 hunters killed 5 bears out of their districts during the sport hunting season. These kills were 2.1% of the total harvest during this period. Group hunting is common, and hunting techniques are taught by skilled hunters to beginners in each group. Therefore, the hunting techniques of each group may differ.

The proportion of spring prophylactic kills in the annual harvest was 82%, 68%, and 44% for the Yakumo, Assabu, and Matsumae areas, respectively (Table 2). Remaining snow depth apparently influenced hunting success during the spring season (Table 2). During summer, bears often move to the farmland and damage crops; these bears are commonly killed at the forest edge.

Because hunting techniques in the study area varied with locality and season, the age and sex structure of harvested bears could also vary. Troyer (1961) reported a seasonal change in the sex ratio of brown bears harvested on Kodiak Island. Moreover, Rogers et al. (1976) found that sex ratios in black bears (*U. americanus*) captured at garbage dumps in Minnesota were biased to subadult males. I compared age structures and proportion of females with cubs or yearlings among the 3 areas to assess local differences. I found no significant differences in sex ratios ($\chi^2 = 1.03$, df $= 1$, $P > 0.05$) and ratios of females with cubs or yearlings ($\chi^2 = 0.40$, df $= 1$, $P > 0.05$) among the 3 areas. The proportion of adults in Assabu differed ($\chi^2 = 11.04$, df $= 1$, $P < 0.05$) from that of other areas. One of the reasons for this might be that the hunters in the Assabu area tended to report subadults as adults. However, this has not been confirmed by comparing actual age structures of harvested bears using the cementum annuli technique. Therefore, I assumed that the structure of harvested animals in the study area does not vary with locality and combined the age data of bears harvested throughout the study area.

Sex and Age Structure of Harvested Bears

From January 1983 to May 1985, 137 males and 106 females were killed in the study area, and I obtained data on 127 males and 104 females. Tooth measurements showed that 2 bears reported as females were males.

The sex ratio (M:F) of all harvested bears (56:44; $N = 243$) did not differ from 50:50 ($\chi^2 = 1.98$, df $= 1$, $P > 0.05$). The sex ratio (54:46; $N = 188$) of bears 2 years old was also even ($\chi^2 = 0.52$, df $= 1$, $P > 0.05$). This information agrees with the results of previous analyses on harvest statistics (Kaji 1982).

Table 2. A comparison of brown bear harvest data[a] and spring snow depth in April among 3 areas within Oshima Peninsula.

	Yakumo (1976–84)[b]		Assabu (1968–84)[c]		Matsumae (1975–84)	
	N	%	*N*	%	*N*	%
Number killed	88		99		86	
Spring hunt	72	82	67	68	38	44
Other season hunt	16	18	32	32	48	56
Maximum snow depth in April (cm)	129		70		15	

[a] From 3 town offices.
[b] Dates during which data were obtained.
[c] Except 1975–76.

Although my sample is small, the combined sex ratio of cubs and yearlings was significantly biased toward males ($\chi^2 = 5.25$, df = 1, $P < 0.05$). McCullough (1981) reported a sex ratio favoring males in juveniles of the Yellowstone grizzly bear (*U. arctos*) population. As McCullough suggested, a male-biased sex ratio might be explained by Fisher's theory (Fisher 1930), which is that natural selection alters the sex ratio until the energy expenditure on the sex with a greater mortality rate during the period of parental care is equal to that provided those with lower mortality rates. However, recent studies (Clutton-Brock et al. 1981, Charnov 1982) suggest that it is difficult to explain male-biased sex ratios in mammals in terms of sex ratio theory.

Although the sex ratio of harvested bears more than 2 years old did not differ from 50:50, younger males constituted a significantly larger portion of the kill than females (Kolomogorov-Smirnov 2-sample test, $P < 0.05$). In the subadult stage (2–3 years old), more males were killed than females; however, more females were killed in the older adult stages (Fig. 3). Because bear hunters in the study area are unlikely to be able to distinguish the sex of bears before harvest, intentional selection by hunters on sex should not be possible.

Craighead and Craighead (1972) observed that female grizzly bears with cubs emerge from dens later in spring than any other animals. Many bear hunters in the study area also pointed out that females with cubs are less vulnerable in spring than other bears because they often appear later than mid-May, after the snow has disappeared. McIlroy (1972) reported that female black bears with cubs are more cautious and thus less vulnerable than males. Rogers (1977) and Beecham (1980) observed that subadult male black bears dispersed more extensively and were more vulnerable than females.

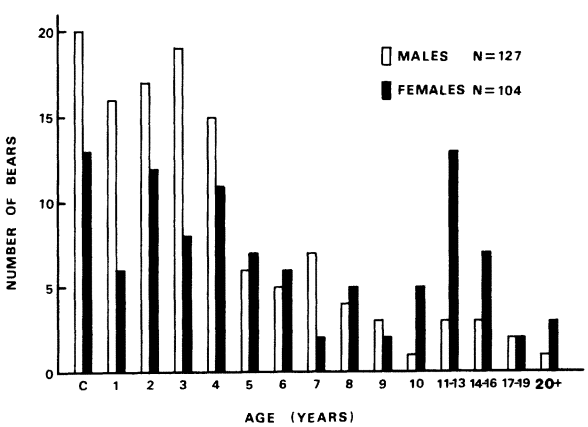

Fig. 3. Age distribution of brown bears killed in Oshima Peninsula, Hokkaido, January 1983-May 1985.

Male-favored sex ratios in younger age groups might be caused by the greater vulnerability of younger males. The increased harvest of females might reflect the female-dominated sex ratios in these segments of the population. Bunnell and Tait (1980) reported similar characteristics in the harvest of bears.

Mortality Rate

Lindzey and Meslow (1980) assumed a low mortality rate from natural causes for black bears in Oregon. They thus considered the hunting mortality data to be representative of ages at death and calculated survival rate using a time-specific life table. In the brown bear population of Oshima Peninsula, hunting may be a dominant cause of death; however, 2 carcasses, probably not killed by hunters, were discovered in the study area in 1983 and 1984 (Mano, unpubl. data). Therefore mortality resulting from factors other than hunting may not be ignored, but it seems appropriate to assume that hunting mortality data represent the frequencies of ages in the living population.

I calculated the average annual mortality rate using the age distribution of harvested bears (Chapman and Robson 1960). Because there were no local differences in the age and sex structure of harvested bears, I combined data obtained from kills throughout the study area. An average mortality rate was calculated for bears greater than 2 years of age. Cubs and yearlings were excluded in the calculations because of the probable differences in vulnerability.

The average annual mortality rates were 20.5%, 14.2%, and 16.9% for males, females, and sexes combined, respectively. The difference in mortality rates between the sexes might partially result from differences in vulnerability to hunting.

LITERATURE CITED

ABE, H. 1980. Distribution of brown bear. Pages 87–98 in Japan Wildlife Research Center, eds. Doubutsu Bunpu Chousa Houkoku Sho. (Honyuurui) Zenkoko Ban (Sono 2). Japan Wildlife Research Center, Tokyo. 176pp. (In Japanese, with English summary).

BEECHAM, J. J. 1980. Some population characteristics of two black bear populations in Idaho. Int. Conf. Bear Res. and Manage. 4:201–204.

BUNNELL, F. L., AND D. E. N. TAIT. 1980. Bears in models and in reality—implications to management. Int. Conf. Bear Res. and Manage. 4:15–23.

CHAPMAN, D. G., AND D. S. ROBSON. 1960. The analysis of a catch curve. Biometrics 16:354–368.

CHARNOV, E. C. 1982. The theory of sex allocation. Princeton Univ. Press, Princeton, New Jersey. 355pp.

CLUTTON-BROCK, T. H., S. D. ALBON, AND F. E. GUINNESS. 1981. Parental investment in male and female offspring in polygynous mammals. Nature 289:487–489.

CRAIGHEAD, F. C., JR., AND J. J. CRAIGHEAD. 1972. Grizzly bear prehibernation and denning activities as determined by radio tracking. Wildl. Monogr. 32. 35pp.

CRAIGHEAD, J. J., F. C. CRAIGHEAD, JR., AND H. E. MCCUTCHEN. 1970. Age determination of grizzly bears from fourth premolar tooth sections. J. Wildl. Manage. 34:357–365.

FISHER, R. 1930. The genetical theory of natural selection (reprint, 1958). Dover, New York. 291pp.

KAJI, K. 1982. Distribution of brown bears in Hokkaido. Hoppou-Ringyou. 34:16–20. (In Japanese.)

LINDZEY, F. G., AND E. C. MESLOW. 1980. Harvest and population characteristics of black bears in Oregon (1971–74). Int. Conf. Bear Res. and Manage. 4:213–219.

MCCULLOUGH, D. R. 1981. Population dynamics of the Yellowstone grizzly bear. Pages 173–196 *in* C. W. Fowler and T. D. Smith, eds. Dynamics of large mammal populations. John Wiley and Sons, New York. 477pp.

MCILROY, C. W. 1972. Effects of hunting on black bears in Prince William Sound. J. Wildl. Manage. 36:828–837.

ROGERS, L. L. 1977. Social relationships, movements, and population dynamics of black bears in northeastern Minnesota. Ph.D. Thesis, Univ. Minn., Minneapolis. 194pp.

———, D. W. LUEHN, A. W. ERICKSON, E. M. HARGER, L. J. VERME, AND J. J. OZOGA. 1976. Characteristics and management of black bears that feed in garbage dumps, campgrounds, or residential areas. Int. Conf. Bear Res. and Manage. 3:169–175.

TROYER, W. A. 1961. The brown bear harvest in relation to management on the Kodiak Islands. Trans. North Am. Wildl. and Nat. Resour. Conf. 26:460–468.

YONEDA, M. 1976. Age determination and age structure of the Ezo brown bear. J. Mamm. Soc. Japan 7:1–8. (In Japanese, with English summary.)

———, AND H. ABE. 1976. Sexual dimorphism and geographic variation in the skull of the Ezo Brown Bear (*Ursus arctos yesoensis*). Memoirs Fac. Agric. Hokkaido Univ. 9:265–276. (In Japanese, with English summary.)