Anthropogenic mortality of Asiatic black bears in two populations in northern Honshu, Japan

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Abstract: I examined the sex and age at death of Asiatic black bears (Ursus thibetanus) killed by sport hunters or during nuisance incidents in 2 neighboring mountain ranges (Kitakami Highland [KH] and Ohwu Mountains [OM]) in northern Honshu, Japan. Between 1993 and 2000, 1,005 bears were killed in these areas (361 nuisance kills, 644 sport-hunting kills). Nuisance bear removals were 1.3 times greater in KH than in OM. Males removed during nuisance incidents tended to be younger in OM than in KH; older males as well as females made up proportionately more of KH nuisance removals. The monthly nuisance removals varied widely by year in both areas, with the largest yearly variation in September in KH and August–September in OM. Female deaths accounted for much of the increase in nuisance kills in KH during September. Both sexes contributed to the increase in OM nuisance kills during August and September. The number of bears killed by sport hunting in KH was 4.7 times larger than in OM. OM terrain is steep and has deep snow during winter, which largely restricts human settlement and agriculture to the eastern edge of this area. Conversely, KH is gently sloping with less snow cover, allowing human settlement and agriculture to disperse more widely into mountainous bear habitat. Such differences in habitat conditions likely influence the degree of human–bear conflict and hunting pressure. Because the population was isolated and many females were removed in KH, I recommend more careful monitoring of the population by examining the sex and age structure of harvested animals relative to densities and real measures of hunting effort.

Key words: Asiatic black bear, northern Japan, nuisance kill, population, sex–age composition, sport hunting, Ursus thibetanus

The Asiatic black bear (Ursus thibetanus) is listed as vulnerable in the 2008 IUCN (International Union for Conservation of Nature and Natural Resources) Red List of Threatened Species (IUCN 2008). The Japanese Ministry of Environment (2002) Red List indicates that some local Japanese populations are small, isolated, and in need of intensive protection (Ministry of the Environment 2002). Nevertheless, 1,100–5,000 Asiatic black bears have been killed annually over the past 20 years.

Anthropogenic bear kills in Japan result primarily from sport hunting and removal of nuisance animals. The regulated sport-hunting season extends from 15 November to 15 February annually, and only firearms are permitted for hunting. Nuisance animals are caught primarily in barrel or cage traps when suspected of nuisance activities such as attacking humans and livestock or damaging crops, orchards, fish farms, or other property.

The sex and age composition of bears killed has been reported to vary with population structure, hunting pressure, capture method, capture season, and habitat conditions (Brannon et al. 1988, Rossell and Litvaitis 1994, Mano 1995, Noyce and Garshelis 1997, Miller and Tutterrow 1999, Diefenbach et al. 2004). These factors make reliable interpretation of population trend from killed bear samples difficult (Paloheimo and Fraser 1981, Fraser et al. 1982, Harris and Metzgar 1987a,b), although the sex and age of killed bears can be useful in determining population trends (Caughley 1977). However, analysis of sex and age composition of harvested bears can be used to identify factors that can be controlled to establish better management policies for sport hunting.

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hunting and nuisance removals. Using this approach, I found contrasts between 2 populations that may be related to differing habitat conditions and harvest periods.

**Study areas**

Asiatic black bears inhabit 2 neighboring mountain ranges in Iwate Prefecture of northern Honshu: the 9,800-km² Kitakami Highland (KH) and the 4,300-m² Ohwu Mountains (OM). Flood plains of the Kitakami and Mabechi Rivers separate KH and OM habitats (Fig. 1). The shortest distance between the 2 habitats is 2 or 3 kilometers. Human settlements, highways, railroads, and cultivated fields spread along the riparian zones and appear to prevent movement of bears between the 2 highlands.

Skull morphology differs between KH and OM bear populations (Amano et al. 2004). Skulls from KH have shorter muzzles and wider faces than those from OM. In addition, the length of the molar row, which stops growing at an early stage of development, also differs; size of the molar row is not influenced by environment. These skull differences suggest genetic differentiation between populations, and accordingly the 2 highland regions are treated as separate management units by local governments.

OM has steep terrain with deep snow during winter (annual maximum snow depth of 180 cm at Yuda meteorological station, altitude 250 m). As a
result, human settlements and cultivated fields (902 km$^2$) are restricted primarily to the eastern edge of this area. In contrast, KH is gently sloping with less snow cover (annual maximum snow depth of 25 cm at Tono meteorological station; altitude 273 m), allowing development of interspersed human settlements and cultivated fields (1,710 km$^2$) throughout the area.

A GIS vegetation analysis of digital map data (Ministry of the Environment 1999) indicated that forest and human settlement or agricultural areas occupied 82% and 18% of the land area in KH and 78% and 21% in OM (Table 1). This analysis also indicated that 35% and 19% of the forested portions of KH and OM, respectively, were vegetated by warm temperate plant communities (e.g., *Camellia japonica*, *Machilus thunbergii*, *Ardisia japonica*); 17% and 33% of the forest portions of KH and OM, respectively, were vegetated with cool temperate plant communities (e.g., *Fagus crenata*, *Quercus mongolica*, *Aesculus turbinata*). Secondary forests and conifer plantations (*Cryptomeria japonica*, *Larix kaempferi*, *Pinus densiflora*) occupied 93% and 69%, respectively, of the forested areas of KH and OM. Hence, the forests in KH are more anthropogenically disturbed than those of OM.

In recent years, over 100 bears have been killed annually in Iwate Prefecture. Between 1993 and 2000, 1,005 bears were killed. Of these, 361 were nuisance kills and the rest were sport-hunting kills. Nuisance removals in Iwate Prefecture were permitted only around human settlements and agricultural areas. Hunters were required to report kill or capture site, sex, and estimated age of the bears they killed, but not hunting effort (e.g., actual trap nights and firearm-hunting days). Hunters estimated the age of bears primarily by examining body size and tooth wear.

### Methods

I determined kill locations for 829 bears: 619 from KH and 210 from OM (Fig. 1). I estimated age by counting cementum annuli of sectioned lower fourth premolar roots (Craighead et al. 1970). I determined age of all ($n = 258$) samples (heads of bears) that hunters sent to our institute: 92 samples from nuisance kills in KH (66% of nuisance kills in KH), 79 samples from sport-hunting kills in KH (16% of sport-hunting kills in KH), 64 samples from nuisance kills in OM (59% of nuisance kills in OM),
and 23 samples from sport-hunting kills in OM (23% of sport-hunting kills in OM). I assumed that these were random samples because there was no reason that hunters selected samples to send. I also made use of 543 bear age estimates made by hunters for calculations of age-class frequencies. Ages estimated by hunters correlated well with ages estimated from tooth-root cementum annuli counts (Kendall’s tau = 0.524, \(n = 238, z = 12, P < 0.001\)). Thus, I regarded hunter-assigned bear ages as rough but adequate estimators for age-class calculations. The adult age class was assigned to bears \(\geq 4\) years old; these animals were assumed to be reproductively mature (Komatsu et al. 1994, Katayama et al. 1996). Bears 1–3 years old were assigned to the subadult category, and animals <1 year old were assigned to the cub category.

I tallied the sex and age composition of nuisance and sport-hunting kills and the temporal change in monthly kill rates, and compared the sex and age composition of kills between the 2 habitats. Departures from evenness in sex ratios, and pairwise sex and age differences between times and populations were examined using Fisher’s exact test (\(\alpha = 0.05\), two-tailed); age differences between the populations were examined using Mann-Whitney \(U\)-tests (\(\alpha = 0.05\), two-tailed). Cubs were excluded from the analysis because they depend on mothers.

Results

Nuisance kills

Nuisance kills accounted for 108 bears (51% of total mortalities) in OM and 137 bears (22% of total mortalities) in KH. The sex ratio (male:female) of nuisance-killed bears in OM (78:26, 4 sex unknown) was strongly weighted toward males (Fisher’s exact test, \(P = 0.00031\)). Among nuisance-killed bears in KH, the sex ratio (81:50, 6 sex unknown) was slightly weighted toward males, but not significantly (\(P = 0.061\)). The sex ratio in OM was more skewed toward males than that in KH (\(P = 0.036\)). Males killed in OM (\(\bar{x} = 5.9\) yr, range = 1–14, \(n = 47\)) were younger than males killed in KH (\(\bar{x} = 8.3\) yr, range = 1–19, \(n = 57\); \(U = 1866, P = 0.0010\); Fig. 2). Age at death of females was not significantly different between OM (\(\bar{x} = 7.7\) yr, range = 3–11, \(n = 17\)) and KH (\(\bar{x} = 7.0\) yr, range = 1–16, \(n = 35\); \(U = 242, P = 0.28\); Fig. 2).

The number of animals killed per month in KH fluctuated the most during September, followed by August (indicated by SD calculations, Table 2). I segregated August and September data into 2 sets of years, the 4 years with the highest numbers of nuisance kills and the 4 years with the lowest numbers of nuisance kills. Frequencies of the sex–age class (adult male, subadult male, adult female, subadult female) in September differed significantly between the 2 sets of years (1993, 1996, 1997, 2000 versus 1994, 1995, 1998, 1999; 3 df, \(P = 0.0053\), Fig. 3). During September in the years with highest number of nuisance kills, the proportion of adult female deaths to the total number of deaths (0.51) was markedly higher than in years with the lowest number of nuisance kills (0.076). In August, the KH sex and age–class frequencies in high-kill years (1994, 1997, 1999, 2000) were not significantly different from low-kill years (1993, 1995, 1996, 1998; \(P = 0.36\); Fig. 3).

In OM, the number of bear kills was also most variable in September (indicated by SD calculations, Table 2). The years with the highest numbers of nuisance kills in September (1993, 1996, 2000, and 1997 in descending order) differed in KH from those...

Table 2. Nuisance killed Asiatic black bears in Kitakami Highland (KH) and Ohwu Mountains (OM), Honshu, Japan, by month and year.

<table>
<thead>
<tr>
<th>Year</th>
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<th>Jun</th>
<th>Jul</th>
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Fig. 3. Proportions of nuisance-killed Asiatic black bears by age–sex class in low-kill and high-kill years during (a) August in Kitakami Highland (KH), (b) September in KH, (c) August in Ohwu Mountains (OM), and (d) September in OM. Subadult: 1–3 yr old, adult: ≥4 yr old.
In short, male and female nuisance deaths contributed equally to the increase of OM totals in August and September in high-kill years.

Sport-hunting kills

Sport hunting accounted for 102 (49\% of total mortalities) and 479 (77\% of total mortalities) bear kills in OM and KH, respectively. The sex ratio of bears killed by sport hunters in OM (64:35, 3 sex unknown) and KH (285:169, 6 sex unknown) were skewed toward males ($P = 0.044$ in OM, $P = 0.00013$ in KH). Sex ratios at OM and KH did not differ ($P = 0.82$). Ages of bears killed by sport hunters at OM and KH did not differ for males ($\bar{x} = 5.7$ yr, range = 1–16, $n = 17$ in OM; $\bar{x} = 6.1$, range = 1–16, $n = 44$ in KH; $U = 410$, $P = 0.57$) or females ($\bar{x} = 4.3$, range = 1–9, $n = 6$ in OM; $\bar{x} = 6.1$, range = 1–13, $n = 35$ in KH; $U = 137$, $P = 0.24$; Fig. 4).

No bears were killed in OM during January and February during the study even though sport hunting was permitted. In KH, bears were killed throughout the hunting season (Nov–Feb; Fig. 5).

Discussion

The bear kill in KH was about triple that in OM (1.3 times more nuisance kills and 4.7 times more sport-hunting kills in KH). The difference may be attributable in part to a larger habitat area in KH (2.3 times larger than in OM), although no precise estimates of bear density in the two highlands were available. The difference in the number of bears harvested may also result from differences in hunting effort. However, the number of hunters active in each of the mountain ranges was not known, although the total number of hunting licenses issued in Iwate Prefecture declined from 6,711 in 1993 to 5,111 in 2000. Differences in climate and topography likely influenced bear harvest. Deep snow and steep terrain in OM probably inhibit winter sport hunting. The more benign KH conditions allow ready access to hunters, even in winter, which is reflected in the bear kills in each month of the hunting season.

Younger males tended to be killed in nuisance incidents in OM, whereas nuisance kills in KH, and sport-hunting kills both in OM and KH did not show a marked pattern in sex or age. Inconsistency in sex and age patterns among OM and KH sport-hunting kills, and OM and KH nuisance kills indicated that sex and age pattern of harvested bears was not a simple reflection of populations (Paloheimo and Fraser 1981; Fraser et al. 1982; Harris and Metzgar 1987a,b; Brannon et al. 1988).

Why did age and sex frequencies of the sport-hunting kills in OM differ so much from those of other categories of mortalities? Differences in local conditions between the two highlands and difference of capture sites between nuisance kills and sport hunting may be the reason. Young male bears disperse actively into foothills both in OM and KH,
causing problems in the fields and villages, resulting in potentially more mortalities than among members of other populations. This behavioral tendency has been reported in American black bears (*U. americanus*; Schwartz and Franzmann 1992, Noyce and Garshelis 1997), but I know of no similar behavioral studies on Japanese black bears. However, the influence of young male dispersion on sex and age composition of killed bears was masked by high-kill rates in females and older males in KH, because the KH landscape allows more extensive human settlement in former wilderness, leading to exposures of female and older males to conflict with humans.

The sex ratios skewed toward males in both OM and KH sport hunts may be due to the behavioral tendencies of males (Bunnell and Tait 1980). In American black bears, males appear more vulnerable to hunters because they travel widely and seem less inhibited about feeding near humans, so they are more likely than females to encounter sport hunters with firearms (Noyce and Garshelis 1997, Koehler and Pierce 2005). The less skewed sex ratio in OM and KH sport-hunting kills than in OM nuisance kills is because sport hunters intruded into forest areas to hunt bears and could encounter more females than in nuisance incidences, where only dispersed bears were killed around agricultural area and human settlements.

There have been marked yearly differences in the number of nuisance kills in OM and KH, with the highest kill rates typically observed during autumn. This may be related to the fall food supply, especially beechnuts (*Fagus crenata*) and acorns (Oka et al. 2004). In both areas, apples, paddy rice, and cattle forage such as corn appear to be major attractants for bears when forest plants fail to fruit. However, the high-kill years in OM and KH were not synchronized (Oka et al. 2004); vegetation types differ between the regions (Table 1), and forage availability probably also differs between the two, resulting in the asynchronous variation in nuisance activities.

Such fluctuations in food supply appeared to have a strong effect on females, as was observed in American black bears in Minnesota (Noyce and Garshelis 1997). The number of females killed in September increased markedly in KH during higher kill years; in OM the numbers of both male and female deaths increased during higher kill years. A similar contrasting tendency in the bear harvest has been documented between New Hampshire and Minnesota during poor fruit years, although the reason for the contrast was unclear (Noyce and Garshelis 1997). In New Hampshire, a lower proportion of females was observed in the harvest, while a high proportion of females was observed in Minnesota kills. This contrast may be due to differing sex and age compositions among populations or, in the case of the OM and KH populations, the contrast may be due to differing human development patterns whereby the accessibility and vulnerability of females was more pronounced in KH during poor food years.

### Management implications

The harvest of American black bears is strongly influenced by alteration of their habitat condition by humans (Rossell and Litvaitis 1994). My data strongly suggest that the habitat conditions of the Asiatic black bear in Japan also influence the degree of human–bear conflicts and hunting pressure.

Because human–bear conflicts are more numerous and many female bears tend to be killed in KH, and because KH is more isolated (whereas OM is continuous with other bear habitats in neighboring prefectures; Amano et al. 2004), more careful population monitoring are warranted for KH. Future monitoring should evaluate the impact of bear kills on the local bear population more carefully by examining the sex and age structure of harvested animals relative to densities and real measures of hunting effort, such as hours of active quarry pursuit and numbers of trap nights (unavailable in the present study).

### Acknowledgments

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### Literature cited

Amano, M., T. Oi, and A. Hayano. 2004. Morphological differentiation between adjacent populations of Asiatic...


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