The influence of the regulation protecting families of brown bears from hunting for the bear population in Sweden

Photo: Ilpo Kojola

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by

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The Scandinavian Brown Bear Research Project (SBBRP) has received funding from the Swedish Environmental Protection Agency to conduct research regarding the importance of the regulation protecting brown bear families from hunting for the bear population's growth, dispersal, and demographic composition. This is a large and important question and addressing it is part of the long-term research goal in the SBBRP. During 2011, we have analyzed data and worked on a manuscript that is now in the final stages of review in a scientific journal (Zedrosser et al. in review). Because we expect that this manuscript will be published soon, we will only summarize the major results of the study here. We have reported earlier on the level of harvest needed to stabilize bear population size (Bischof and Swenson 2009).

In iteparous mammals, conditions experienced early in life may have long-lasting effects on lifetime reproductive success. However, human-induced mortality is an important demographic factor in many populations of large mammals and may influence lifetime reproductive success. We explored the effects of early development and population density on survival and lifetime reproductive success in hunted brown bear females, using a 25-year database of individually marked bears in two populations in Sweden.

We documented complete life histories for 92 female bears from 1988-2008. Of those, 66 (71.7%) died due to human causes, 18 (19.6%) died of natural causes, and for 8 (8.7%) the cause of death was unknown (Figure 1). Thirty-six (39.1%) females reached reproductive age, and 28 (30.4 %) made at least one breeding attempt. Of 64 females with complete life histories that died before breeding, 42 (65.6 %) died due to human causes, 16 (25 %) died of natural causes, and 6 (9.4%) died of unknown causes. Neither yearling mass ($P = 0.17$), population density ($P = 0.62$), study area ($P = 0.42$), nor their interactions (all $P > 0.10$) affected yearling survival to age 2. Yearling females that were independent of their mother, however, were less likely to survive ($\beta = -2.499 \pm 1.051$ SE, $Z = -2.377$, $P = 0.017$). Of the 30 females that died in their yearling year, we were able to establish whether 27 of them were dependent or independent of their mother at the time of death. Only 1 was dependent, and died of unknown causes. Of the 10 independent bears dying from human causes, 9 were shot. None of the yearlings included in our study were shot while accompanying their mothers. Thus, independent yearlings were more prone to both hunting and natural mortality than yearlings that remained with their mothers.

Our study produced three main findings. First, yearlings that remained associated with their mothers had higher survival than independent yearlings, partly because they were protected from hunting, possibly leading to artificial selection on maternal investment. Second, body mass early in life is a key life-history trait for female brown bears, because mass as a yearling was positively related to both the lifetime number of litters produced and lifetime number of cubs that survived to one year of age. Finally, we confirmed the expectation that longevity is a key factor in determining lifetime reproductive success in Swedish brown bears. The best strategy to increase fitness for female brown bears was to stay alive; longevity alone explained 51.8% and 67.8% of the variance in lifetime production of litters and yearlings, respectively. To survive in Sweden, adult female bears must avoid being shot (Bischof et al. 2009).

The positive association between age at weaning and yearling survival may appear surprising at first, because yearlings that remain associated longer with their mother are often smaller (Dahle and Swenson 2003). However, this result is partly explained by hunting regulations. Because it is illegal to kill bears that are part of a family group, remaining with the mother for an additional year increases the survival of female yearlings. In addition, adult females that keep their young for an additional year spend more years of their life protected from hunting. Rughetti and Festa-Bianchet (2011) found a similar result in chamois (*Rupicapra rupicapra*); because hunters tend to avoid shooting females with a kid, nonlactating females had a higher probability of being harvested than lactating females. High harvest pressure has been suggested to affect life history traits and population productivity in both fish and mammals (Conover and Munch 2002, Proaktor et al. 2007, Darimont et al. 2009). In both chamois and brown bears, high hunting pressure may select for early primiparity and protracted mother-offspring associations. More studies are needed to verify whether hunting regulations that protect family groups can lead to artificial selection. Ideally this should involve individual-based long-term studies and experimental manipulations of hunting regulations to combine the analysis of genotype frequencies, morphology, and life-history attributes in populations subjected to different harvest regimes (Festa-Bianchet 2003).

The lifetime reproductive success of female brown bears was strongly correlated with longevity. The average age at primiparity is 4.7 years in the south and 5.3 years in the north (Zedrosser et al. 2009), but in Sweden average female longevity is 4.8 years (Bischof et al. 2008), with almost all mortality caused by humans (Table 1; Bischof et al. 2009). A female brown bear's ability, or good fortune, to survive several hunting seasons will therefore have an overwhelming effect on her lifetime reproductive success. It is currently unknown which life history or behavioral traits affect a female's ability to survive hunting, but it seems reasonable to speculate that any behavior that may decrease encounter rate with hunters would be strongly selected for.

Our results indicate that hunters seem to be abiding by the regulation protecting families from hunting. With this result, it is surprising that Ågren and Söderberg (2010) have reported that 21% of the hunter-harvested adult female bears were actively lactatin. This result was based on macroscopic and microscopic examinations of the teats and mammae. It appears that this method should be evaluated, preferably using known reproductive histories of research bears that have been killed by hunters.

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TABLE 1. Generalized linear models of the early determinants of lifetime reproductive success of female brown bears in two study areas in Scandinavia in 1988-2008; a) the number of cubs that survived to one year of age over a female's lifetime, and b) the lifetime number of litters produced. Variables included were study area (North = 0; South = 1), age at death, mass as a yearling, population density in the yearling year, and interactions of these variables. After a successive exclusion of the least significant term, the final model is shown in the table. *Df* is degrees of freedom, β is the quasi-poisson regression coefficient, *SE* is the standard error, *t* denotes the t-value and *P* denotes the significance level. N=38.

Explanatory variables	*df*	β	*SE*	*t*	*P*
a) Litters born					
Intercept	36	-2.799	0.734	-3.812	< 0.001
Age at death	36	0.203	0.024	8.378	< 0.001
Mass as yearling	36	0.060	0.026	2.306	0.028
Population density at yearling age	36	0.013	0.006	2.143	0.040
b) Yearlings produced					
Intercept	36	-4.186	0.992	-4.218	< 0.001
Age at death	36	0.283	0.033	8.659	< 0.001
Mass as yearling	36	0.108	0.033	3.235	0.003

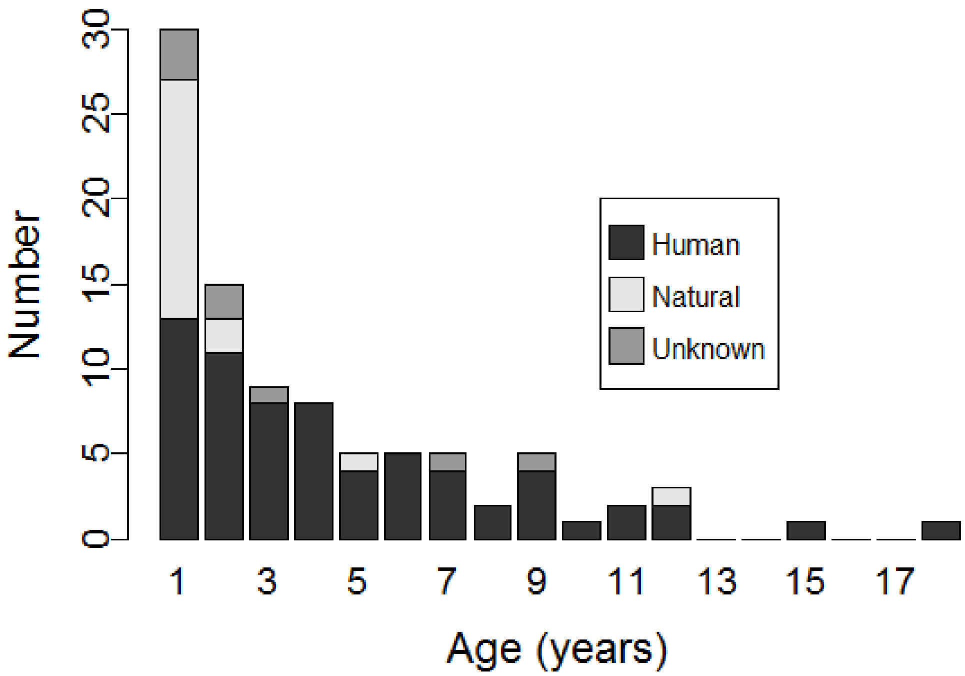

FIG. 1. Number of female brown bears with complete life histories and their causes of mortality in two study areas in Sweden, 1988-2008 (N=92). Human-caused mortalities are legal hunting, poaching, road-kills, or management removals; natural mortalities refer to traumas due to fall or being killed by another bear.