Do brown bear litter sizes reported by the public reflect litter sizes obtained by scientific methods?

Andreas Zedrosser and Jon E. Swenson

Abstract Litter size, an important reproductive parameter used in the management and conservation of brown bears (*Ursus arctos*), is determined from reported observations by the public in some areas. We compared brown bear litter sizes based on reported public observations with those obtained by counting young from a helicopter or the ground by researchers. Mean litter sizes based on public observations were lower and showed more variance between seasons (spring and autumn) than mean litter sizes based on research methods. Public mean litter sizes showed significant variation among years, unless data from at least 6 years were analyzed. In south-central Sweden annual correction factors ranging from 1.120–1.260 must be used to correct the mean litter size based on public observations to agree with the mean litter size obtained by research, depending on how evenly public observations are spread throughout the year.

Key words brown bear, litter size, *Ursus arctos*

Life history and population demography characteristics are important information for wildlife managers because they are needed for managing hunting or conservation efforts. Although Knight and Eberhardt (1985) have pointed out that adult female survival is the most important variable influencing population growth in brown bears (*Ursus arctos*), litter size is an essential parameter when calculating reproduction for population models for bears (Wiegand et al. 1997, Sæther et al. 1998, Freedman et al. 2003). Obtaining accurate mean values of litter sizes for bears is an expensive and difficult task because it usually requires counting the offspring of radiocollared females for several years due to variations in litter size within and among females. Female American black bears (*U. americanus*) may be visited in their maternal dens to determine the number of offspring (McDonald and Fuller 2001, Noyce et al. 2002); however, for human safety reasons it is not advisable to visit maternal brown bear dens. Spring litter size in brown bears is mostly obtained by direct observation after the family has left the den (Craighead et al. 1995). If no female bears are radiocollared, information on litter sizes often is obtained from reported observations by the public. The management of several brown bear populations, some of them small and endangered, relies on litter sizes obtained by observations by the public (Austria—Rauer et al. 2001; Finland—Kojola and Laitala 2000, Slovakia—Hell and Slamecka 1999; Spain—Naves and Palomero 1993, Wiegand et al. 1997) as well as the acquisition of basic biological information of poorly known bear species (e.g., Andean bear [*Tremarctos ornatus*]—X. Velez-Liendo, Laboratory of Animal Ecology, Univ. of Antwerp, Belgium, personal communication). Observations of females with cubs also are important in the monitoring of the brown

Address for Andreas Zedrosser: Institute of Wildlife Biology and Game Management, Department for Integrative Biology, University of Natural Resources and Applied Life Sciences, Vienna, Peter Jordan Strasse 76, A - 1190 Vienna, Austria, and Department for Ecology and Natural Resource Management, Norwegian University of Life Sciences, PO Box 5003, NO - 1432 Ås, Norway; e-mail: andreas.zedrosser@umb.no. Address for Jon. E. Swenson: Department for Ecology and Natural Resource Management, Norwegian University of Life Sciences, PO Box 5003, NO - 1432 Ås, Norway, and Norwegian Institute for Nature Management, Tungasletta 2, NO - 7485 Trondheim, Norway.

bear population in the Yellowstone Ecosystem, U.S.A. (Knight et al. 1995, Keating et al. 2002). However, in the Yellowstone area, only observations from verified observers are used (C.C. Schwartz, United States Geological Survey, Biological Resources Division, personal communication).

A disadvantage associated with public observations is that their reliability cannot be verified; not all young may be visible to the observer. Swenson et al. (2001) found litter sizes of 2.4 and 2.3, with no significant difference, in 2 study areas separated by 600 km in Sweden. However, Haglund (1968) reported a mean litter size of 1.88 based on public observations and newspaper clippings from an area between the study areas of Swenson et al. (2001). This suggested that litter sizes of bears obtained by public observations may not reflect the actual litter size, and managers and modelers using these litter sizes may underestimate an important life-history parameter. To examine the possibility that litter sizes from public observations differ from those obtained by scientific methods, we compared litter sizes of brown bears obtained from public observations (hereafter called "public litter size") with the litter sizes obtained by researchers of the Scandinavian Brown Bear Research Project (hereafter called "scientific litter size"). If a difference was found, we also sought a correction factor to convert mean litter sizes based on public observations to the mean litter size obtained by research.

Study area

The study was carried out in Dalarna and Gävleborg counties in south-central Sweden (approximately 61°N, 14°E). The area consisted of 49,000 km^2 of intensively managed boreal forest dominated by Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), and contained a hunted bear population. The public had access to almost all parts of the study area via an extensive network of forestry roads open to public travel, and the area was intensively used for timber extraction as well as recreational activities such as berry picking, fishing, and hunting. Female brown bears in south-central Sweden stayed in the den from late September–October until March–April, depending on their reproductive status (Friebe et al. 2001).

Methods

We (researchers) determined litter sizes of radio-collared females 3 times a year by counting cubs of the year from a helicopter or from the ground as part of the regular fieldwork in the Scandinavian Brown Bear Research Project (Swenson et al. 1997, 2001). We conducted the first count soon after the family group had left the den (usually late April), the second count shortly after the mating season (usually at the beginning of July), and the third count in autumn (September).

People making observations of bears in Sweden are encouraged to report them to the local branch of the Swedish Organization for Hunting and Wildlife Management, where the date, coordinates, and number of bears observed are recorded. Some females with cubs may have been observed more than once. Female bears in south-central Sweden usually wean their offspring as yearlings in May–June, before or during the mating season (Dahle and Swenson 2003). Thus, almost all observations of family groups of bears after the mating season involve a female with cubs of the year. During April–June, a layman may confuse observations of yearlings with cubs of the year. However, the large size difference between yearlings and cubs of the year reduces the potential for mistaking the age classes.

Our study was conducted during 1995–2002. Eighty-five percent of the cub mortality in Scandinavian brown bears occurs during the mating season in spring (Swenson et al. 2001); therefore, spring and autumn litter sizes are not necessarily the same. For this reason, we divided our analysis into two observation periods, spring (April, May, June) and autumn (July, August, September, October), to evaluate seasonal effects in public observations. The differences in sample size between scientific spring and autumn litter observations are due to complete litter losses and some radiotransmitter failures. We have compared scientific and public observations while controlling for the effect of year using an analysis of variance (ANOVA) (Sokal and Rohlf 1995). To evaluate the statistical influence of outlier years, we selected the year with the most different mean litter size based on public observations. By randomly adding additional years step by step, we determined how many years of data were necessary to reduce the potential effect of the outlier year to an insignificant level. Seasonal differences in litter size within types of observations (scientific litter size and public litter size) over the whole study period were compared using independent sample *t*-tests (Sokal and

Table 1. Mean and overall mean brown bear litter sizes as determined from observations by research personnel (scientific litter size) and reported by the public (public litter size) during 1995–2000 in Dalarna and Gävleborg counties, Sweden. "All year" = litter sizes from spring and autumn combined, "Spring" = litter size in spring, "Fall" = litter size in autumn, "–" = no data available, n = sample size, $\bar{x}$ = mean litter size, SE = standard error.

	Scientific litter size									Public litter size								
	All year			Spring			Fall			All year			Spring			Fall		
Year	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
1995	13	2.46	0.144	7	2.43	0.202	6	2.50	0.224	62	2.00	0.080	24	2.04	0.141	38	1.97	0.096
1996	10	2.00	0.298	7	2.14	0.404	3	1.67	0.333	45	2.27	0.112	38	2.32	0.131	7	2.00	0.000
1997	16	2.00	0.204	11	2.09	0.251	5	1.80	0.374	56	1.77	0.105	25	1.84	0.160	31	1.71	0.141
1998	18	2.33	0.198	11	2.27	0.273	7	2.43	0.297	65	2.14	0.107	64	2.14	0.109	1	2.00	–
1999	23	2.09	0.177	14	2.14	0.231	9	2.00	0.289	99	2.10	0.072	99	2.10	0.072	–	–	–
2000	15	2.47	0.215	10	2.50	0.269	5	2.40	0.400	63	2.11	0.105	62	2.11	0.106	1	1.00	–
2001	22	2.45	0.171	14	2.36	0.225	8	2.63	0.263	58	2.07	0.069	58	2.07	0.069	–	–	–
2002	24	2.25	0.138	14	2.29	0.194	10	2.10	0.200	45	1.64	0.096	17	1.59	0.150	28	1.68	0.127
Overall	141	2.26	0.067	88	2.27	0.087	53	2.25	0.104	493	2.02	0.034	387	2.08	0.038	106	1.81	0.064

Rohlf 1995). The parameter estimate β obtained by the ANOVA was used to calculate a correction factor for adjusting public litter size to scientific litter size. The statistical package SPSS 11.5 was used in all analyses.

Results

We calculated overall mean litter size and mean litter sizes per year (Table 1). The overall litter size in the present study was somewhat smaller than the litter size reported by Swenson et al. (2001) for the same study area. However, Swenson et al. (2001) used data from 1988–1998, whereas the data of the present study were collected in the years 1995–2002. Overall litter sizes obtained by research were always significantly larger than overall litter sizes reported by the public (Table 2). The mean public litter size differed the most from the mean scientific litter size in 2002 (Table 1), and the effect of this outlier year ceased when data from at least 6 years were included in the statistical analysis (time period of 5 years [1998–2002], variable *year*: $F_{1,\ 390} = 6.132$, $P = 0.014$; time period of 6 years [1997–2002], variable *year*: $F_{1,\ 457} = 0.087$, $P = 0.769$). Mean scientific litter size was not significantly different when comparing data from 6 years

Table 2. Results of the Analyses of Variance (ANOVA) comparing brown bear litter sizes as determined from observations by research personnel (scientific litter size) and reported by the public (public litter size) while controlling for the effect of year in Dalarna and Gävleborg counties, Sweden, during the study period 1995–2000. "All year" = litter sizes from spring and autumn combined, "Spring" = litter size in the spring, "Fall" = litter size in autumn. The variable "year" refers to the study period, the variable "type" refers to if the observation has been made by research personnel ("scientific") or is based on public observations ("public"). n is the sample size, df is degree of freedom, β is the slope, SE is the standard error, F denotes the F-value, and P denotes the significance level.

ANOVA-model	Variables	n	df	β	SE	F	P
Scientific litter size/All year		141					
vs. public litter size/All year		493					
	Year		1	–0.011	0.014	0.595	0.441
	Type		1			11.258	0.001
	Scientific			0.243	0.073		
	Public			0	0		
Scientific litter size/Spring		88					
vs. public litter size/Spring		388					
	Year		1	–0.015	0.015	1.014	0.314
	Type		1			8.462	0.004
	Scientific			0.255	0.088		
	Public			0	0		
Scientific litter size/Fall		53					
vs. public litter size/Fall		105					
	Year		1	–0.024	0.021	1.332	0.250
	Type		1			15.052	0.000
	Scientific			0.471	0.121		
	Public			0	0		

with data from 8 years ($t_{257} = -0.003$, $P = 0.998$). Public litter size showed significant variation among years (ANOVA, $F_{7, 485} = 2.247$, $P = 0.029$), but the scientific litter size did not (ANOVA, $F_{7, 141} = 1.044$, $P = 0.404$). Comparing seasonal differences (spring, autumn) in litter size by types of observations (scientific, public) showed no statistically significant difference between scientific spring litter size and scientific autumn litter size ($t_{141} = 0.199$, $P = 0.842$, two-tailed test). However, there was a statistically significant difference between public spring litter size and public autumn litter size ($t_{493} = 3.361$, $P = 0.001$, two-tailed test). Because there was no statistically significant difference in scientific litter sizes with data from 6 or 8 years, we used all available data and based the correction factors on data from 8 years. Correction factors for public litter sizes to adjust them to match scientific litter sizes were 1.120 for all observations, 1.091 for spring observations, and 1.243 for autumn observations.

Discussion

Some problems are associated with the use of mean litter sizes from public observations. The number of observations varied greatly among years, as did the distribution of observations within a year. The reasons cannot be fully evaluated here, but they probably include the presence or absence of the species in the media and public discussions and variations in data-collection efforts by the Swedish Association for Hunting and Wildlife Management.

Mean litter size based on reported public observations was significantly lower than mean litter size observed by researchers. Due to the wary nature of bears, especially in hunted populations, public observations often are made in dense habitat, are usually of short duration, or are made at long distances. All these factors contribute to poor visibility, and therefore not all animals may be visible to the observer. Obviously, litter sizes observed by researchers, unless they are carried out in the natal den, may not be absolutely correct either. However, researchers deliberately try to observe bears to count the number of cubs and repeat the effort if unsure, whereas most of the public outside national parks try to avoid bear encounters. In addition, close observations of female bears with cubs of the year may involve a protective female, thus stressing untrained public observers. The public litter size underestimate was more severe in autumn than in spring. Two potential reasons may be that cubs in autumn are already more independent and explorative and not as closely associated with the female anymore and that vegetation is more fully developed. Thus, not all cubs may be visible when the female is seen by public observers.

It is unclear why mean litter sizes based on public observations showed more variance among years than scientific mean litter sizes. Litter sizes based on public observations were especially lower than the scientific litter size in 2002, suggesting that single years may have a strong statistical impact on the results. The statistical influence of the year 2002 disappeared in the analysis when using data from 6 years, suggesting that if mean litter sizes are determined from public observations, data from at least 6 years are needed.

Management implications

In south-central Sweden mean litter size based on public observations must be multiplied by correction factors ranging from 1.091–1.243 to adjust them to correspond with the mean litter size obtained by research. Which correction factors to use depends on the seasonal distribution of public observations. The use of public observations obviously results in an underestimate of an important life-history parameter. It is important to know that data collected by the public can be used for brown bear management purposes. However, these data need to be corrected. Which correction factors are needed may depend on the population in question and the habitat. Therefore, we encourage this type of research in other bear populations so that correction factors important for management purposes can be obtained and compared.

Acknowledgments. We thank the Swedish Association for Hunting and Wildlife Management for providing access to its database. B. Dahle, E. Bellemain, O.-G. Støen, G. Rauer, and X. Velez-Liendo provided comments to earlier drafts of the manuscript. The Scandinavian Brown Bear Research Project was funded by the Swedish Environmental Protection Agency, the Norwegian Directorate for Nature Management, the Swedish Association for Hunting and Wildlife Management, World Wildlife Foundation Sweden, the Norwegian Institute for Nature Research, and the Research Council of Norway. We thank the research personnel in the

Scandinavian Brown Bear Research Project for their assistance in the field and Orsa Communal Forest for field support. A. Zedrosser was financially supported by the Austrian Science Fund Project P16236-B06.

Literature cited

CRAIGHEAD, J. J., J. S. SUMNER, AND J. A. MITCHELL. 1995. The grizzly bears of Yellowstone. Their ecology in the Yellowstone ecosystem, 1959–1992. Island Press, Washington, D.C., USA.

DAHLE, B., AND J. E. SWENSON. 2003. Family breakup in brown bears: are young forced to leave? Journal of Mammalogy 84: 536–540.

FREEDMAN, A. H., K. M. PORTIER, AND M. E. SUNQUIST. 2003. Life history analysis for black bears (*Ursus americanus*) in a changing demographic landscape. Ecological Modelling 167: 47–64.

FRIEBE, A., J. E. SWENSONS, AND F. SANDEGREN. 2001. Denning chronology of female brown bears in central Sweden. Ursus 12: 37–46.

HAGLUND, B. 1968. De stora rovdjurens vintervanor II. Viltrevy 5: 213–361. (In Swedish)

HELL, P., AND J. SLAMECKA. 1999. Medved v slovensky Karpatoch a vo svete. PaRPRESS, Bratislava, Slovakia. (In Slovakian)

KEATING, K. A., C. C. SCHWARTZ, M. A. HAROLDSON, AND D. MOODY. 2002. Estimating numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. Ursus 13: 161–174.

KNIGHT, R. R., B. M. BLANCHARD, AND L. L. EBERHARDT. 1995. Appraising the status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23: 245–248.

KNIGHT, R. R., AND L. L. EBERHARDT. 1985. Population dynamics of Yellowstone grizzly bears. Ecology 66: 323–334.

KOJOLA, I., AND H. M. LAITALA. 2000. Changes in the structure of an increasing brown bear population with distance from core areas: another example of presaturation female dispersal? Annales Zoologici Fennici 37: 59–64.

MCDONALD, JR., J. E., AND T. K. FULLER. 2001. Prediction of litter size in American black bears. Ursus 12: 93–102.

NAVES, J., AND G. PALOMERO, editors. 1993. El oso pardo en España. Instituto Nacional para la Conservacíon de la Naturaleza, Madrid, Spain. (In Spanish).

NOYCE, K. V., P. L. COY, AND D. L. GARSHELIS. 2002. Bone prominence and skin-fold thickness as predictors of body fat and reproduction in American black bears. Ursus 13: 275–284.

RAUER, G., P. AUBRECHT, B. GUTLEB, P. KACZENSKY, F. KNAUER, C. PLUTZAR, L. SLOTTA-BACHMEYER, C. WALZER, AND A. ZEDROSSER. 2001. Der Braunbär in Österreich II. Environmental Protection Agency, Monography Series M-110, Vienna, Austria. (In German)

SÆTHER, B.-E., S. ENGEN, J. E. SWENSON, Ø. BAKKE, AND F. SANDEGREN. 1998. Assessing the viability of Scandinavian brown bear, *Ursus arctos*, populations: the effects of uncertain parameter estimates. Oikos 83: 403–416.

SOKAL, R. R., AND F. J. ROHLF. 1995. Biometry. Freeman and Company, New York, New York, USA.

SWENSON, J. E., F. SANDEGREN, S. BRUNBERG, AND P. SEGERSTRÖM. 2001. Factors associated with loss of brown bear cubs in Sweden. Ursus 12: 69–80.

SWENSON, J. E., F. SANDEGREN, A. SÖDERBERG, A. BJÄRVALL, R. FRANZÉN, AND P. WABAKKEN. 1997. Infanticide caused by hunting of male bears. Nature 386: 450–451.

WIEGAND, T., J. NAVES, T. STEPHAN, AND A. FERNANDEZ. 1997. Assessing the risk of extinction for the brown bears (*Ursus arctos*) in the Cordillera Cantabrica, Spain. Ecological Monographs 68: 539–570.

Andreas Zedrosser (left) obtained his M.S. degree in wildlife ecology and management from the University of Vienna, Austria in 2001. He currently is working on his Ph.D. on life-history aspects of brown bears in a joint program of the University for Natural Resources and Applied Life Sciences, Vienna, Austria, the Norwegian University of Life Sciences, and the Scandinavian Brown Bear Research Project. ***Jon E. Swenson*** (right) is professor in ecology and natural resources management at the Norwegian University of Life Sciences and the leader of the Scandinavian Brown Bear Research Project. His degrees are from Montana State University (B.S., M.S.), University of Alberta (Ph.D.), and University for Natural Resources and Applied Life Sciences, Vienna (Dr. Habil). His research interests include the ecology and management of large carnivores, especially brown bears, and the ecology of grouse.

Associate editor: *Bowman*