PLAY BEHAVIOR OF BROWN BEARS (*URSUS ARCTOS*) AND HUMAN PRESENCE AT PACK CREEK, ADMIRALTY ISLAND, ALASKA

ROBERT FAGEN, Juneau Center for Fisheries and Ocean Science, University of Alaska Fairbanks, 11120 Glacier Highway, Juneau, AK 99801 USA
JOHANNA FAGEN, University of Alaska Southeast, 11120 Glacier Highway, Juneau, AK 99801 USA

Abstract: Brown bears of all ages play. They use fighting movements and postures to interact harmlessly with conspecifics, they chase birds, they roll and slide, and they manipulate objects. Individual bears at the Pack Creek estuary on northern Admiralty Island played from less than 1% to over 20% of their total time in sight in 1987-8. Play frequencies in 1987-8 were independent of presence or absence of human visitors.

Int. Conf. Bear Res. and Manage. 8:315–319

Mammals and birds of many species play by themselves, with others of their own species, and with members of other species (Fagen 1981, Smith 1984). Henry and Herrero (1974) recognized play in bears of several species and outlined its characteristics: specific signal patterns, silence (in comparison with potentially injurious fights), incompleteness of motor patterns, and greater repetition of certain motor patterns.

Herrero (1985) observes that although humans enjoy watching bears at play, superficial impressions of cuteness can trick untrained observers and conceal important differences between human and bear behavior. Detailed behavioral analyses can reveal these differences and shed light on evolutionary questions about play in bears.

This paper discusses play frequencies in relation to individual differences and selected environmental variables, particularly visitor use, in a community of free-ranging brown bears on a small salmon stream. The authors' long-term study in progress is the source of the data. In addition to play, our study addresses family relations, habitat use, bear-human interaction, adolescence, foraging, aggression, and dominance.

Brown bear play continues across the entire lifespan, both in free-ranging populations (Herrero and Hamer 1977, Murie 1981) and in confinement (Aldis 1975, Fagen 1981). Play is a sensitive behavioral indicator of environmental conditions (review in Fagen 1981). Because it is so sensitive to environmental change, animal play behavior can provide noninvasive behavioral bioassays for stress and disturbance. Play is used clinically to assess physiological and emotional well-being of humans (Morris 1968, Susser and Watson 1968, Rutishauer and Whitehead 1972).

The current DSM (a standard diagnostic reference for medical practitioners) cites disturbance or absence of normal play patterns as key clinical signs of autism and other developmental disorders of communication and emotional expression. Studies of nonhuman primates in confinement (Cummins and Suomi 1976) and in the wild (Goodall 1986) furnish additional evidence that stressed animals play less and play differently from nonstressed animals, or do not play at all. A behavioral measure of well-being, play further suggests the possibility of emotional experience in nonhuman species (Bekoff 1972, Fagen 1981, Henry 1986).

We thank K.E. Mitchell, Monument Manager, Admiralty Monument (U.S. Department of Agriculture Forest Service, Tongass National Forest) and D. Anderson, Regional Supervisor (Alaska Department of Fish and Game, Division of Wildlife Conservation) for permission to conduct research in the Pack Creek Cooperative Management Area and for logistical support and permission to use equipment, and the Whitehall Foundation Inc. and American Philosophical Society for grants in support of our research. We acknowledge the cooperation of State and Federal resource management agency personnel and the help of N. Muigwa, S. Herbison, D. Jandl, H. Kwasny, and L. and C. McNutt with data collection and other aspects of field work during 1987-8. Computing facilities for data analysis were furnished by the University of Alaska Computer Network.

STUDY SITE AND POPULATION

Pack Creek, a small salmon stream on Seymour Canal on northern Admiralty Island, is located in a designated Research Natural Area within the Seymour Canal Closed Area. No bear hunting is allowed within the Closed Area. Pack Creek flows through old-growth spruce-hemlock forest (age ca. 300 years, Alaback 1982), dividing into 3 channels as it emerges from the forest to form a 2-km long estuary with sedge and mud flats. Chum (*Oncorhynchus keta*) and pink (*O. gorbuscha*) salmon spawn in Pack Creek during July and August. Habituated and relatively unhabituated brown bears, mainly females, young, and adolescents, use the Pack Creek estuary, forest and mountain ridges year-round. Bears are most observable, in terms of time-in-sight and total numbers of individuals,

during the peak of the pink salmon run in late July and early August. Previous research at Pack Creek (Post 1982, Warner 1987) detailed these and other site and population characteristics and changing patterns of human use.

In 1988, 3 cooperating management agencies (Alaska Department of Fish and Game Division of Wildlife Conservation, United States Forest Service Admiralty Monument, and Alaska Department of Natural Resources) implemented regulations limiting visitors to a sandspit overlooking the estuary. This observation point was accessible by foot from the public floatplane and boat landing via a 1-km beach (a 15-minute walk for most visitors). The bear observation area and access route were open to visitors from 0900-2100 daily.

MATERIALS AND METHODS

Observations since 1985 were made from elevated tree blinds with an unobstructed view of the Pack Creek estuary. Before 1988 some observations were made from the public viewing spit. Individual bears were recognized using facial and body conformation as chief characteristics, with the aid of videotape and a synoptic catalogue of bears seen each year. This information is sufficient to identify individuals from the year of their birth at least through middle adolescence (age 5-8). In addition, 3 bears retain eartags from Warner's (1987) study.

The field season began during the second week of July and ended during the last week of August. Observers collected data daily from 0500-2100. Beginning in 1987, scan samples were taken every 15 minutes. Each scan included the identity of each bear, the behavior of the bear, and the number of humans present in the area. Since 1985, focal-animal samples were taken on all mother-cub families, and presence or absence of visitors recorded for each focal-animal sample. This paper reports results from analysis of the 1987-8 scan sample data only. Analysis of the focal samples in progress will be reported elsewhere.

In comparing bear behavior with and without visitors present, "visitors present" meant that the observer could see or hear visitors. The beach by which visitors travelled to the area from the float plane and boat landing was partially within the observer's field of view. Most visitors travelled in groups and were heard before they were seen.

Statistical analysis of the scan sample data treated social units separately. In this analysis of play, a social unit consisted of all members of a single litter or all members of an adolescent play group. Since these individuals generally played with each other, their rates of play were not independent and scans of 1 individual in the group were selected for analysis. Data from 1987 and 1988 were analyzed separately.

To assess the roles of 2 environmental variables that could potentially affect play and the interactions among these variables, cross-tabulated counts of behavior (play vs. all nonplay behaviors) from the scan samples were analyzed as a function of date (before or after 28 July), and visitor presence or absence. 28 July was selected as the midpoint of the field season because bear fishing success and the condition of fish caught indicate that most chum salmon enter Pack Creek before this date, whereas pink salmon are just beginning to enter the creek in large numbers. For brevity, the early dates (on or before 28 July) are referred to as "July" in this paper, and the later dates (on or after 29 July) as "August".

Play was defined as in the Introduction to this paper, consistent with definitions used in earlier studies by Henry and Herrero (1974) and Egbert and Stokes (1976). A number of nonplay behaviors were observed. These behaviors were recorded separately and their frequencies totalled for the "nonplay" category of this analysis. They included various foraging acts (browse, dig, eat fish, graze, pursue and handle fish), resting, rubbing, travelling, nonplay social behaviors, and several other less frequent categories (bipedal alert, defecate, interact with humans, urinate).

Data were tabulated from computer scan sheet files. The result (Table 1), a cross-classified table of counts known as a contingency table, reported the frequencies of play and nonplay as a function of the 2 environmental variables and all of their possible combinations. For example, 1 cell of the table gave the number of times that a particular bear was observed playing during July of a particular year with visitors absent. A separate table was constructed for each bear that a sufficiently large sample was available. As explained above, for a family or group of bears that played together, only 1 individual per social unit was analyzed to ensure independence of the data in the sample. When the total number of observations for a social unit was less than 150, similar social units were combined for observations. The combined samples all represent unhabituated immature bears (some still following their mothers and others moving independently).

Hierarchical loglinear models (Fienberg 1980) of these contingency tables were fit to the data. Alternative models were tested according to a systematic scheme, beginning with the simplest model and adding progressively more complicated interactions. When the difference between the model being tested and the data was

Table 1. Three-way contingency tables relating play to month and visitor use for different bears.

Bear, Year	Visitors			
	Absent		Present	
Behavior	Jul	Aug	Jul	Aug
b1[a] 1988				
No play	365	158	98	60
Play	15	7	6	1
kd-kl[b] 1988				
No play	129	38	58	10
Play	3	0	2	0
k1-k2[c] 1988				
No play	84	35	20	20
Play	6	0	0	0
8 unhab. imm.[d] 1988				
No play	355	175	82	63
Play	32	63	11	0
3 mothers 1988				
No play	595	246	188	94
Play	10	4	3	2
kd-kl 1987				
No play	56	85	18	10
Play	6	4	0	1
sjb-sjs 1987				
No play	60	123	3	22
Play	2	6	0	2
b-c[e] 1987				
No play	117	270	24	74
Play	1	12	1	4
k1-k2 1987				
No play	26	222	6	49
Play	0	14	0	1
8 unhab. imm. 1987				
No play	149	215	21	32
Play	0	38	0	9
3 mothers 1987				
No play	167	285	30	50
Play	0	4	0	2

[a] 1988 spring cub
[b] male-female siblings - born 1987
[c] 3-year-old male-female siblings
[d] unhabituated immature males
[e] 3-year-old male-female siblings

small enough to be explained by chance error, the next most complicated model was tried. If no further improvement in goodness-of-fit resulted, the simpler model was selected as a plausible description of the data. The G-squared statistic (Fienberg 1980) was used to test goodness-of-fit. Degrees of freedom were calculated according to Table 3-4 in Fienberg (1980). Braaten and Gilbert (n.d.) previously used this method to analyze multivariate data on Katmai National Park brown bears and their responses to environmental factors, but they did not conduct independent analyses on different individuals.

The S data analysis and graphics system (Becker and Chambers 1984), including user-defined code for computing G-squared statistics, was used for all data tabulation and analysis.

RESULTS

Overall frequencies of play by 5 bears or bear groups in 1987 and 4 in 1988 (Table 1) ranged from 0.0% for several units in July 1987 or August 1988 to 16.0% of 294 scans (standard error = 2%) for unhabituated immature bears in August 1987.

Best-fitting hierarchical loglinear models were found for all 9 cases (Appendix). In no case was it necessary to assume an interaction between play frequency and visitor presence or absence to adequately fit the data.

Play frequencies were independent of date and of visitors for most groups analyzed: a 1988 spring cub, the male-female sibling pair kd-kl (born 1987) in 1987 and 1988, the free-ranging 3-year-old male and female siblings b-c in 1987, the 2-year-old female siblings sjb-sjs (still following their mother) in 1987, and the free-ranging 3-year-old male and female siblings k1-k2 in 1987. All of these bears were relatively habituated to visitors. Unhabituated immature bears also played at rates independent of the presence or absence of visitors, but their rates of play depended on the date, increasing from 0% to 16% from July-August 1987 and decreasing from 9% to less than 1% from July-August 1988. For k1-k2 in 1988, play was again independent of visitors and date, but a visitor-date interaction appeared in the best-fitting model.

DISCUSSION

Although the environment of Pack Creek bears includes human visitors, presence or absence of visitors in 1987-8 did not appear to affect overall rates of play for any bear observed, whether habituated or unhabituated. Since play is a recognized behavioral measure of well-being, this finding may indicate that during those years human use did not impair the well-being of the bears observed, as measured by their tendency to play. Visitor education efforts by on-site Admiralty Monument rangers based on explicit guidelines for human use in 1987, and continuing visitor education by Monument and Alaska Department of Fish and Game rangers combined with closure of the estuary in 1988, may be responsible in part for this result. In the past, visitors occasionally ap-

proached bears in all areas of the estuary and actually interrupted play at least 3 times in 1985 and 1986. Young bears (cubs of the year and yearlings) at Pack Creek played less frequently in the presence of visitors (2.6% of 194 scans) than in their absence (4.5% of 1052 scans) in 1983-1984 (Warner 1987).

Dates of most frequent play were also dates of highest apparent salmon abundance for the unhabituated immature bears. A strong pink salmon run in August 1987 and a moderately large chum salmon run in July 1987 coincided with the significantly higher frequencies of play in August 1987. In July 1988, chum salmon abundance was below average. The August 1988 pink salmon run failed. Unhabituated immature bears played less in August 1988 than in July 1988.

Play frequencies were never significantly greater when visitors were absent. These frequencies were non-significantly greater in 6 out of 18 bear x month combinations. This result does not differ from chance expectation for a sample of 18 cases (matched-pairs test, $p > 0.5$).

Although results reported above indicate that visitors had no strong effects on play frequencies for bears observed in 1987-8, we do not yet know whether visitors might have influenced qualities of play such as bout duration, behavioral content, or tendencies of mothers to accept play solicitation from their young.

Bout duration and behavioral content were recorded on the focal samples, not on the scans analyzed here. The scans provide information on 3 mothers in 1987, and on 2 of these same mothers plus a third (a different individual from the third 1987 mother) in 1988.

Mother bears played at rates that did not appear to depend on visitor presence or date in 1987 and again in 1988. Since these results are not statistically independent of their cubs' play frequencies reported above, no statistical tests were performed, but the rates of play were as follows: mothers in July 1987, 0% (visitors present and visitors absent); mothers in August 1987, 1% visitors absent, 4% visitors present; mothers in July and August 1988, visitors present and visitors absent, all 2%. These results do not indicate any tendency of mothers to play less with their young with visitors present.

In 1987-8, 2 additional families (a mother with 2 cubs born in 1987 and a mother, identified from 1985 videotapes, with 3 cubs born in 1988) were seen only occasionally. Whether bears like these would use Pack Creek more often if fewer visitors were present is not known. Obviously, no statistically valid estimates of play frequencies in these families can be made for 1987-8. However, both families were seen playing at least once, and unhabituated bears have been seen playing in other areas of northern Admiralty Island. There is no evidence that either the overall frequencies of play or other characteristics of play observed at Pack Creek are unique to the Pack Creek community. Great individual differences among bears within watersheds make long-term research necessary to discriminate between overall cultural differences among bear communities and specific differences induced by human activity.

CONCLUSIONS

Individual differences among bears account for most variation in frequencies of play by brown bears observed at Pack Creek. Habituated bears do not appear to play any more frequently than unhabituated bears. There is no evidence that human visitors affected bear play frequencies in 1987-8, although data and observations from past years had suggested some negative impact. Active visitor education efforts by the management agencies in 1987, followed by closure of the estuary in 1988, may be reducing impact.

LITERATURE CITED

ALABACK, P. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of southeast Alaska. Ecology 63:1932-1948.

ALDIS, O. 1975. Play fighting. Academic Press, New York. 319pp.

BECKER, R.A., AND J.M. CHAMBERS. 1984. S: an interactive environment for data analysis and graphics. Wadsworth, Belmont, Calif. 550pp.

BEKOFF, M. 1972. The development of social interaction, play, and metacommunication in mammals: an ethological perspective. Q. Rev. Biol. 47:412-434.

BRAATEN, A., AND B. GILBERT. n.d. Profile analysis of human-bear relationships in Katmai National Park and Preserve. Tech. rep. to U.S. Natl. Park Serv. 104pp.

CUMMINS, M.S., AND S.J. SUOMI. 1976. Long-term effects of social rehabilitation in rhesus monkeys. Primates 17:43-51.

EGBERT, A.L., AND A.W. STOKES. 1976. The social behaviour of brown bears on an Alaskan salmon stream. Int. Conf. Bear Res. and Manage. 3:41-56.

FAGEN, R. 1981. Animal play behavior. Oxford Univ. Press, New York and Oxford. 684pp.

FIENBERG, S. 1980. The analysis of cross-classified categorical data. Second ed. MIT Press, Cambridge, Mass. 198pp.

GOODALL, J. 1986. The chimpanzees of Gombe. The Belknap Press of Harvard Univ. Press, Cambridge, Mass. 673pp.

HENRY, J.D. 1986. Red fox, the catlike canine. Smithsonian Inst. Press, Washington, D.C. 174pp.

_____, AND S.M. HERRERO. 1974. Social play in the American black bear: its similarity to canid social play and an examination of its identifying characteristics. Am. Zool. 14:371-389.

HERRERO, S. 1985. Bear attacks. Winchester Press, Piscataway, N.J. 287pp.

_____, AND D. HAMER. 1977. Courtship and copulation of a pair of grizzly bears, with comments on reproductive plasticity and strategy. J. Mammal. 58:441-444.

MORRIS, D. 1968. Play and the sick child. Lancet 2:1391.

MURIE, A. 1981. The grizzlies of Mount McKinley. Univ. of Washington Press, Seattle and London. 251pp.

POST, K. 1982. Human and bear movement, activity and interaction at Pack Creek, Alaska. M.S. Thesis. Univ. of Idaho, Moscow. 174pp.

RUTISHAUER, I.H.E., AND R.G. WHITEHEAD. 1972. Energy intake and expenditure in 1-3 year old Ugandan children living in a rural environment. Br. J. Nutr. 28:145-152.

SMITH, P.K., ED. 1984. Play in animals and humans. Blackwell, Oxford. 334pp.

SUSSER, M., AND W.B. WATSON. 1968. Play and the sick child. Lancet 1:369.

WARNER, S.H. 1987. Human impacts on brown bears at Pack Creek, Admiralty Island, Alaska. M.S. Thesis, Univ. of Alaska, Fairbanks. 95pp.

APPENDIX

Analysis of 3-way contingency table data

Each contingency table of bear behavior and visitor data (in Table 1 of the text) is a 2x2x2 table of counts. There are 3 classificatory variables, each with 2 levels: Variable 1 (no play, play), Variable 2 (before 29 July, on or after 29 July), and Variable 3 (visitors present, no visitors present).

As a null hypothesis, the analysis assumed no interaction between play and visitors. If the table could be explained using models that did not contain a play-visitor (13 in the notation of Fienberg 1980) interaction, it would not be possible to reject this null hypothesis. If, instead, a 13 interaction had to be included in a model before it would fit the table satisfactorily, the null hypothesis would be rejected and the conclusion would be that visitor presence or absence affected the individual bear's tendency to play.

Significance levels for the G^2 statistic are best used as a guide to intuition, rather than as a rigid criterion, when fitting hierarchical loglinear models to multiway contingency tables (Fienberg 1980). In this analysis, a level of 0.05 was arbitrarily used as a criterion of goodness-of-fit. Any model, or any difference between models, yielding a G^2 value for which the upper tail probability of the chi-squared distribution with appropriate degrees of freedom was less than 0.05 was considered to furnish a less than adequate fit.

The simplest model of the data assumes complete independence of the 3 variables. This model, denoted (1,2,3), fitted most of the individual datasets, with a chi-squared distribution with 4 degrees of freedom as the distribution of the G^2 statistic under the null hypothesis of complete independence (1988 b1, $G^2 = 4.46$, $p = 0.35$; 1988 kd-kl, $G^2 = 4.55$, $p = 0.34$; 1987 kd-kl, $G^2 = 8.38$, $p = 0.08$; 1987 sjb-sjs, $G^2 = 7.25$, $p = 0.12$; 1987 b-c, $G^2 = 5.63$, $p = 0.23$; 1987 k1-k2, $G^2 = 4.88$, $p = 0.30$).

For unhabituated immatures in 1987 and in 1988, the simplest model to fit the data adequately was (12,3). In this model, play frequencies depended on month but not on visitors and visitors were independent of month (1988, $G^2 = 6.68$, 3 d.f., $p = 0.08$; 1987, $G^2 = 1.41$, 2 d.f. due to marginal zeroes, $p = 0.49$).

For k1-k2 in 1988, the simplest adequate model was (1,23). In this model, play frequencies were independent both of visitors and of month, but visitor presence or absence *with k1-k2 in sight* depended on month ($G^2 = 7.46$, 3 d.f., $p = 0.06$).