

DENNING OF BROWN BEARS IN CROATIA

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Abstract: Twenty-eight dens of 15 different European brown bears (*Ursus arctos*) were located, monitored and measured during 1981–92. Ten of them were used by females with cubs, 9 by single females, 5 by males, and 4 by bears of unknown category. Occasionally bears used >1 den in the same winter (4 bears used 2–5 dens, mean = 3). Only 2 of these den changes were attributed to human disturbance. The local abundance of natural caves is probably the reason most dens (22) were built in rock cavities; 3 were ground nests under the canopy of conifers; 2 were excavated cavities under the roots of large standing trees, and 1 was in a horizontal hollow tree.

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Brown bears exhibit pronounced seasonal behavior, mostly imposed by their nutritional and physiological demands. Bears have developed a complex strategy to survive during periods of food shortage in winter. In fall, they become hyperphagic, drastically reduce movements in winter and usually use dens. Also in winter the female gives birth to cubs (1–4), which are born very small (<1% of mother's mass) but are fed a very concentrated milk (Jenness et al. 1972) which allows them to grow fast enough to be able to follow the mother during spring foraging.

There are few scientifically published descriptions of dens of European brown bears (Roth 1972, Elgmork 1981). The denning of American brown bears and of American black bears (*U. americanus*) has been described for a variety of habitats in North America.

In this paper we describe dens and den sites of brown bears in Croatia. The denning of known (radio-marked) bears was also analyzed according to sex and age. The objective of the study was to locate and describe important den areas and sites for proper habitat management.

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STUDY AREA

Brown bear dens studied were located in the section of Dinara Mountains in Croatia: in Lika and Gorski kotar regions, with Plitvice Lakes and Risnjak National Parks, respectively, as bear core areas. Elevations ranged from 417 to 1,528 m above sea level. Depending upon elevation, the mean January temperature ranged from -1.2 C in

Delnice to -3.6 C on Risnjak Mountain (Makjanić 1971/72); there was snow cover from 60 to 165 days (Bertović and Martinović 1981).

Forest covers about 70% of the area and is dominated by a mixture of common beech (*Fagus sylvatica*), silver fir (*Abies alba*), Norway spruce (*Picea abies*), and other tree species varying in composition with elevation and exposure. The topography exhibits typical karst features with various depressions without surface drainage. Limestone bedrock is covered by shallow soils; the mountain peaks and steep slopes (>60 degrees) are comprised of bare rocks.

METHODS

During 1981–92 bears were captured with spring activated foot snares, immobilized with ketamine hydrochloride and xylazine hydrochloride, and collared with radiotransmitters. The rudimentary first premolar was extracted for age estimation (Stonenberg and Jonkel 1966).

Locations of marked bears were made by triangulation with hand-held telemetry equipment, by driving forest roads and occasionally by aerial tracking. Visual observations supplemented telemetry data. Dens were inspected and measured after bears had left. Located dens of unmarked bears were also measured. Accessible dens were visited in subsequent years to a check for re-use.

Data were sorted for calculations, and *t*-test was used for comparisons; *P* < 0.05 was considered significant difference. Measurements of dens in natural rock cavities that differed >2.5 SD from the mean were excluded from calculations.

RESULTS

Of 28 dens located, 22 were slightly modified natural rock cavities, 3 were ground nests under the canopy of

conifers, 2 were cavities excavated under the roots of large standing trees, and 1 was in a horizontal hollow tree. We did not record the re-use of any den by radiomarked bears, but 2 of their dens had remains of old nests below the new material. Nine dens were checked for a total of 19 den-years, and only 1 was used again, 5 years later by an unknown bear.

The dens inspected were used by 15 different bears. Ten dens were used by females with cubs, 9 by single females, 5 by males, and 4 by bears of unknown category. Occasionally bears used >1 den in the single winter, (i.e., 4 bears used 2–5 dens, mean = 3). Only 2 of these den changes could be attached to human (researcher) disturbance. In 2 other cases, our close approaches caused den abandonment but the alternative den was not found or the bear did not den again. Den flooding was the likely cause of 2 den abandonments or changes.

Den sites were on elevations from 450 to 1370 m (mean = 836 m) with 50% ($N = 14$) of them from 400 to 800 m, 37% ($N = 9$) from 800 to 1200 m, and 18% ($N = 5$) from 1200 to 1600 m. Den entrances opened to all exposures with no significant preferences (Fig. 1). Mean distance from a den to a road accessible by motor vehicles was 486 m (39–1,550 m), and to the nearest house or settlement 1,434 m (200–4,000 m) (Fig. 2). Fifty percent ($N = 14$) of dens were distributed evenly in the bear habitat, but the other 50% were found in small concentrations (3–5 dens) on steep rocky slopes in areas >1 km².

Twenty (71%) dens were in the beech–conifer forest; the remaining 8 were in semi-open or shrubby deciduous

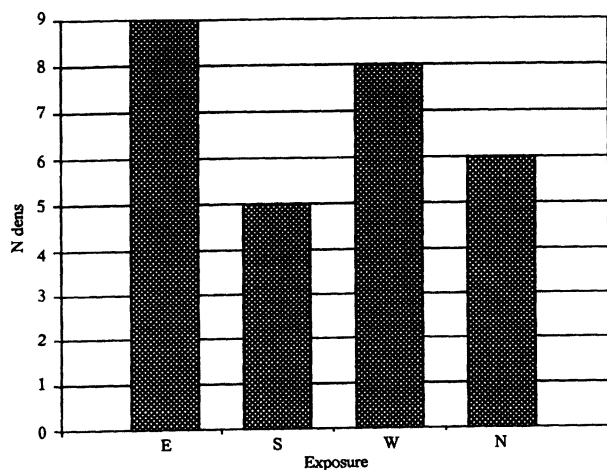


Fig. 1. Frequency of occurrence of European brown bear dens in Croatia by direction of opening, 1981–92. (East = 46–135, South = 136–225, West = 226–315, North = 316–360 and 0–45 degrees.)

forest. All but 4 dens were on steep slopes ($\geq 35^\circ$, mean = 48° , Fig. 3). Three dens were on or near the bottom of small karst valleys, and 1 was on a ridge. For dens in rock cavities the mean slope was 53° ; 4 were above vertical rock walls. Fifteen of 24 (63%) dens on slopes were associated with a vertical cliff wall, built on the bottom ($N = 10$) or in a fracture ($N = 5$) of solid rock. The mean height of rock above dens was 9.4 m (range 3.1–20.0 m), and for the dens in fractures the rock extended downward for 25.6 m (range 18–34 m). Cavities represented ancient water sinkholes ($N = 19$) or space among large boulders ($N = 3$). Modifications by bears were restricted to the dirt on the cave bottom: enlarging entrance and/or tunnel and shaping the nest depression. Only the cavities of 2 (7%) dens situated below the roots of large standing trees had been totally excavated by bears.

Mean measurements of den entrance, tunnel, chamber, porch, slope angle, elevation, and distance to the road or house were calculated for dens in rock cavities and root excavations (Table 1). From this data a hypothetical rock cavity den was drawn (Fig. 4). There was no significant difference in any den dimension due to the bear reproductive status or size class, i.e., maternal vs. nonmaternal (male and female) and bears weighing more or less than 100 kg. Only nest sizes (Table 2, Fig. 4) were significantly ($P < 0.05$) larger (79 x 98 cm) for mothers with cubs and for all bears >100 kg versus single females and all bears <100 kg (57 x 60 cm). Depths of nests and bedding were similar for all groups. Bears used grass, conifer twigs with needles, deciduous twigs, leaves, moss, and ferns for bedding material. Four dens contained no bedding material.

At the distance of 2–30 m (mean = 16 m) from 8 dens we found 10 nest-like structures on open ground. Visual confirmation showed that 1 bear, even in the middle of winter (first half of January) and another in March, spent at least a part of the daytime in this nest, which we called a “sun-bed”. A mother and her 2 yearling cubs were seen walking in the vicinity (up to 150 m) of a den during daytime in the first week of denning in November. Another female that had at least 1 cub in the den (confirmed by hearing the cub’s voice) was repeatedly seen browsing alone around the den until June 4 when the den was abandoned. No den-related mortality was revealed in our study.

For 6 bears radiomonitored over the whole winter, the mean denning time was 86 days (range 6–189 days). The total number of documented bear den-days for 11 bear-winters was 593, distributed as follows: November, 4 den-days; December, 83; January, 170; February, 170; March, 101; April, 30; May, 31; and June, 4.

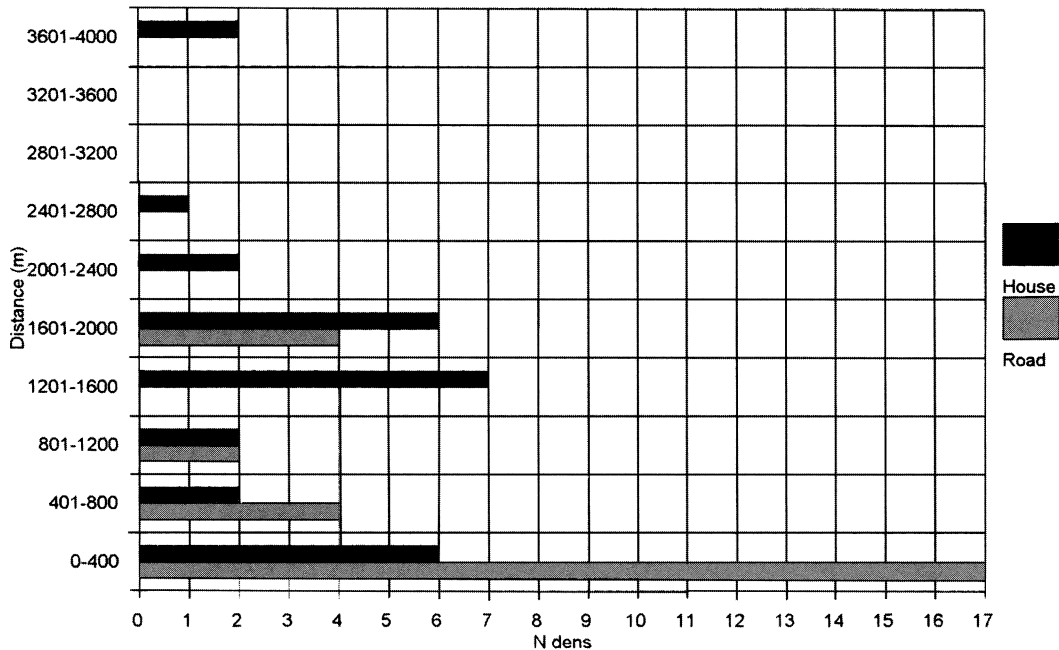


Fig. 2. Frequency of occurrence of European brown bear dens in Croatia by distance from roads accessible to motor vehicles and from house(s), 1981-92.

DISCUSSION

A clear preference for rock cavities (79%) as den sites is apparently due to combined effects of the karst environment abundant with appropriate rock formations and to relatively mild winters. Only Schoen et al. (1987) reported equally high (79%) use of natural cavities for North American brown bears on Admiralty island (Alaska),

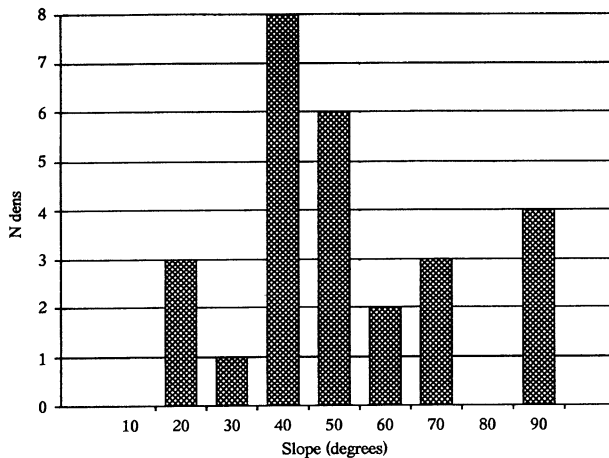


Fig. 3. Frequency of occurrence of European brown bear dens in Croatia by slope angles, 1981-92.

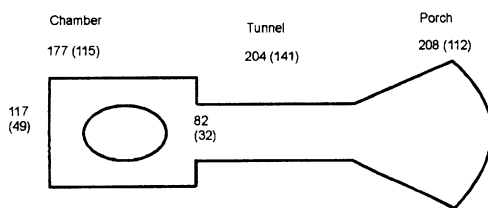
though on the nearby Chichagof island it was only 11%. Pearson (1975), Vroom et al. (1980), and Servheen and Klaver (1983) reported 0% use of natural cavities, Miller (1990) 1%, Judd et al. (1986) 10%, Van Daele et al. (1990) 13%, and Reynolds et al. (1976) 25% in different parts of North America. Most bear dens in Scandinavia are associated with ant-hills and tree stumps (Elgmork 1981). However, for the American black bear in Arizona, LeCount (1983) reported 100% use of rock related dens.

Van Daele et al. (1990) reported 18% reuse of dens by the same bear in successive years and 2 cases of females using the same dens for 5 consecutive years. Our data do not allow us to comment about the fidelity of Croatian brown bears to den sites. Occasional use of a den that was previously used by another bear (13%) was reported by Servheen and Klaver (1983), which is comparable to 8% in this study. Den abandonment occurred (4 cases) whenever our approach made it clear that the den site was known to humans. We feel that any approach <30 m is likely to chase a bear out of its den in any part of the winter. Changes of dens during the winter by European brown bears due to different reasons was reported by Elgmork (1981). Abandonment due to flooding (2 in this study) was also reported by Van Daele et al. (1990) and Schoen et al. (1987) for Kodiak brown bears, and Alt

Table 1. Mean dimensions of European brown bear dens in Croatia, 1981–92. (Extreme values lying outside ± 2.5 SD were excluded from calculation; *N* excluded = 3).

Dimension	Rock cavities					Root excavations		
	<i>N</i>	Mean	Range	SD	SE	<i>N</i>	Mean	Range
Entrance (cm)								
height	22	79	30–173	39.7	8.5	2	78	65–90
width	21	86	22–159	36.1	7.9	2	47	46–47
Tunnel (cm)								
height	20	79	30–173	44.5	9.9	2	75	65–85
width	20	82	33–159	32.1	7.2	2	55	46–63
length	22	204	30–520	140.6	29.9	2	82	63–100
Chamber (cm)								
height	19	95	40–220	50.8	11.7	2	98	92–104
width	21	117	64–200	48.9	10.7	2	124	112–136
length	22	177	50–605	115.1	24.5	2	104	90–112
Porch leng.(cm)	16	208	40–420	111.8	27.9	2	220	160–280
Slope (degree)	22	53	19–90	20.4	4.3	2	31	23–39
Elevation (m)	22	849	450–1,370	333.9	71.2	2	620	460–780
Nearest								
road (m)	22	509	39–1,550	507.7	108.2	2	470	300–640
house (m)	22	1,281	200–3,800	837.1	178.5	2	975	300–1,650

A) Top view



B) Profile

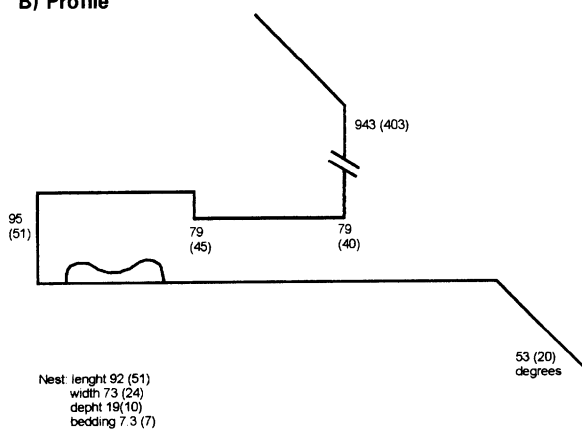


Fig. 4. Top view and profile of the hypothetical European brown bear den in rock cavity in Croatia, 1981–92. Means (SD) values are shown in cm.

(1984) even noted American black bear cub mortality due to flooding of natal dens.

No preference in selection of the exposure of den opening was also reported Van Daele et al. (1990), whereas other authors noted preferences to various aspects: Vroom et al. (1980), west; Judd et al. (1986), north; and Schoen et al. (1987), south. The mean slope angle (48° overall, or 53° for the rock cavities dens) of den sites was higher than that reported in North American studies; Servehen and Klaver (1983) found 30°, Judd et al. (1986) found 20°–75°, and Schoen et al. (1987) reported 35°. The use of steeper cliffs may be related to availability and also enables bears to cope with a highly human-influenced habitat. For instance, bears could use sites near a road or inhabited house, but because of the steepness of the cliffs, such sites would seldom be visited by man.

Table 2. Mean dimensions of nests in European brown bear dens in Croatia, 1981–92.

Dimension (cm)	<i>N</i>	Mean	Range	SD	SE
Width (outer)	27	73.2	26–127	24.2	4.7
Length (outer)	27	92.4	26–210	51.1	9.8
Depth (from nest rim)	27	19.3	5–48	10.3	2.0
Depth of bedding ^a	23	8.6	2–29	7.0	1.5

^a Excluded are 4 nests with no bedding material. The depth of bedding was measured after compression by bear use.

Only 14% (4 of 28) of the dens in this study had no nest material. This contrasts with studies by Servheen and Klaver (1983) and Judd et al. (1986) who found no bedding in 27% and 24% of their dens, respectively. At least 3 of 4 such nests in this study were in dens used only temporarily and then abandoned or in emergency constructed dens.

While in the den the activity level of bears was around 5% (Roth and Huber 1986). The discovery of sun beds and the visual confirmation of their use during winter explained part of that den-related activity. Similar structures and bear winter behavior has not been reported for other bears. Based on telemetry results, fresh bear scats and tracks in snow found in all winter months, we conclude that many bears in Croatia do not hibernate for the entire winter, and some may even spend the entire winter out of a den. While each bear showed at least some period of reduced mobility, we could not find a typical winter den for every bear. Comparable data were reported by Van Daele et al. (1990) for Kodiak brown bears, where 22% did not den.

We conclude that in a shrinking habitat, certain areas will remain as critical sites for European brown bear denning and reproduction. For such areas identified in this study, we propose strict protection and exclusion of all human-related activities (construction, forestry, hunting, sports activities).

LITERATURE CITED

- ALT, G. 1984. Black bear cub mortality due to flooding of natal dens. *J. Wildl. Manage.* 48:1432-1434.
- BERTOVIĆ S., AND J. MARTINOVIĆ. 1981. Bioekološke značajke. Pages 27-43 in I. Tomac, ed. *Gorski kotar*. Fond knjige "Gorski kotar", Delnice, Croatia. (In Croatian.)
- ELGMORK, K. 1981. Denning behaviour of a female brown bear, *Ursus arctos* (Linne, 1758), with three young. *Saugetierkundliche Mitteilungen* 29:59-66.
- JENNESS, R., A.W. ERICKSON, AND J.J. CRAIGHEAD. 1972. Some comparative aspects of milk from four species of bears. *J. Mammology* 53:34-47.
- JUDD, S.L., R.R. KNIGHT, B.M. BLANCHARD. 1986. Denning of grizzly bears in the Yellowstone National Park area. *Int. Conf. Bear. Res. and Manage.* 6:111-117.
- LECOUNT, A.L. 1983. Denning ecology of black bears in central Arizona. *Int. Conf. Bear. Res. and Manage.* 5:71-78.
- MAKJANIĆ, B. 1971/72. O klimi užeg područja Plitvičkih jezera. *Geografski glasnik* 33-34:5-24. (In Croatian with English summary.)
- MILLER, S.D. 1990. Denning ecology of brown bears in southcentral Alaska and comparisons with a sympatric black bear population. *Int. Conf. Bear. Res. and Manage.* 8:279-287.
- PEARSON, A.M. 1975. The northern interior grizzly bear *Ursus arctos* L. *Can. Wildl. Serv. Rep. Ser.* 34. 86pp.
- REYNOLDS, H.V., J.A. CURATOLO, AND R. QUIMBY. 1976. Denning ecology of grizzly bears in northeastern Alaska. *Int. Conf. Bear. Res. and Manage.* 3:403-409.
- ROTH, H.U. 1972. Standorte von Winterlagern des Braunbären (*Ursus arctos*) im Trentino, Italien. *Jahresbuch naturhschaft Museum Bern* 4:219-230. (In German.)
- , AND D. HUBER. 1986. Diel activity of brown bears in Plitvice Lakes National Park, Yugoslavia. *Int. Conf. Bear Res. and Manage.* 6:177-181.
- SERVHEEN, C., AND R. KLAVAR. 1983. Grizzly bear dens and denning activity in the Mission and Rattlesnake Mountains, Montana. *Int. Conf. Bear. Res. and Manage.* 5:201-207.
- SCHOEN, W.J., L.R. BEIER, J.W. LENTFER, AND L.J. JOHNSON. 1987. Denning ecology of brown bears on Admiralty and Chichagof islands. *Int. Conf. Bear. Res. and Manage.* 7:293-304.
- STONEBERG, R.P., AND C.J. JONKEL. 1966. Age determination of black bears by cementum layers. *J. Wildl. Manage.* 30:411-414.
- VAN DAELE L.J., V.G. BARNES, AND R.B. SMITH. 1990. Denning characteristics of brown bears on Kodiak Island, Alaska. *Int. Conf. Bear. Res. and Manage.* 8:257-267.
- VROOM, G.W., S. HERRERO, AND R.T. OGIIVIE. 1980. The ecology of winter den sites of grizzly bears in Banff National Park, Alberta. *Int. Conf. Bear. Res. and Manage.* 4:321-330.