

# SELECTION OF DENNING CAVES BY BROWN BEARS IN TRENTINO, ITALY

CLAUDIO GROFF, Gruppo Operativo Orso Trentino, Via Alt Spaur 82–38010, Spormaggiore (TN), Italy, email: ciolli@ing.unitn.it  
ANGELO CALIARI, Gruppo Operativo Orso Trentino, Via Alt Spaur 82–38010, Spormaggiore (TN), Italy, email: ciolli@ing.unitn.it  
ENRICO DORIGATTI, Gruppo Operativo Orso Trentino, Via Alt Spaur 82–38010, Spormaggiore (TN), Italy, email: ciolli@ing.unitn.it  
ALBERTO GOZZI, Gruppo Operativo Orso Trentino, Via Alt Spaur 82–38010, Spormaggiore (TN), Italy, email: ciolli@ing.unitn.it

**Abstract:** We studied 21 brown bear (*Ursus arctos*) dens in the mountains of the northeast Brenta range in Trentino, Italy. Of these, 2 dens were located during the late 1970s using radio-tracking, 1 den was located in 1989 by a different researcher, and 18 dens were located by the authors between 1988 and 1994. Two dens were excavated and 19 were in natural cavities. Bedding material in these dens consisted of nest-like beds ( $n = 15$  dens), a hole dug in the earth ( $n = 2$ ), bedding materials spread out on the ground ( $n = 3$ ), and no bed in 1 excavated den. Nine dens showed signs of recent use. To determine factors bears use to select a hibernation site, characteristics (e.g., elevation, exposure, slope angle, and distance from sources of disturbance) were noted for 19 dens located in the area where bears are constantly present and compared with the same characteristics taken from 100 uniformly distributed sites in the same area. Elevation of the den sites ranged between 970–1940 m. The angle of the slopes on which the dens were located ranged between 28°–60°. Brown bears preferred den sites with southern exposure over those with a northern exposure and used slopes facing all cardinal compass directions.

*Ursus* 10:275–279

**Key words:** brown bear, den selection, Italy, Trentino, *Ursus arctos*.

The last remaining autochthonous brown bear population in the Alps exists in the northeast Brenta range in Trentino, Italy. The size of the population has been debated. Research carried out to date support the existence of <5 bears in the Trentino Alps (Gruppo Operativo Orso and Parco Naturale Adamello–Brenta, Attività svolta nell'anno 1993, Spormaggiore, Italy, 1993, unpubl. rep., in Italian).

In this paper we describe the configuration and location of winter dens of Trentino bears. Winter dens have been mentioned in other studies to be important for brown bear survival as shelter from both humans and inclemental weather; dens help bears maintain energy reserves during seasonal shortages of food (Craighead and Craighead 1972, Servheen and Klaver 1983, Schoen et al. 1987, MacHutchon et al. 1993). Knowledge of the habitat requirements of Trentino bears that included den sites would enable resource managers to more accurately predict how resource development and changing land use patterns would affect the brown bear population (see Kolenosky and Strathearn 1987), but prior to our study there were no published accounts of hibernation sites of Alpine bears based on direct observations. Our purpose was to provide authorities with the knowledge needed to protect den sites from human uses that would prevent bears from using them.

We gratefully thank the following people and institutions: A. Brugnoli of the Servizio Faunistico, Provincia Autonoma di Trento, for the initial stimulus, advice, and materials; the Parco Naturale Adamello–Brenta for logistical support; and W. Schröder of the Wildbiologische Gesellschaft München for useful advice.

## STUDY AREA

Our study area was the northeast sector of the Brenta range in West Trentino, Italy, almost all of which is part of Adamello–Brenta Natural Park. Progressive reduction of habitat by humans over millennium have restricted brown bears to approximately 140 km<sup>2</sup> in this area. The area is densely populated by people (approximately 70 inhabitants/km<sup>2</sup>). They are concentrated almost exclusively in valleys at elevations of 200–600 m and surround the higher elevations where bears live. Most people live in villages of 500–2,000 inhabitants 1.5–4 km apart (Roth 1983).

Brown bears occupy the steep forested slopes (500–2,000 m elevation) between the cultivated valley floor and the rocky peaks at 3000 m. Up to 900 m the slopes are covered with Scots pine trees (*Pinus silvestris*). Thick forests of European beech (*Fagus sylvatica*), oak (*Quercus pubescens*), and hop horn-beam (*Ostrya carpinifolia*) exist up to 1,400 m. These forests are managed as a natural silviculture zone that converts coppice into tall forest. Silver fir (*Abies alba*) and Norway spruce (*Picea abies*), used in timber production, occur at 1,400–1,800 m, where they are gradually replaced by European larch (*Larix decidua*) and low thickets of mountain pine (*Pinus mugo prostrata*). Between 1,900 and 2,200 m, there are mountain pastures between the rocks.

The study area is visited annually by thousands of tourists who concentrate, almost exclusively, around Lake Tovel, which was renowned for the reddening phenomenon of its waters. The forested slopes receive low levels of tourism where most of the evidence of bear presence is found. The area above the tree line is vis-

ited by excursionists and climbers in summer months and is sporadically used by bears. Several active mountain dairy farms (malghe) are used during the summer; however their use does not often place people in remote bear habitat. Hunting, which has no spatial limits in bear habitat, is probably a source of disturbance for bears at the time of denning.

At 1,600 m elevation the average temperature is 4.8 C (January, -4 C; July, 13.9 C) and annual rainfall is 115 cm (maximum in May, minimum in January). Snow normally covers the ground from late November–late March (Roth 1983).

Extensive apple orchards at the forest edge (500–700 m elevation) are an important food source for bears in autumn. This biotope also has the most steep and inaccessible slopes of the study area, making it well suited for the autumnal trophic habits of bears and for safe shelter for hibernation (Osti 1982).

## METHODS

Field research was done from 1988–94. The selection of areas to be searched for dens was guided by: (1) bear sign found during surveys on the distribution of the bear population (Osti 1991; Gruppo Operativo Orso and Parco Naturale Adamello–Brenta, unpubl. rep.), (2) news and other references to killings, hunting, sightings, and reports on bear use of habitat during winter as well as periods immediately before and after hibernation (Ambrosi 1886, Bonomi 1888–1910, Ramponi 1928, Castelli 1935, Daldoss 1981), and (3) testimony from people who knew where to find hibernation sites or areas used by bears during winter.

We planned field searches for dens on 1:25,000 scale maps. We tried to sample the study area equally in terms of elevation, slope angle, and exposure. Long daily walks were conducted by 2–4 researchers who watched for and evaluated all large boulders and rock faces for possible dens and other signs of bear presence. Nineteen dens were identified with the help of descriptions found in the literature and from experience gained in the field. Field evidence included cavities with similar configurations and whose dimensions were within the range of those provided by comparable studies in North America (Craighead and Craighead 1972, Servheen and Klaver 1983, Mollohan 1987, Schoen et al. 1987, McLellan and Shackleton 1989, MacHutchon et al. 1993), Scandinavia (Elgmork et al. 1977, Mysterud 1983), and Abruzzo, Italy (Zunino 1976, 1988). We excluded 9 sites from our analysis because we were not certain they were den sites. Field research was done

during summer, and no hibernation site was visited more than once a year.

Data were recorded to describe dens and to determine habitat characteristics that brown bears might use to select den sites. Descriptive data included the size of the den (maximum width, height, and length with respect to the entrance axis), bed dimensions (diameter measured from the highest point of the edges, and depth), the composition of bedding material if present, and other evidences of bear presence (e.g., scats, footprints, hair, etc.). For the 19 dens in the area currently used by bears, we recorded elevation and the slope angle and aspect of the den entrance. Using 1:25,000 maps we measured the distance between the den location and the nearest human land-use (e.g., trail, tractor road, town or provincial road, or center of human habitation). These 4 characteristics of den sites were compared with the same data recorded at 100 locations chosen randomly in the same area to determine if they affected the sites chosen by bears for hibernation. The 100 chosen locations were located at the intersection of the grid lines on a universal transverse mercator (UTM) map and represented the habitat features for the study area. The distance between grid locations was 1 km. We tested the null hypothesis of no difference between bear use of these 4 habitat variables and their availability using chi-square and Mann–Whitney *U* statistics.

## RESULTS

### Den Descriptions and Nest Dimensions

We located 21 den sites, including 2 sites located by researchers at the end of the 1970s using radiotracking (Osti and Roth 1979) and 1 site discovered by a researcher from the Autonomous Province of Trento in 1989 (Osti 1991). Nineteen of these dens were in natural cavities and 2 were excavated. All dens were located at the base of rock formations of varying size, from large boulders to rock faces that were hundreds of meters high. Eleven dens were situated in tall forests of mixed conifers (52%), 9 in mixed coppice areas (43%), and 1 in an alpine meadow (5%).

Nine dens showed evidence of being used after 1988. Evidence in 3 dens suggested that they had been visited frequently by bears. These dens had been modified (e.g., entrance threshold lowered, cavity enlarged, and bed remade, removed, or moved). We could not determine if these modifications were done by a single bear or by different bears over time.

The internal dimensions of the 21 winter dens varied, but the size of entrances (width and especially height) was more uniform (Table 1). The surface area of the cavities ranged from 3–40 m<sup>2</sup>. On average, low entrances (0.55 m high, 2.05 m wide) provided access to a chamber 4.55 m deep, 3.00 m wide, and 1.13 m high. In comparison, the chambers of the 2 excavated dens were much smaller in size (2.05 m deep, 1.25 m wide, 0.68 m high and 2.20 m, 1.80 m, 0.65 m, respectively).

Den entrances were well camouflaged by vegetation, and sometimes by rocks. In 3 dens, vegetation had been brought in from the outside and distributed uniformly on the floor to form a bed. Two dens had beds that were excavated in the ground, and 1 excavated den had no bed. Nest-like beds were found a mean distance of 2.58 m from the entrance of 15 dens. This location was just over half way from the entrance to the back of the den (mean den length = 4.40 m). The nests were slightly oval, 60–130 cm diameter, and 10–35 cm deep. The mean dimensions measured from the rim were 97 cm long, 91 cm wide, and 18 cm deep. A small bed (diameter = 25 cm) found next to 1 nest was probably for a newborn cub. The materials used to construct 17 nest-like beds included the following: graminaceous plants ( $n = 10$  beds or 59% of the cases), Norway spruce branches (7 or 41%), heather branches (*Calluna vulgaris*, 6 or 35%), silver fir branches (5 or 29%), bear-berry branches (*Arctostaphylos uva-ursi*) and European beech branches (4 or 23%), maple leaves (*Acer pseudoplatanus*, 3 or 18%), and juniper (*Juniperus communis*) and pear tree branches (*Amelanchier ovalis*, 1 or 6%).

### Habitat Characteristics of Dens

The den elevations ranged from 970–1,940 m. There was no difference between the elevation of 19 winter dens located in the area of constant bear presence ( $\bar{x} = 1,449$  m) and the elevation at the 100 regularly distributed sites ( $\bar{x} = 1,331$  m, Mann–Whitney  $U$  test,  $P = 0.47$ ).

**Table 1. Mean dimensions of hibernation sites used by brown bears in the Brenta Range of Trentino, Italy, in the late 1970s and 1988–94.**

| Den measurement     | $n$             | $\bar{x}$ | SE   | Range |       |
|---------------------|-----------------|-----------|------|-------|-------|
|                     |                 |           |      | Min   | Max   |
| Entrance height (m) | 22 <sup>a</sup> | 0.55      | 0.31 | 0.30  | 1.30  |
| Entrance width (m)  | 22 <sup>a</sup> | 2.05      | 1.62 | 0.55  | 7.00  |
| Maximum length (m)  | 21              | 4.55      | 3.17 | 1.60  | 16.00 |
| Maximum width (m)   | 21              | 3.00      | 1.83 | 0.90  | 8.00  |
| Maximum height (m)  | 21              | 1.13      | 0.85 | 0.60  | 4.40  |

<sup>a</sup> One den had 2 entrances

The dens were on slopes between 28° and 60°. The slope of den sites ( $\bar{x} = 39^\circ$  or 86%) was greater than what was available in the study area ( $\bar{x} = 24^\circ$  or 52%, Mann–Whitney  $U$  test,  $P < 0.0001$ ).

Ten of the dens were on southeast facing slopes. The remaining 11 dens faced east ( $n = 4$  dens), south (3), northwest (3), and west (1). Bears used southern exposures (SW, S, SE) more and northern exposures (NW, N, NE) less than their availability ( $\chi^2 = 5.97$ ,  $P < 0.025$ ), and eastern (NE, E, SE) and western (NW, W, SW) facing slopes were used according to their availability with most den sites occurring on the eastern facing slopes ( $\chi^2 = 0.02$ ,  $P > 0.75$ , Table 2). The average distance on the map to the closest source of disturbance to the dens ( $\bar{x} = 276$  m) was greater than what characterized the study area ( $\bar{x} = 209$  m, Mann–Whitney 1-tailed test,  $P = 0.03$ ).

## DISCUSSION

Brown bears appeared to chose den sites in the Brenta Range to provide security from humans and thermal insulation, although our search efforts could have biased us toward this conclusion. Den sites are of critical importance to bears and must be protected against human disturbance.

### Thermal Insulation and Security from Humans

Our results show Trentino's brown bears have a high priority to be safe from human disturbance. Whereas natural cavities that offered thermal protection were available closer to human disturbance, brown bears used sites that were farther away. The steeper slopes that bears selected for den sites also might reflect security concerns. People have difficulty accessing these sites and therefore have little interest doing so. These results corroborate other studies that document the negative effects of human activity in hibernation areas (Craighead and Craighead 1972, Zunino 1976, Servheen and Klaver 1983, Schoen et al. 1987, McLellan and Shackleton 1989).

Several lines of evidence support the importance of thermal protection in den selection. Trentino's brown bears may have chosen steep slopes to allow snow to accumulate and block the den entrance without sliding into the den (Servheen and Klaver 1983), thereby insulating against colder air outside the den. The low den entrance would also limit heat loss from the den interior and favor its being covered by snow. Studies in Montana revealed that the den entrance height is directly proportional to the size of the bear (Servheen and Klaver 1983). The particularly narrow dimensions of our den entrances reflect

**Table 2. Habitat characteristics at 19 den sites used by brown bears and mean value of those characteristics for 100 sites chosen from a grid in the Brenta Range of Trentino, Italy, 1988–1994. Source of disturbance included trails, tractor roads, town or provincial roads, and centers of human habitation.**

| Habitat characteristic                              | Mean |            |
|---|------|------------|
|   | Dens | Grid sites |
| Distance from trails (m)                            | 236  | 410        |
| Distance from tractor roads (m)                     | 534  | 460        |
| Distance from town or provincial roads (m)          | 1191 | 1321       |
| Distance from centers of habitation (m)             | 3525 | 3442       |
| Distance from the closest source of disturbance (m) | 276  | 209        |
| Elevation (m)                                       | 1449 | 1331       |
| Slope angle (degrees)                               | 39   | 24         |
| Exposure <sup>a</sup>                               |      |            |
| N   | 0    | 8          |
| NE  | 0    | 14         |
| E   | 16   | 33         |
| SE  | 52   | 19         |
| S   | 16   | 6          |
| SW  | 0    | 2          |
| W   | 0    | 4          |
| NW  | 16   | 11         |
| Flat ground   | 0    | 3          |

<sup>a</sup> Reported values for exposure are frequency in %.

the small size of the last Alpine bears. Finally, the nest-like bed most preferred by bears in the study area probably provided greater insulation and a more comfortable hibernation than excavated holes or bedding material on the den floor which were less frequently observed. The same kind of nest is cited in Norway (Elgmork et al. 1977). We did not find >1 bed in the same den, although Zunino (1976) found dens containing 2–3 beds, probably from different periods.

Trentino's bears may have preferred den sites with southern exposures; warmer slopes have an earlier growth of food plants that bears could exploit when they emerged from the dens. Our results contradict previous work that hypothesized no preference for slopes facing south over those facing north (Roth 1972) or greater use of slopes facing east (Osti 1991). Preference for sunny exposures was also revealed by some American studies (Schoen et al. 1987), but some authors maintain that aspect is irrelevant (MacHutchon et al. 1993).

## Research Method

Our research method probably biased finding dens in natural cavities. In carefully examining rock formations we could have missed dens of other types (Roth 1972;

Osti 1991). We believe, however, that the choice of the bear shown by our data is close to reality, because the karst nature of the area resulted in terrain that is particularly rich in suitable natural cavities. Similar biases have been reported by American researchers aware that they may have undersampled dens in natural cavities. For example, Servheen and Klaver (1983) located the dens for their study by searching for large mounds of excavated material in front of the den entrances on expansive tree-free slopes. We also did not explore the full range of elevations. Hibernation sites in the Brenta Range >2,000 m and <560 m were mentioned by Roth (1972) and Daldoss (1981).

Our research could not address several questions. Our small sample size did not allow us to investigate whether brown bears selected den sites with regard to the degree of human influence or whether some human uses such as recreational activity posed a greater threat to bear denning behavior than vehicular transit through bear habitat.

## MANAGEMENT IMPLICATIONS

The continual reuse of den sites by bears demonstrates how important these sites are for the survival of Trentino's brown bears. During our study we gathered evidence indicating the prolonged use of several dens by generations of bears. Castelli (1935) reported the killing of a female and her cub in a den in 1922. Seventy-seven years later, in 1989, the presence of a nest-like bed in the same den testifies to its ongoing use. We also find dens in places known since time immemorial by names that refer to bears; these place names figure in legends of epic hunts, supporting the long-time use of dens. These cavities are geologically very stable, as demonstrated by the limestone concretions that are sometimes present, and some of these dens may have been used by bears for centuries (Schoen et al. 1987). In some sites the low roof of the chamber above the bed was polished smooth, possibly due to continuous reuse by bears.

Every effort should be made to secure these sites from human disturbance. Although some trails through bear habitat were recently removed from tourist maps, provincial law was also modified in August 1994 to permit local people to drive through bear habitat on tractor roads without authorizations.

## LITERATURE CITED

AMBROSI, F. 1886. L'orso nel Trentino—Cenni Storici. *Annu. della Società Degli Alpinisti Tridentini* 12:3–27. (In Italian.)

- BONOMI, A. 1888–1910. Brevi relazioni sull'orso nel Trentino. Bollettino Del Naturalista, Siena and Rivista Italiana di Scienze naturali, Siena, Italy. (In Italian.)
- CASTELLI, G. 1935. L'orso bruno nella Venezia Tridentina. Edizioni Ass. Prov. Cacciatori Trento, Trento, Italy. 171pp. (In Italian.)
- CRAIGHEAD, F.C., AND J.J. CRAIGHEAD. 1972. Grizzly bear prehibernation and denning activities as determined by radiotracking. Wildlife Monographs 32. 35pp.
- DALDOSS, G. 1981. Sulle orme dell'orso. Edizioni Temi, Trento, Italy. 251pp. (In Italian.)
- ELGMORK, K., O. BREKKE, R. SELBOE, AND S. UNANDER. 1977. Post-hibernation activity and habitat selection in a small remnant brown bear population (*Ursus arctos* L.) in Southern Norway. Viltrevy Swedish Wildlife 10:113–144.
- KOLENOSKY, B., AND S.M. STRATHEARN. 1987. Winter denning of black bears in east-central Ontario. Int. Conf. Bear Res. and Manage. 7:305–316.
- MACHUTCHON, A.G., S. HIMMER, AND C.A. BRYDEN. 1993. Khutzymateen Valley grizzly bear study. Ministry of For. Wildl. Hab. Res. Rep. WHR-31 and Ministry of Envir., Lands, and Parks Wildl. Rep. R-25. Victoria, B.C., Can. 107pp.
- MCLELLAN, B.N., AND D.M. SHACKLETON. 1989. Immediate reactions of grizzly bears to human activities. Wildl. Soc. Bull. 17:269–74.
- MOLLOHAN, C.M. 1987. Characteristics of adult female black bear daybeds in Northern Arizona. Int. Conf. Bear Res. and Manage. 7:145–149.
- MYSTERUD, I. 1983. Characteristics of summer beds of European brown bears in Nowary. Int. Conf. Bear Res. and Manage. 5:208–222.
- OSTI, F. 1982. Osservazioni sul comportamento autunnale dell'orso bruno delle Alpi (*Ursus arctos* L.). Natura Alpina 3:25–30. (In Italian.)
- . 1991. L'orso bruno nel Trentino. Edizioni Arca, Trento, Italy. 209pp. (In Italian.)
- , AND H. ROTH. 1979. Prime esperienze di radiolocalizzazione di due orsi bruni del Trentino. Natura Alpina 17:27–38. (In Italian.)
- RAMPONI, S. 1928. Mammalofauna rapace. Biblioteca Venatoria Ed. Monauni, Trento 1928:7–69. (In Italian.)
- ROTH, H. 1972. Standort der Winterlager des Braun Bär (*Ursus arctos* L.) in Trentino. Jahrbuch des Naturhistorischen Mus. der Stadt Bern 1972: 219–230. (In German.)
- . 1983. The activity of a remnant population of European brown bear. Int. Conf. Bear Res. and Manage. 5:223–229.
- SCHOEN, J.W., L.R. BEIER, J.B. 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.
- SERVHEEN, C., AND R. KLAVER. 1983. Grizzly bear dens and denning activity in the Mission and Rattlesnake Mountains, Montana. Int. Conf. Bear Res. and Manage. 5:201–207.
- ZUNINO, F. 1976. Orso bruno marsicano. Risultati di una ricerca sull'ecologia della specie. Pages 603–710 in F. Pedrotti, ed. S.O.S. Fauna. Animali in pericolo in Italia. Edizioni dell'Associazione Italiana per il World Wildlife Fund, Roma, Italy. (In Italian.)
- . 1988. Osservazioni sullo svernamento di un individuo di orso bruno (*Ursus arctos* L.) nel Parco Nazionale d'Abruzzo. Tipografia Pasqualini–Sora (FR), Pescasseroli, Italy. 80pp. (In Italian.)