

# DEFECATION RATES OF CAPTIVE BROWN BEARS<sup>1</sup>

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**Abstract:** The number of scats dropped by captive European brown bears (*Ursus arctos*) was recorded in all months of the year, 1971-73. An overall total of 3,634 scats was recorded in 1,094 bear-days. Clear seasonal differences were found, with low values of about 2 scats per bear-day from November through June and higher values in the remaining months, and with a distinct peak in August of 7.19 scats per bear-day for adults. Extremes observed ranged from 0 to 11 scats per bear-day. Preliminary data indicate at least a 28 percent higher defecation rate for cubs. Significant ( $P < 0.01$ ) differences were found among individual bears kept under identical conditions. Possible application of these findings to estimation of bear densities or bear use in the wild is discussed.

While studying the last autochthonous brown bears of the Alps (province of Trento, also called Trentino, northern Italy), we were forced by the secretive habits of the animals and the dense cover to use indirect methods to arrive at least at an informed guess of population size and distribution. Since the species apparently does not select special locations for defecation (although exceptions have been noted by Tratz 1963:47f and Ustinov 1974), and because finding droppings depends much less on ground conditions than finding tracks, scats are the best indicators of bear presence. This study was made in the hope that information about defecation rates would enable us to draw direct conclusions from numbers of scat finds.

Pelton (1972) used scat counts to monitor distribution of black bears (*Ursus americanus*), and he cites Spencer (1955) as having used scats to estimate black bear density. In a less quantitative way, scats were used by Lentfer et al. (1969:29) as indicators of relative bear use of various habitats. I am aware neither of others having systematically used scats to document the presence of bears nor of any literature dealing with bear defecation rates, except for a single observation made by Zunino (1971).

Special thanks are given to E. Hänni, Sr., who made most of the daily scat counts.

## METHODS AND MATERIALS

Scats were counted daily by zoo keepers cleaning the stables and runs of the captive bears. Since it was often not possible to determine the defecation rates of individual bears, only part of the data could be used in some analyses. All counts were made during 1971-73 and involved 26 different bears (8 adult males, 9 adult females, and 9 cubs). Small proportions of the counts were made in the zoo of Basel (1 male, 3 females, 1 cub; total of 38 bear-days, all in September) and in a small

private zoo near Gossau, Switzerland (3 males; 99 bear-days, September and October). In both places, feeding by the public is prohibited.

Most of the data (from 4 males, 6 females, 8 cubs; 957 bear-days, all months except October) originated from the bear pit of Bern, where the public is encouraged to feed the bears; carrots, feed cubes, and dried figs are sold for this purpose. This bear pit consists of 3 semicircular outdoor compartments and 9 unheated indoor stables. The 2 larger compartments each have a maximum linear dimension of about 23 m and a surface area of roughly 300 m<sup>2</sup>; the smaller compartment, about 15 m and 150 m<sup>2</sup>.

The adults are kept in pairs (sometimes 1 male with 2 females) except when the females are in late pregnancy or have their cubs (November-December until spring). Being, as a rule, separated from their offspring by mid-May, the females usually breed every year. Each pair normally is kept in an outdoor compartment in the morning or afternoon and in an indoor stable the other half day and the night. The females, usually pregnant, generally remain voluntarily in the stables all winter (mid-November, or December, until April).

On days when visitors are few, additional food is offered so that the animals feed practically *ad libitum* throughout the year. The main diet consists of carrots and supplementary items such as artificial feed cubes (containing fish flour, meat flour, and cereals), dried figs, and old bread and apples. The diet changes little throughout the year.

## RESULTS

Defecation rates observed ranged from 0 (or 0.13 for longer periods: 1 female in December had 2 scats in 15 days) to 11 scats per bear-day (10 or 11 scats a day counted 4 times for a male and 8 times for a female in 24 calendar days in August). The overall average was 3.3 (3,634 scats in 1,094 bear-days). This last figure, however, is of little significance, since seasonal varia-

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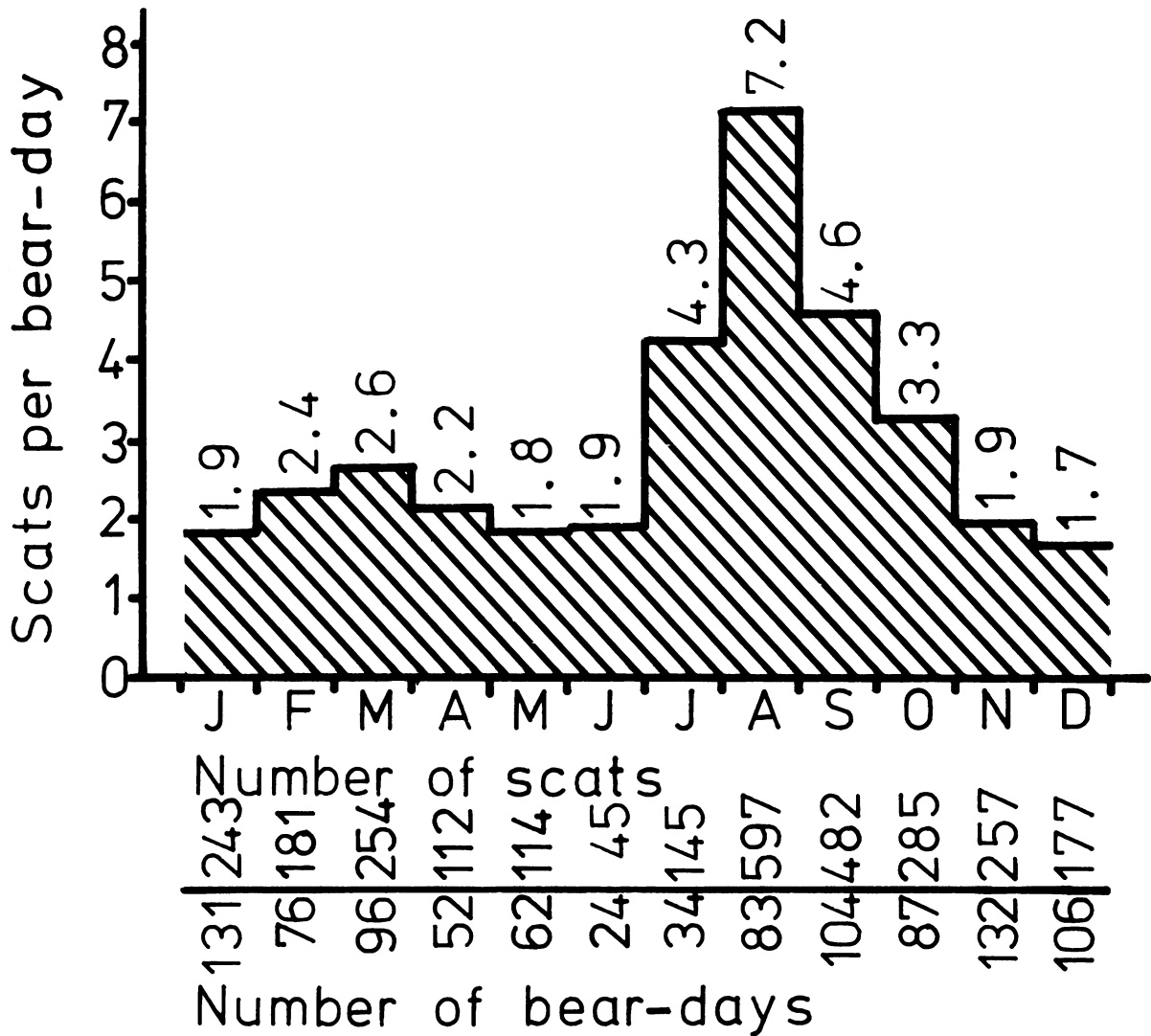


Fig. 1. Seasonal variation of the defecation rate. Counts made for 8 adult males and 8 adult females in 3 different years (1971-73) were combined.

tions were large (Fig. 1). Although the bears eat practically *ad libitum* throughout the year, some doubt arose as to possible influences of visitor frequencies on the defecation rates through intensity of feeding. Figures from the Swiss Federal Bureau of Statistics show that the greatest numbers of tourist-nights and tourist arrivals in Bern occur in August, the time when bear defecation rates are highest. The breakdown of data according to the day of the week (Table 1) shows highest defecation rates on Mondays ("weekend effect" with some time lag; footnote a, Table 1). But this weekly pattern differed seasonally, with no consistent peak in August-November (no data from October), whereas the weekly maximum was usually on Sunday or Mon-

day during January-May. We suspect that the visiting public to some extent stimulates the bears to eat more food than they would otherwise consume, even with unlimited food available.

But increased tourism can explain only a small part of the August peak in defecation rates. The July-August increase in defecation rates amounted to 69 percent (Fig. 1), which is 4.6 times (95 percent confidence interval, 2.8-7.4) as great as the increase in tourist-nights and 3.9 times (2.3-6.3) as great as the increase in tourist arrivals (statistics summed over the years 1971-73 when scats were counted). The difference between the increase in defecation rates and the increase in tourism is highly significant ( $P < 0.01$ ; test

**Table 1. Defecation rate of bears of the pit of Bern as a function of the day of the week. Combined data from 18 bears (4 adult males, 6 adult females, and 8 cubs) and from all months except June, July and October (data lacking because year was inadvertently omitted from 2 record sheets).**

Day of week	Number of scats <sup>a</sup>	Number of bear-days	Defecation rate
Monday	393	105	3.74
Tuesday	266	89	2.99
Wednesday	231	75	3.08
Thursday	363	106	3.42
Friday	380	108	3.52
Saturday	196	70	2.80
Sunday	202	65	3.11

<sup>a</sup>For technical reasons the afternoon scats of those bears that had to spend the afternoon indoors were recorded as being of the following day.

and confidence limits arbitrarily taking Poisson limits for numbers of scats, tourist-nights, and tourist arrivals, and using procedures given in Roth 1976). The seasonal variations in defecation rates appear to be largely caused by annual physiological cycles still functioning in captive bears living out-of-doors much of the time.

The few counts available from cubs indicate that they have a higher defecation rate than adults. In 11 calendar days in late August and early September, 8 cubs had a rate of 6.9 (608 scats/88 bear-days). In the same period, 7 adults had a rate of 5.4 (415/77, cubs 28 percent higher). Data from the zoo of Basel point to an even larger difference. There, a group of 3 adults produced 92 scats in 21 bear-days in September, a defecation rate of 4.4. A sow-cub group in the same days achieved a rate of 7.6, which is 74 percent higher (107 scats/14 bear-days). This difference is significant ( $P < 0.05$ , sign test).

Because the bears in Bern are usually kept in pairs, we have few data to clarify differences of defecation rates between the sexes, but from spring through fall, these differences do not seem to be important (Table 2). In winter, however, the pregnant females show a much clearer tendency than males to enter winter dormancy and often refuse food and water for up to 1 month, also after giving birth to cubs (E. Hänni, personal communication). Accordingly, their defecation rate approaches zero (Table 2: Jan. 1973). Also, the temporary decrease in the rate of defecation from April to June (Fig. 1) may be attributable to males and not to females (Table 2). The males show little appetite during the rut (May-June) (E. Hänni, personal communication).

Compared with seasonal variations, small but statistically significant differences among defecation rates of individual bears were found. In August-September 1971, for a group of 5 adults (2 males, 3 females), a defecation rate of 5.0 was determined (302 scats/60 bear-days), whereas for a pair the rate was 6.0 (145/24) over the same days (higher rate for 10 of 12 calendar days, difference significant,  $P < 0.05$ , sign test). Again, in November, the same pair had a higher value of 2.1 (50/24) than the group of 5 with 1.8 (110/60, difference significant,  $P < 0.05$ ). The figures for single adults (Table 2) substantiate the hypothesis that there are individual differences in defecation rates. Male 1 showed consistently low rates. From January to March, defecation rates of all 4 males increased, but the order from low to high remained M1-M4-M3-M2 in all 3 months. Data for M4 are incomplete but conform to the pattern. Even small differences seem to be relatively consistent.

**Table 2. Comparison of defecation rates (scats/bear-day) of individual adult bears. Number of bear-days is equal to number of calendar days of counting. Figures in parentheses are numbers of scats counted.**

Month	Number of bear-days	Bear number						Statistical significance of difference <sup>a</sup>
		Male 1	Male 2	Male 3	Male 4	Female 1	Female 2	
Jan. '72	15	1.1 (16)	2.8 (42)	2.6 (39)	-	-	-	M1 — each of the others**
February	19	1.3 (25)	3.1 (58)	2.8 (54)	2.3 (44)	-	-	M1 — each of the others**
March	24	1.7 (41)	3.2 (76)	3.0 (73)	2.7 (64)	-	-	M2 — M4**; M3 — M4*
April	15	2.2 (33)	-	-	-	1.9 (28)	-	-
May	31	1.5 (46)	-	-	-	2.2 (68)	-	**
June	12	1.3 (15)	-	-	-	-	2.5 (30)	**
July	17	3.5 (60)	-	-	-	-	5.0 (85)	**
August	24	8.0 (192)	-	-	-	8.8 (210)	-	*
September	6	5.2 (31)	-	-	-	5.7 (34)	-	-
November	11	1.9 (21)	-	-	-	2.5 (27)	-	*
December	26	1.5 (39)	-	-	-	1.0 (26)	-	-
Jan. '73	23	1.4 (32)	-	-	-	0.3 (7)	-	**

<sup>a</sup>Sign test, comparing numbers of scats of each day, \* $P < 0.05$ . \*\* $P < 0.01$ .

APPLICATION OF FINDINGS TO ESTIMATION OF DENSITY AND USE

The well-known method of estimating population density from numbers of scats or pellet groups can be expressed in the following equation:

$$D \text{ (animals/km}^2\text{)} = \frac{s \text{ (scats)}}{t \text{ (days)} a \text{ (km}^2\text{)} d \text{ (scats/animal-day)}}$$

where dimensions are shown in parentheses, and  $D$  = density,  $s$  = number of scats found,  $t$  = time interval in which scats were deposited by the animals,  $a$  = area searched for scats, and  $d$  = average defecation rate. If we multiply the density by the factor 365, we get the use expressed in animal-days per year and unit area, which shows that *use* is simply another, finer, measure of density.

This method as it is used to estimate densities of ungulates, where the sample area  $a$  is cleared of old pellets and newly deposited pellet groups are counted after a period  $t$  (Neff 1968), would in most cases not yield enough data for bears, which occur at much lower densities and have low defecation rates. We must therefore modify the procedure in such a way that all scats found can be used. Thus, for  $t$  we use the average time for scats to decompose, for which we have a rough and preliminary estimate of 18 days (Fig. 2); and for  $a$  we

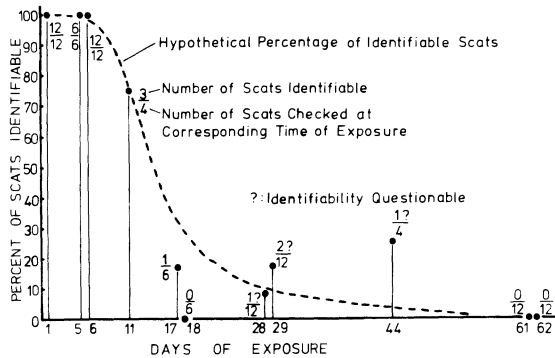


Fig. 2. Identifiability of weather-exposed bear scats as a function of the time of exposure. The decomposition of 3 series of a total of 28 scats was observed. Graphical integration of plausible smooth curves yielded the following values for the average time required for scats to decompose to unidentifiability: lower limit = 13 days; upper limit = 22 days; medium value = about 18 days.

multiply the length of a sample route by the effective strip-width, for which we have a preliminary value of about 3.5 m (Fig. 3). Seasonal variations in defecation rates force us either to make all counts in the field during the same month or to make adjustments by calculation. Using observations collected by interviewing

local residents, we obtained a peak of frequency of scat finds in October for the wild bears in the Trentino region (Roth and Huber 1972). These figures were corrected for a hunter bias (hunting season unduly increases the fall peak) and were then standardized by placing the average of the 2 peak months (September and October) equal to unity. We get the following values, which can be interpreted as relative probabilities (expected frequencies) of finding bear scats in the Trentino (January to December): 0, 0, 0, 0.1, 0.4, 0.2, 0.3, 0.4, 0.9, 1.1, 0.3, 0. The numbers of kilometers walked each month in 1969 were multiplied by the factor for the corresponding month, giving the number of September-October km equivalents. Summing over the whole year of 1969 yields 164 September-October km equivalents (real km = 397), which, through multiplication by the  $3.5 \cdot 10^{-3}$  km of effective strip-width, results in an estimate of  $a = 0.57 \text{ km}^2$  September-October equivalents (real  $a$  searched =  $1.4 \text{ km}^2$ ).

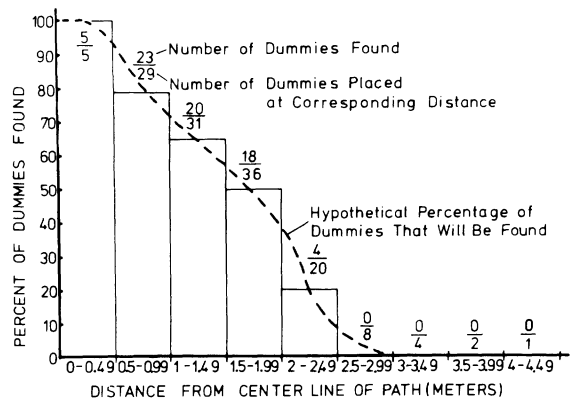


Fig. 3. Rate of success of finding bear scat dummies as a function of the perpendicular distance from center line of path. The dummies were 11 black-painted round pieces of wood, 6.5-15.5 cm long and 3.0-4.5 cm in diameter, used in 14 trials for a total of 136 placements. The test path was walked with field-average attention after dummies were roughly placed (pacing) by another person using 3 random numbers (location along route, distance from path, and left-right of path according to uneven-even). The exact distances from the center line of the path were measured after the trial. Graphical integration of a plausible smooth curve yielded a half-width of a hypothetical strip within which all dummies would be found and which would produce the same number of finds (at same dummy density) of 1.585 m (strip-width = 3.17m). Some measurements in the field when scats were found indicated somewhat higher values, which put our rough estimate of strip-width at 3.5m.

Analogous to the standardizing procedure used to calculate  $a$ , we take for the defecation rate  $d$  the average of the 2 months with highest values (August and September, Fig. 1; captivity could have easily shifted the annual cycle 1 month), which is 5.9 scats per bear-day. In 1969 I made 12 scat finds along the 397 km walked. Not included in these figures are the finds and

the routes walked while purposely searching specific areas selected on the basis of recent bear or bear-sign observations made by other persons. Also, to avoid undue variance (which ideally should not exceed that of a Poisson distribution), only the *first* observation of a *clump* in space and time was considered. According to the bear density in the Trentino, a clump was defined as any 2 or more scat finds that were less than 1 km apart and were made within a month's time. So we have  $s = 12$  scats,  $t = 18$  days,  $a = 0.57$  km<sup>2</sup> September-October equivalents (real km<sup>2</sup> = 1.4), and  $d = 5.9$  scats/bear day. We calculate a density of about 20 bears per 100 km<sup>2</sup> (rough 95 percent confidence interval: 11-36). Using the real  $a$  of 1.4 km<sup>2</sup> and the average defecation rate for April-November of 3.4 scats/bear-day, we get a density estimate of 14 bears per 100 km<sup>2</sup>. These density figures are much higher than estimates based on direct counts using sightings, tracks, etc., and on comparing frequencies of observations from the

Trentino with those of other areas, which give seemingly more reasonable values of 2-4 bears per 100 km<sup>2</sup>.

One of the reasons for the too-high estimate of bear density could be a considerably higher defecation rate of wild bears. Zunino (1971) observed a wild bear feeding on berries in the Abruzzo mountains of central Italy during 1 day (24 hours?) and counted 15 defecations. Also, some of our data from Yugoslavia indicate a higher defecation rate by wild bears. It is hoped that more direct measurements of defecation rates of free-roaming animals will become available through the use of radiotelemetry.

In summary, we are still very far from having a satisfactory method of estimating bear densities by counting scats. But the defecation data presented here may give some insight into possible correlations (month, age, sex) and variabilities (individuals) that are likely to be found — probably to an even larger extent in wild bear populations — on the way to this goal.

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