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Use of dawn and dusk sight observations to determine colony size and family composition in Eurasian beaver *Castor fiber*

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The methods used to determine family composition and colony size in Eurasian beaver *Castor fiber* Linnaeus, 1758 are often poorly described in published reports. Here we show how repeated counts of colony size in a random sample of colonies (n = 19) varied between dusk and dawn, between the months of August and September, and following successive counts. Mean counts at dusk and the following dawn did not vary significantly, though mean colony size was significantly greater in August than September. However, because all colony members are rarely seen during a single dusk or dawn count, successive counts often provided new information about the maximum number in each age class. This allowed us to adjust colony size following each count using the largest values thus far obtained, with the result that the mean adjusted colony size increased during six successive counts over seven weeks from 2.4 to 3.8. Family composition based on information from all six counts was 54% adults, 26% yearlings and 19% kits. Evidence suggests that kits in particular are undercounted by this method. Figures for colony size and composition in beaver should be viewed with caution if not obtained by methods tested for both precision and accuracy.

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Introduction

The Eurasian beaver *Castor fiber* Linnaeus, 1758 is monogamous (Kleiman 1977, Dunbar 1984) and primarily nocturnal (Wilsson 1971). Family groups defend shoreline territories and the beaver social group is commonly called a colony, regardless of the fact that it does not fit the precise sociobiological definition of a colony (Wilson 1975). Modern, quantitative studies have documented the beaver social unit as being a family group consisting of an adult pair, kits, yearlings and sometimes two-year-olds (Wilsson 1971, Djoshkin and Safonov 1972). Single animals may also defend a territory, and in such instances constitute a colony. Normally, subadults will stay in the natal colony for two winters and disperse at the age of two years (Wilsson 1971, Hartman 1997).

Three methods of assessing the size and composition of individual colonies are complete removal dead-trapping, mark and release live-trapping, and nocturnal censuses conducted using night-vision binoculars. Removal trapping probably provides the best estimate of colony size and composition (Hay 1958) but is labor intensive and sacrifices animals, thereby disrupting population structure. Live-trapping in conjunction with mark-recapture observations can provide a complete census (Busher *et al.* 1983) but is time-consuming and therefore less suitable for population-level studies. Others have used night-vision optics to survey North American beaver *C. canadensis* colonies (Svendsen 1980, Easter-Pilcher 1990, Osmundsen and Buskirk 1993, McTaggart and Nelson 2003). Easter-Pilcher (1990) reported that she was able to distinguish kits, yearlings and adults using night-vision scopes, but McTaggart and Nelson (2003) were not confident assigning ages to beavers observed at night. Environmental conditions such as wind and ice made viewing swimming beavers very difficult, especially under a tree canopy. Night-vison optics were most effective in areas with little canopy and during brighter phases of the moon. Although the night-vision equipment did not perform well enough to confidently assign individuals to age classes, the correlation between the number of beavers observed and the number present (estimated by removal trapping) in each colony suggests that periodic censuses of random colonies may provide a useful method (McTaggart and Nelson 2003).

An alternative method is sight observations conducted during the dim light of dawn or dusk. Sight observations generally require less effort than trapping and also maintain intact colonies. Numerous authors have employed this method when conducting experimental studies on chemical communication (Müller-Schwarze and Houlihan 1991, Schulte 1993, 1998, Sun 1996, Sun and Müller-Schwarze 1997, Rosell *et al*. 1998, Rosell and Bjørkøyli 2002, Rosell and Steifetten 2004) or when studying other forms of beaver behaviour (Hodgdon and Larson 1973, Brady and Svendsen 1981, Busher 1983, Buech 1985, 1995).

Despite numerous reports of colony size and family composition in populations of Eurasian beaver in the published literature, the methods employed to obtain these data are often lacking and at best poorly described (Heidecke 1984, Tyurnin 1984, Rosell and Parker 1995, Brozdnyakov *et al.* 1997). Thus reliable information on colony size and family composition for this species is rare (Rosell and Parker 1995), despite its importance for population studies and beaver management. Replicated counts of beavers at colony sites during dawn and dusk has potential for obtaining counts or indexes of colony size (Semyonoff 1957, Rosell 1994, Kile and Nakken 1995), particularly at more northerly latitudes where twilight conditions of late summer considerably extend the light period available for observation. The method is also less time consuming and disruptive than complete dead-trapping or capture-mark methods, and provides a much wider field of view than the use of night-vision optics.

Beaver kits first emerge from the lodge approximately 1–2 months after birth (Wilsson 1971), which for most litters in southeastern Norway is before the end of July (Parker and Rosell 2001, pers. obs.). Thus counts can potentially be made during August and September before the start of the Norwegian hunting season on October 1. The aim of this study was therefore to determine how repeated counts of colony size in a random sample of colonies varied between the months of August and September, and between dawn and dusk, in order to evaluate which of these periods might be most suitable for obtaining reliable results. We also provide figures for family composition in a stable population of Eurasian beaver in boreal forest habitat of which there are presently few examples in the literature.

Material and methods

Field study

The study was carried out in 1995 in Bø Township, Telemark County, southeastern Norway (59°29'N, 9°13'E) situated in the southern boreal forest region of Fennoscandia (Parker *et al.* 2002a). Beaver repopulated the township in the 1920s (Olstad 1937) and densities have been relatively stable since the 1970s. Prior to the study, hunting pressure had been light and loss from large mammalian predators almost non-existent.

The selection of colonies used for sight observations were based on a previous survey by Johnsen and Kaasa (1991) who located active beaver colonies dispersed over 53 1 km^2 grids on a 1:50 000 map. These grids were surveyed by ground reconnaissance between 15–31 July 1995, and 34 active beaver colonies were found. Criteria used to decide if the colony was active were recent maintenance of lodges and dams, freshly cut woody vegetation, remains of freshly browsed vegetation, recently used channels and paths, and fresh footprints and scent marks. Of these 34 colonies we randomly selected 19 for the study; 3 of these were on streams (10 m wide), 7 on rivers (> 10 m wide), 7 on ponds (< 500 m wide at the widest) and 2 on lakes (> 500 wide at the widest).

Beavers were counted from 1 August – 30 September. Sight observations during evenings were initiated approximately 4 hours before dusk and terminated when it got too dark to see. A new count was initiated the following morning starting with the return of sufficient light and continued for 4 hours. During the night, observers either slept in a tent nearby or walked out and then back in the pre-dawn darkness for the morning observation.

During August we made one set of dusk-dawn observations at each colony between 1–16 August (Dusk 1 and Dawn 1) and a second between 17–31 August (Dusk 2 and Dawn 2). For September only dusk observations were made, one between 1–15 September (Dusk 3) and a second between 16–30 September (Dusk 4). Dawn observations were terminated in September because preliminary results from August showed no significant difference between dusk and dawn counts, and because dawn observations were more difficult to conduct. Thus a total of six observations were made for each colony. We differentiated between August and September observations in order to divide the potential observation period into 2 equal time periods, but also because changing day length, the increased age of kits and the onset of the food-caching period (Parker *et al.* 2002b) might be expected to affect beaver behaviour, and therefore their observability.

We counted beaver as they emerged from the lodge or swam around the visible area near the lodge. We used one observer per site and the same observer made all six observations for a colony. Observations were done either from land or a canoe and were conducted with high quality, light-sensitive binoculars (8 56) from down-wind sites that provided good visibility. Observation from a canoe was often an advantage on larger bodies of water as the observation point coud be quietly moved without disturbing animals. The aim was to record all individual beaver in each age class seen during each dusk or dawn count. This is usually difficult as colony members rarely appear together as a group. Thus only animals positively identified as different were tallied to avoid overestimations. Animals were classified as kits, yearlings (15–16 months), or adults (> 27 months) based on differences in body and tail size (Townsend 1953, Patric and Webb 1960, Jackson 1991, Parker *et al.* 2001). Kits from the same population in August and September normally weigh 2–4 kg and are readily distinguishable from the other two age groups. Most yearlings at this time weigh 8–14 kg and most adults 15–25 kg (F. Rosell, unpubl.). Consequently, kits are rarely misclassified, though yearlings and adults may occasionally be confused, particularly in poor light. Thus the six observational periods at each colony provided six different counts for each age class. By selecting the largest value observed for each age class after each successive count, including values from previous counts, we were able to calculate what we termed an adjusted colony size following each count. The largest value among the six for each age class was used to calculate the final adjusted colony size. Colonies were also categorized as single, pair, or family (3 individuals) units (Gunson 1970, Payne 1982).

Data analyses

The data did not fit assumptions of distribution and homogeneity of variance for parametric analysis (Sokal and Rohlf 1995) and we therefore used nonparametric statistics in accordance with Siegel and Castellan (1988). We used a Wilcoxon's matched-pairs signed-ranks test to check for differences in colony size between dusk and dawn, and between August and September. We used a Friedman's test for within-subject effects (related samples) to test for differences between median adjusted colony sizes for counts one through six (Siegel and Castellan 1988). Tied observations were dropped from the analyses (Siegel and Castellan 1988). Linear regression was used to test for correlation between mean age class size and count sequence. For this analysis we used only the 4 dusk counts as they were spaced at 2-week intervals throughout the study period. All tests were two-tailed and a probability level < 0.05 was considered significant. Mean values are shown with standard deviations. Statistical analyses were performed with the statistical package SPSS version 12.0.

Results

Mean colony size did not differ significantly between Dusk 1 and Dawn 1 in early August ($\bar{x}$ = 2.4 ± 1.3 and 2.5 ± 1.7 respectively, $Z = -0.7$, $p = 0.548$, $n = 12$) nor between Dusk 2 and Dawn 2 in late August ($\bar{x}$ = 2.0 ± 1.3 and 2.0 ± 1.3, respectively). In contrast, the mean dusk count for August (Dusk 1 and Dusk 2 pooled, $\bar{x}$ = 2.2 ± 1.3) was significantly greater than the corresponding mean dusk count for September (Dusk 3 and Dusk 4 pooled, $\bar{x}$ = 1.6 ± 1.4) ($Z = -2.3$, $p = 0.020$, $n = 31$). This decline was primarily a result of a fall in the mean number of adult beaver observed from early August to late September (Fig. 1). The mean adjusted colony size increased with each successive count (1 to 6) from 2.4 to 3.8 (χ^2 = 48.9, df = 5, $p < 0.001$) (Table 1).

The final mean adjusted colony size for the 19 colonies based on all six counts was 3.8 ± 1.8. Thirty-nine (54.2%) of the 72 individual beaver observed were adults, 19 (26.4%) were yearlings, and 14 (19.4%) were kits. Fourteen (73.7%) of the 19 colonies were families, 3 (15.8%) were pairs, and 2 (10.5%) were singles. No kits were observed in 12 (63%) of the 19 colonies and 4 colonies (21.1%) had more than 2 adults. In 5 colonies we observed only one adult, though kits were observed in one of these. Three of the remaining 4 contained yearlings and 1 was a single adult.

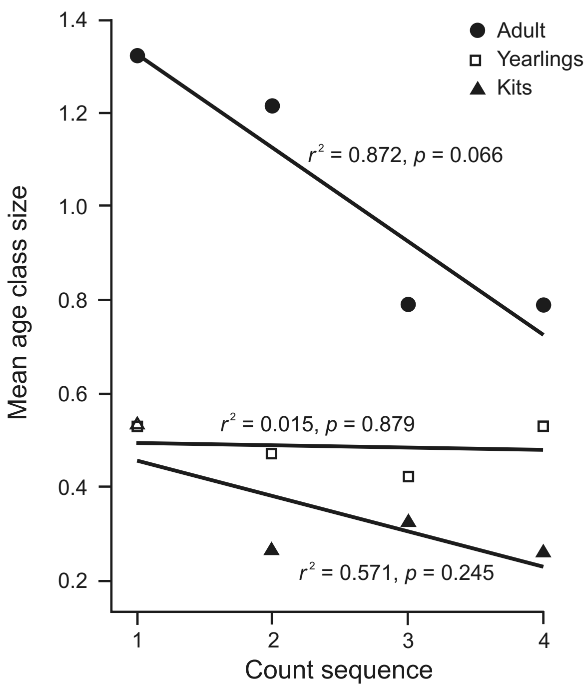

Fig. 1. Regression of the mean age class size on count sequence for adult, yearling and kit beaver. The 4 dawn counts were conducted at 2-week intervals at 19 occupied colonies in Bø Township, southeastern Norway from 1 August to 30 September, 1995.

Table 1. Mean adjusted colony size[a] after six consecutive dawn and dusk counts conducted at 19 occupied beaver colonies in Bø Township, southeastern Norway from 1 August to 30 September, 1995. [a]See Material and methods for definition of mean adjusted colony size.

Count	Mean ± standard deviation	Median	Range
1	2.4 ± 1.3	2	0–5
2	3.0 ± 1.6	3	1–6
3	3.1 ± 1.5	3	1–6
4	3.3 ± 1.6	3	1–6
5	3.5 ± 1.8	4	1–6
6	3.8 ± 1.8	4	1–7

Discussion

The mean values for consecutive dusk and dawn counts did not vary significantly. Dusk counts however are more convenient to conduct as observers can approach and select an observation post in good light before beaver leave the lodge in the evening. In contrast, both approaching and selecting an observation post in the dark before dawn and spending the night near the colony are logistically more demanding.

Mean colony size was significantly greater in August than September. Assuming no mortality during this period, this could possibly have resulted because the light available for observation at dawn and dusk decreased as autumn approached, thereby reducing observability. For reasons unknown, this seems to have affected the observability of adults more than yearlings and kits.

The mean adjusted colony size increased with each successive count. Because all members of a family are rarely observed outside the lodge at the same time, repeated observations will often give different values for the number in each age class. The adjusted mean calculated after each count is then based on the maximum values obtained up to that point. As the adjusted mean for the 19 colonies increased gradually after each count, with no apparent sign of abate, this suggests that further counts would have led to even greater increases. Because there was no means of obtaining the true mean colony size and composition, we do not know how many counts would have been necessary to obtain an accurate estimate of this. It is also conceivable that our adjusted mean after six counts was, in fact, an over-estimate of the true mean. However, our results were in accordance with the average colony size commonly used for estimating population size in the Nordic countries (Rosell and Parker 1995). A review of 13 Eurasian studies on colony size by Rosell and Parker (1995) revealed a mean value of 3.8 ± 1.0 SD (range 2.4–5.5).

Kile and Nakken (1995) counted colony size and composition in 31 randomly selected colonies in an adjacent population in southeast Norway between 28 July – 11 August, but conducted only one dawn or dusk sight observation per colony. They arrived at a mean colony size of 2.1, ie similar to our value of 2.4 after one count. Our results would suggest that their census gave an underestimate.

Our family composition results were in accordance with Kile and Nakken (1995) and Parker *et al.* (2002a) [beavers shot (n = 126) during March–May 1997–1999 in Bø Township]. They found 54% adults, 26% yearlings and 20% kits, and 64% adults, 22% 2 year olds and 14% juveniles, respectively. However, our results from 1995 showed a low mean litter size (0.7) compared with results of foetus counts (2.3) for the same population in Bø Township 2–4 years later (Parker and Rosell 2001). Unfortunately, to our knowledge, no studies have been conducted on the mortality of beaver kits prior to leaving the lodge.

A possible explanation for the low mean litter size reported here may be that many kits did not leave the lodge until after total darkness. This suggestion is partly supported by the greater colony size observed in August than in September, as total darkness occurs earlier in September. Similarily, during a study in the Netherlands the first author was able to observe four and five kits inside two different lodges in the Netherlands during the end of May. However, only once after numerous dusk and dawn observations did he manage to observe all five kits outside the one lodge in August, and was never able to observe all four kits outside of the other lodge.

There is a distinct need to test the accuracy and precision of both the method described here and other population estimation techniques for beaver against what appears to be the current most accurate colony counting methods, i.e. total dead-trapping of all colony members (eg Hay 1958) and multiple counts of colonies of marked individuals (eg Schulte 1993, Sun 1996). This might be accomplished in conjunction with the removal of nuisance colonies or population studies involving marked individuals (eg Busher *et al.* 1983, Novak 1987).

In conclusion, autumn counts of beaver at dawn or dusk should provide a relatively low-cost index of colony size and composition, and following adequate tests of accuracy and precision, the method might be modified to properly estimate these parameters. Published accounts of colony size and composition in beaver in the absence of a proper description of the methods employed to gather this data should be viewed with caution.

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