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Original Investigation

Efficiency of scat-analysis lab procedures for bear dietary studies: The case of the Apennine brown bear

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ABSTRACT

Bear food habits are often quantified using scat analysis, mainly due to its non-invasiveness and because samples are relatively easy to collect. However, lab processing time can be daunting and may end up competing with other field activities. Sub-sampling a bear scat to analyze its contents may reduce the lab processing time, but the number of subsamples per scat is usually chosen arbitrarily. We investigated the effect of the number of subsamples per bear scat on the estimatation of the diet composition of the Apennine brown bear in the Abruzzo Lazio and Molise National Park. Based on a sample of 328 bear scats collected in 2006, and from 5 to 1 subsamples (10 ml) per scat, dietary analysis showed qualitative and quantitative stability at a decreasing number of subsamples, and only food items of negligible importance were occasionally missed using 1–2 subsamples per scat. We concluded that 2 subsamples can be used without significant loss in accuracy, corresponding to a 60% reduction in lab time, and to more than 50 days of lab work for one operator to process our entire bear scat sample. By assessing the effect of sub-sampling a bear scat for dietary analysis, we also present preliminary data on the seasonal food habits of the Apennine brown bear population.

Introduction

Bear diet analysis can be conducted using different techniques such as stomach content analysis (e.g., Sato et al. 2000), scat analysis (e.g., Mattson et al. 1991; Craighead et al. 1995; McLellan and Hovey 1995; Dahle et al. 1998; Naves et al. 2006) and stable isotopes analysis (e.g., Hobson et al. 2000; Felicetti et al. 2003). Scats analysis is a widely used technique to investigate food habits of brown bears, mostly due to its non-invasiveness and practicality in obtaining large sample sizes. On the other hand, the lab time required for processing (hand separation, measurement and identification of food remains) large samples of scats can be prohibitively long (Ciucci et al. 2004), a problem particularly relevant for brown bear scats, whose wet volumes can measure up to more than 1800 ml (Dahle et al. 1998). Conversely, reducing lab time required per individual scat could eventually allow to analyze larger samples, as opposed to often deficient data when breaking down the sample to seasons, elevations, or management units. In bear studies, this problem has generally been circumvented by analyzing only a fragment (subsample) of each scat, though number and volume of subsamples are arbitrarily chosen, usually ranging from 2 to 5 subsamples of 6–100 ml each (Hamer and Herrero 1987; Hamer et al. 1991; Raine and Kansas 1990; Dahle et al. 1998; Mac Hutchon and Wellwood 2003). Subjective choice of subsamples rests on the assumption that food item-remains in the subsample qualitatively and quantitatively reflect those in the whole scat (e.g., Hamer and Herrero 1987; Hamer et al. 1991; Dahle et al. 1998; Persson et al. 2001; Mac Hutchon and Wellwood 2003). However, neglecting formal measures of sampling variability, or its effect on diet quantification, does not allow a formal assessment of optimal sub-sampling criteria for a given diet composition.

Food habits of the Apennine brown bear (*Ursus arctos masricanus*) have been studied little (Zunino and Herrero 1972). Within a broader ecological study on this bear population we used scat analysis as a complementary technique to investigate dietary ecology of bears inhabiting the Abruzzo Lazio and Molise National Park (PNALM). In doing so, we were interested in assessing the optimal sub-sampling procedure to process each scat in the lab, with the aim to save laboratory time while providing an unbiased representation of the scat content. In particular, using 373 bear scats collected in 2006, and subsamples of 10-ml from each scat (Hamer and Herrero 1987; Mac Hutchon and Wellwood 2003), we compared diet composition based on a decreasing number of subsamples (from 5 to 1), drawing conclusions in terms of cost/benefit analysis (i.e., potential sub-sampling bias/reduction in processing time). In this paper, by discussing the general implications of our findings for bear food-habit studies, we also present preliminary information on the Apennine brown bear diet.

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Material and methods

Bear scats were systematically collected from June to December 2006 in the Abruzzo Lazio and Molise National Park, central Italy, where a remnant population of about 40 individuals survives (Ciucci and Boitani 2008; Gervasi et al. 2008). Scats were collected along bear trails and pastures throughout the study area at 1–2-week intervals, and only fresh and unweathered scats were collected. To reduce autocorrelation among scats harvested at the same site, we adopted the quantitative criteria of Dahle et al. (1998), unless scat content was visually deemed to be different (Mattson et al. 1991). Scats were collected in nylon bags and frozen (−20 °C) until analyzed. Lab processing involved washing the whole scat through 0.8 mm- and 0.1 mm-mesh sieves (Elgmork and Kaasa 1992; Dahle et al. 1998; Persson et al. 2001; Große et al. 2003) in order to retain the smallest items (i.e., insects, seeds). Once washed, we thoroughly mixed the scat content to obtain an even distribution of all items, and selected five 10-ml subsamples from different portions of the entire scat (Hamer and Herrero 1987; Mac Hutchon and Wellwood 2003). For each subsample, we separated all items by hand, and identified them at the highest taxonomic (e.g., ants) and/or structural (e.g., graminoid vs forbs) resolution attainable using 7–30× stereoscope and 40–360× microscope (Dahle et al. 1998; Persson et al. 2001). With the aid of a reference grid, we then estimated the relative volume of different items by assigning them to one of the following volumetric classes (0–1%, 2–5%, 6–25%, 26–50%, 51–75%, 76–95%, 96–100%; Mace and Jonkel 1986; Dahle et al. 1998), whose midpoints were then used for volumetric quantifications. We quantified diet composition using Frequency of Occurrence (FO; number of scats with a given food item/total number of scats) and Fecal Volume (FV; cumulative volume for a given food item/total number of scats) (Dahle et al. 1998; Hashimoto et al. 2003). Although FV was computed to allow correction for differential digestibility (see below), for statistical testing we expressed volumetric data as mean percent volume (Vm; cumulative volume of a given food item/number of scats containing the item). We also measured, to the nearest minute, the time required for each phase of scat processing in the lab (i.e., washing, hand separation, identification, quantification).

To assess the effect of a decreasing number of subsamples per scat on the overall diet quantification, we first quantified diet composition based on 5 subsamples per scat for all scats (reference sub-sampling scheme). We used presence/absence and percent volume for each item across subsamples to compute FO and FV values for the entire sample of scats. We then repeated the process randomly selecting a decreasing number of subsamples per scat (i.e., 4, 3, 2, 1; reduced sub-sampling schemes), and tested concordance, both for FO and FV values, between the reference and the reduced sub-sampling schemes using non-parametric pair-wise correlation. To further investigate direction and extent of discrepancies between sub-sampling regimes for the different items in the diet, we pair-wise regressed percent volume values obtained from each reduced sub-sampling scheme on those obtained from the reference sub-sampling, forcing the models through the origin and testing (*t*-test) for regression coefficients different from 1 (Sato et al. 2000). Similarly, we used contingency tables and chi-square analysis to compare frequency values of the main item categories between reference and reduced sub-sampling schemes.

By using 5 subsamples per scat, we quantified the overall bear diet in the PNALM according to the FO and FV values. Using correction factors developed by Hewitt and Robbins (1996; CF_1, Table 1), we corrected FV values to account for differential digestibility (Estimated Dietary Content, EDC); in turn, multiplying EDC values by correction factors calculated by Pritchard and Robbins (1990) and Dahle et al. (1998) (CF_2; Table 1), we expressed dietary content in terms of energetic intake (Estimated Dietary Energetic Content, EDEC). For ungulates, we chose the correction factor proposed by Mealey (1980), which refers to a 50:50 consumption of hair and skin versus meat.

We defined three dietary seasons (early summer: June–July; late summer: August–September; fall: October–December), and

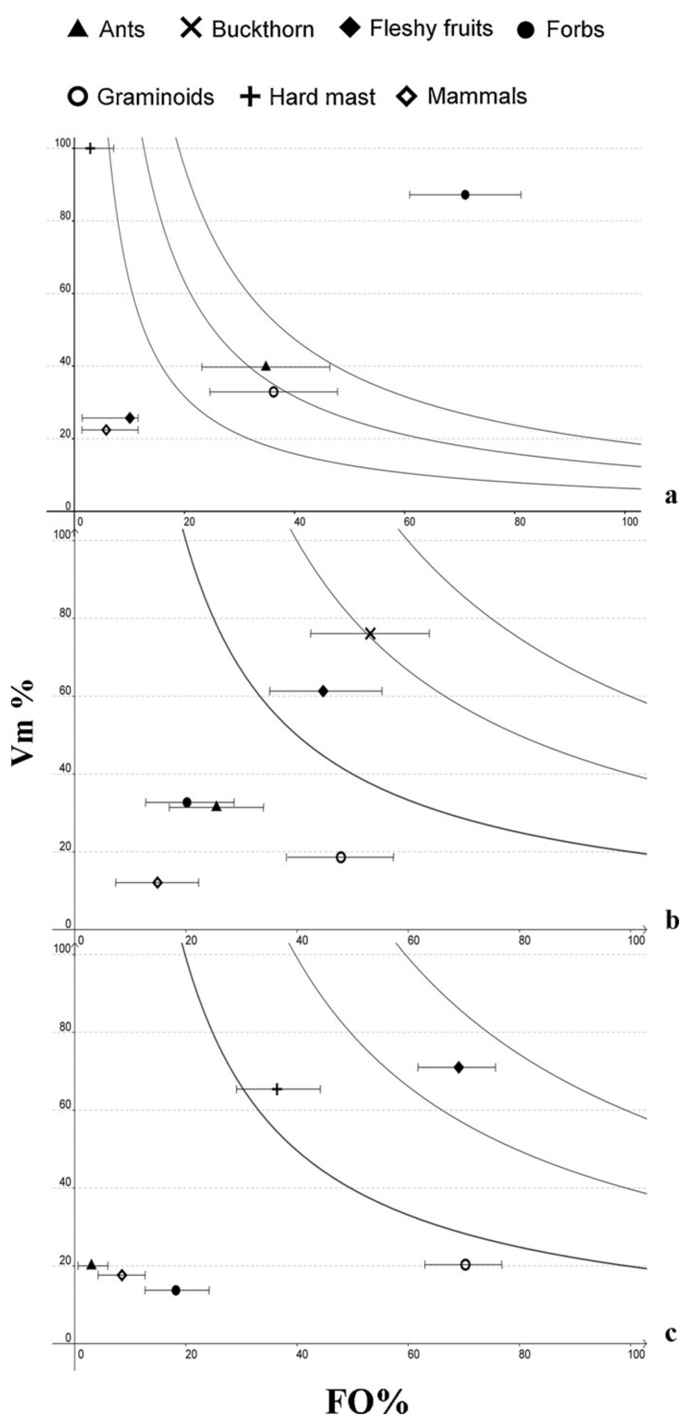

Fig. 1. Relative contribution, in terms of Frequency of Occurrence (FO) and mean percent volume (Vm), of the main food items in the diet of the Apennine brown bear in early summer (a), late summer (b), and fall (c), as from the analysis of 328 bear scats collected from June – December 2006 in the Abruzzo Lazio and Molise National Park, Italy. For each food item, horizontal bars represent the bootstrapped 95% confidence interval around FO values. Lines connecting equal FO × Vm values (isophlets) demarcate, from the upper right of each panel, the upper 25%, 50% and 75% of the seasonal diet.