



Estimating Biomass of Berries Consumed by Gray Wolves

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ABSTRACT Gray wolves (*Canis lupus*) consume berries and other wild fruits seasonally when available or abundant. However, a method to convert percent frequency of occurrence or percent volume of berries in wolf scats to percent biomass has not yet been developed. We used estimates of the average number of blueberry (*Vaccinium* spp.) seeds in 10 individual wolf scats collected in and adjacent to Voyageurs National Park, Minnesota, USA, along with published values of the number of seeds per blueberry and blueberry masses to estimate that a wolf scat containing only berries equated to an average of 0.468 kg of berries consumed. We recommend using this berry conversion factor (0.468 kg/scat) to convert the percent frequency of occurrence or percent volume of berries and other wild fruits to percent biomass when estimating wolf diets from scats. © 2017 The Wildlife Society.

KEY WORDS *Canis lupus*, correction factor, fruits, scat analysis, wolf diet.

Wolves (*Canis lupus*) are carnivorous mammals that feed primarily on ungulates and other prey species such as beavers (*Castor* spp.) or hares (*Lepus* spp.; Newsome et al. 2016). Wolves are opportunists, however, and will take advantage of other food sources such as human garbage, flightless molting birds, and spawning salmon (*Oncorhynchus* spp.) when available (Szepanski et al. 1999, Peterson and Ciucci 2003, Wiebe et al. 2009). Wolves also consume fruits such as wild blueberries (*Vaccinium* spp.) and raspberries (*Rubus* spp.) when these fruits are abundant. In areas where berry consumption occurs, berries typically constitute a minor (<10% frequency) portion of the summer diet (Messier and Crête 1985). However, in some areas, berries can be a significant summer food item for wolves. Berries (primarily blueberries) constituted 10–30% (frequency) of the diet of wolves from 1 June to 15 September in southern Quebec, Canada (Tremblay et al. 2001). Similarly, vegetation (primarily berries) occurred in 52% of scats collected at home sites in July and 20% of scats collected on trails in August and September in north-central Minnesota, USA (Fuller 1989). In Voyageurs National Park, Minnesota, berries constituted 30–50% (volume) of wolf diets in July and August 2015 (T. D. Gable, personal observation). Though berries can be an important summer food for wolves in boreal systems, the percent biomass of wolf diets composed of berries is largely unknown.

Percent frequency of occurrence or percent volume of a particular species in wolf scats does not always equate to percent biomass consumed of that species because smaller

prey have a larger proportion of indigestible material than larger prey. The following equation (Weaver 1993) has been used to correct for this bias and convert percent frequency of occurrence or percent volume of mammalian prey to percent biomass:

$$\hat{Y} = 0.439 + 0.008 \times X \quad (1)$$

where X is the average live mass of a prey species and \hat{Y} is the prey mass per scat. The biomass of each prey species in the wolf diet is determined by multiplying the prey mass per scat by the proportion (based on volume or frequency) of that species in the diet. The percent biomass of each prey species is determined by dividing the biomass value of each prey species by the summation of all biomass consumed and multiplying by 100.

However, Weaver's equation is not applicable to nonmammalian food items. Diet correction factors are generally determined by feeding captive animals a known mass (or volume) of food and measuring the mass (or volume) of fecal material produced (e.g., Hewitt and Robbins 1996) or counting the number of collectible scats produced (e.g., Floyd et al. 1978). Such work has not been done for wolves and berries, and digestibility of soft fruits by wolves is unknown. Therefore, a method to convert percent frequency of occurrence or percent volume of berries in wolf diets to percent biomass of berries consumed needs to be developed to better understand the contribution of berries and other fruits to the diet of wolves. Wild fruits contain seeds that cannot be digested by wolves; therefore, the biomass of ingested fruits can be estimated based on the number of seeds that pass in fecal material. Thus, our objective was to develop a conversion factor to convert the percent frequency of occurrence or percent volume of berries in wolf diet to percent biomass by estimating

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the mass of blueberries consumed to produce one scat. Use of this conversion factor should reduce overestimation of the percent biomass of mammalian prey species in wolf diets where berry consumption is high.

METHODS

As part of a larger study of wolf diets in and around Voyageurs National Park, Minnesota (48°30'N, 93°00'W), we collected 557 wolf scats during July–August 2015 from 3 wolf packs with ≥ 1 wolf/pack fitted with a Global Positioning System (GPS) collar. Scats were collected on trails and logging roads, at home sites, and at clusters of GPS locations. We transferred individual scats to nylon stockings and sterilized them by boiling in water for >45 min. We then washed the scats in a washing machine and allowed them to air dry for >12 hr (Gable 2016).

To estimate the biomass of berries consumed, we randomly selected 10 out of 46 scats that contained only blueberries. We spread the contents of each cleaned scat over an 8×8 -cm grid so that the seeds were uniformly distributed across each grid cell. We then counted the number of seeds in one randomly selected grid cell. We estimated the total number of seeds in each scat by multiplying the number of seeds counted in one grid cell by the total number of grid cells (64), and then calculating an average number of seeds per scat. We estimated the number of blueberries consumed by dividing the average number of seeds per scat by the average number of seeds per blueberry (14.6 seeds/berry; based on 12 seeds/berry [Vander Kloet and Hill 1994] and 17.2 seeds/berry [Usui et al. 2005]). This value was multiplied by the average mass of a wild blueberry (0.335 g/berry; based on 0.300 [Welch et al. 1997] and 0.369 g [Usui et al. 1994]) to produce an estimate of the mean biomass of blueberries (the berry conversion factor) consumed per scat. Although we think that the estimates derived from the literature represent a broader sample of wild blueberries from across a larger geographical region, we wanted to evaluate how the mean mass of wild blueberries derived from Welch et al. (1997) and Usui et al. (1994) compared with those in our study area. To do so, we collected 2,000 individual blueberries from one location in our study site and divided by the total mass of the berries to derive an estimate of mass/berry.

RESULTS

We counted an average of 319 ± 93 (SD, range = 209–477) seeds/grid cell in the 10 scats examined, which was an average of $20,415 \pm 5,938$ (SD, range = 13,372–30,508) seeds per scat. Our minimum estimate of the biomass of blueberries consumed by wolves was 0.356 kg/scat based on 17.2 seeds/berry (Usui et al. 2005) and 0.300 g/berry (Welch et al. 1997). Our maximum estimate was 0.628 kg/scat based on 12 seeds/berry (Vander Kloet and Hill 1994) and 0.369 g/berry (Usui et al. 1994). Using combined averages of 14.6 seeds/berry and 0.335 g/berry, we estimated the berry conversion factor, which is the mean biomass of blueberries consumed per scat, to be 0.468 ± 0.136 kg/scat (SD, range = 0.306–0.699 kg/scat). Our estimate of mass of wild blueberries in our study area was 0.329 g/berry.

DISCUSSION

We recommend using our conversion factor of 0.468 kg/scat (prey mass per scat) to estimate the percent biomass of berries in wolf diet from percent frequency of occurrence or percent volume in wolf scats. For scats that are only partially composed of berries, the results can be scaled to the volumetric proportion of the scat that is berries (e.g., 50% of scat volume consisting of blueberries = 0.234 kg blueberries consumed). The estimated mass of a blueberry (0.329 g) in our study area was similar to the combined mean mass (0.335 g) that we used from literature values, though we acknowledge the limitations of this simple evaluation. Future studies that use our method could be improved by deriving local estimates of berry mass.

The contribution of berries relative to mammalian prey in summer wolf-diet biomass can now be examined because the prey mass per scat of both berries (using the berry conversion factor) and mammalian prey (using Weaver's [1993] equation) can be determined. However, percent biomass in the diet should not be confused with the energy derived from a prey source. For example, wild blueberries contain 0.51 kcal/g of energy, whereas ungulate prey contains 1.87 kcal/g (Usui et al. 1994, Peterson and Ciucci 2003). Wolves almost certainly cannot digest berries as efficiently as they can digest ungulate prey (Litvaitis and Mautz 1976). However, even if digestibility of berries is low, great abundance of berries on the landscape might make berries an important food source because berries can be acquired with little energy expenditure in the summer months when availability of mammalian prey is low (Tremblay et al. 2001).

In systems where berry consumption is high, use of the berry conversion factor could help reduce overestimation of the consumption of mammalian prey. Our conversion factor is most appropriately applied to gray wolves that consume blueberries. However, our conversion factor can also be applied to other fruits of similar size and digestibility (e.g., raspberries) that wolves may eat, because each scat should represent the same amount of food consumed. We caution against extrapolating our results to other canids because our results are based on individual wolf scats, which are larger than those of other canids. Thus, using the berry conversion factor for other canids would overestimate the biomass of berries consumed. Further, differences in the digestibility of berries by wolves and other canids are largely unknown and as a result, the mass of scat produced per berry consumed by other canids will likely be different from wolves. Additional research may improve the accuracy and precision of our berry conversion factor, especially for use in other regions where the types of soft fruits consumed by wolves may be different.

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