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Note

Canada Jay (*Perisoreus canadensis*) harvesting and caching fruits of Thin-leaved Snowberry (*Symphoricarpos albus*)

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Abstract

On 17 September 2021, we observed three Canada Jay (*Perisoreus canadensis*) harvesting and caching Thin-leaved Snowberry (*Symphoricarpos albus*) fruits in a mixed conifer forest in western Montana, USA. Thin-leaved Snowberry has not been reported previously in their diet. During 3 min of direct observation, each jay harvested snowberries similarly and cached them on the trunks of nearby pines. In each case (11 caches), the jay flew by the snowberry shrubs twice, plucking a fruit while airborne, landing on the ground between passes, the first fruit carried in the throat, the second in the bill. The jays then landed, most often out of view on tree trunks, but, nevertheless, appeared to cache the fruits each time. One cache observed in the making contained two harvested fruits wedged in a crevice on the trunk and covered with a flake of bark. Thin-leaved Snowberry is considered a low-quality fall-ripening fruit because of the small energy gain for each fruit consumed. Nevertheless, the energy density of snowberries (16.65 kJ/g dry mass) collected at the same location in October exceeded that required by non-migratory Canada Jays for daily maintenance during winter. It is unlikely jays could cache enough fruits each day to sustain them for several winter months. Instead, snowberries could be an important and readily available autumn and winter food for Canada Jays resident in this region when used to supplement other stored foods with greater energy, fat, and protein content.

Key words: Caching behaviour; Canada Jay; diet; energy density; foraging behaviour; fruits; Montana; *Perisoreus canadensis*; *Symphoricarpos albus*; Thin-leaved Snowberry

Canada Jay (*Perisoreus canadensis*) is a permanent year-round resident inhabiting boreal and montane coniferous forests in North America, although some local autumn movements have been reported (Bent 1946; Goodwin 1976; Strickland and Ouellet 2020). The strategies that Canada Jays employ for survival during winter differ substantially from those of birds that breed in the same coniferous forest habitats but migrate long distances to avoid harsh and food-limited conditions during the non-breeding season. Similar to many corvids, Canada Jays are omnivorous and opportunistic (Bent 1946; Goodwin 1976; Strickland and Ouellet 2020). They feed on arthropods, carrion, nestling birds, small mammals, fungi, a variety of human foods and waste, and berries. Classified as a scatter-hoarding species (Vander Wall 1990), jays cache large quantities of food in autumn and retrieve and consume it throughout winter when food is otherwise scarce. Caches are spread widely, typically above ground to avoid burial in snow, and contain only one or two items (at most, the contents of a single throat and bill load) in a sticky saliva-coated bolus (Strickland and Ouellet 2020; Swift *et al.* 2022). Although Canada Jays are frequently encountered in the mountains of western Montana, their biology and food habits in the state remain unstudied (Marks *et al.* 2016).

Thin-leaved Snowberry (*Symphoricarpos albus* (L.) S.F. Blake) is an open-canopy and understorey shrub widely distributed across Canada and the western United States (Lesica 2012) within the range of Canada Jays. It reaches ~1.5 m in height and produces numerous fleshy white fruits, which ripen in late summer and autumn; fruits may remain available on shrubs for several months (Martin *et. al.* 1951). The

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fruits of snowberry may at times be important autumn and winter food for some resident birds (Gabrielson 1924; Martin *et al.* 1951; Crawford *et al.* 1986), such as Dusky Grouse (*Dendragapus obscurus*) and Pine Grosbeak (*Pinicola enucleator*). Although considered low-quality food among bird-dispersed species (Stiles 1980), largely because the energy gain per fruit consumed is low, they have sometimes appeared in relatively large numbers in the stomachs of the mentioned species. Here we report opportunistic observations of a trio of Canada Jays harvesting and caching Thin-leaved Snowberry fruits during autumn in western Montana. We describe the behaviour of the jays while they collected and stored fruits, provide an assessment of the nutritional quality of the fruits harvested, and speculate on why Canada Jays would spend time and energy harvesting seemingly low-quality fruit.

On 17 September 2021, while P.H. hiked a road at the University of Montana's Lubrecht Experimental Forest, Missoula County, Montana, three Canada Jays suddenly appeared at 1020 Mountain Daylight Time about 10–15 m from him. Forest cover at the site (46.88898°N, 113.44490°W; 1276 m elevation) included Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco), Ponderosa Pine (*Pinus ponderosa* Douglas ex P. Lawson and C. Lawson), and Western Larch (*Larix occidentalis* Nuttall), in order of abundance, with numerous snowberry shrubs lining the road and in the adjacent understorey. At this season and location, snowberries were relatively abundant and the most-available fleshy fruit in the forest, and the three jays busied themselves with harvesting and caching snowberries. During the next 3 min, P.H. watched the jays with 10× binoculars, attention focussed on whichever bird was in view, as all appeared to be behaving similarly. The jays were spread over a linear distance of ~10 m.

Each jay harvested snowberries in a similar manner using a method apparently unreported previously (Bent 1946; Strickland Ouellet 2020). The first bird to appear flew through a low (0.5–0.6 m tall) patch of snowberries and plucked a fruit from one shrub while airborne, landed on the ground near the shrub, then flew with the first fruit carried in its throat and plucked a second fruit from a different shrub, again while airborne, and then flew with the second fruit grasped in its bill to the trunk of a pine about 4–5 m distant, where it was out of view ~1–2 m above ground. It appeared to cache the two fruits in the bark on the tree trunk because it departed from the pine without a fruit in the bill and the throat not enlarged. This behavioural sequence was observed multiple times for each bird before the three jays flew together into the forest and out of view. In every case observed (n = 11) the birds harvested only two fruits at a time (one carried in the throat, one in the bill) and cached the fruits on the trunks of pines within 2–8 m of where fruits were harvested. In some cases, it appeared that multiple caches were created on the same tree trunk by the same bird. Snowberries that the jays harvested appeared to be the largest ones (~8 mm × 10 mm in length and diameter); the wet weight of 20 fruits of this approximate size collected just after the jays departed was 4.3 g (~0.2 g each).

After the jays departed, P.H. attempted to locate some of the presumed caches, but was unsuccessful. Fortunately, he directly observed one jay creating a cache. What appeared to be both fruits were wedged into a vertical crack in the bark of the tree trunk (Figure 1) and covered with a flake of pine bark taken from the trunk while the jay remained clinging to the trunk at the cache site (Figure 2a); the cached fruits were coated with sticky saliva (Bock 1961; Dow 1965) on the lower part of the cache bolus (Figure 2b) to which the flake of bark was attached. This cache was 140 cm above ground in a pine with diameter at breast height (DBH) of 15.4 cm. Diameter at breast height for three of the apparent cache trees was 11.7 cm, 14.2 cm, and 16.3 cm. The cache was still present at 1220 the following day (18 September), 26 h after creation, but had been removed by the next check on 30 September.

Cache location on tree trunks, cache concealment with bark, and cache duration (<14 days) were consistent with findings for other fruits from elsewhere (Strickland and Ouellet 2020; Swift *et al.* 2022). Caching behaviour of Canada Jays is influenced by the potential for their caches to be pilfered by other resident species during periods of food scarcity (Dally *et al.* 2006), thus their need to spread caches widely, place them above ground in obscure sites and sometimes conceal them, which helps reduce the total amount of cached food lost if a few caches are pirated. Our observations of three Canada Jays openly caching in close proximity to each other are consistent with those of Burnell and Tomback (1985), who suggest cache pilferage is more likely by individuals of other species rather than conspecifics. Steller's Jay (*Cyanocitta stelleri*) routinely attempt to steal Canada Jay caches (Burnell and Tomback 1985) and are present throughout much of the range of Canada Jays, including western Montana (Marks *et al.* 2016); Canada Jays suppress or hide caching activity in the perceived presence of Steller's Jay or Blue Jay (*Cyanocitta cristata*; Burnell and Tomback 1985; Martin and Sherry 2021). Three Canada Jays harvesting and caching together in autumn suggests they were related (Strickland and Ouellet 2020) and not likely to steal each other's caches.

We wanted to determine energy content of the

FIGURE 1. Cache location (white circle) on the trunk of a Ponderosa Pine (*Pinus ponderosa*) made by a Canada Jay (*Perisoreus canadensis*) on 17 September 2021 at Lubrecht Experimental Forest, Missoula County, Montana USA. Cache is partly concealed by a flake of pine bark. Photo: P. Hendricks.

snowberries, because we have rarely observed birds feeding on snowberries. On 19 October 2021, P.H. collected fruits up to 0.5 km from the harvest and cache site of 17 September 2021, and S.S.P. analyzed them for energy density, crude fat, crude protein, and water content. Fruits were stored frozen at -20°C until analyses. They were dissected in aluminium trays to remove seeds (nine trays of 20 fruits), and the remaining pulp, juice, and skin were freeze-dried for 48 h (FreeZone Triad benchtop freeze dryer, Labconco, Kansas City, Missouri, USA). Water content (%) was determined by mass loss from dissected fruit trays after freeze-drying, averaged over all trays. Freeze-dried samples were homogenized and combined for further nutritional analysis. Percent dry mass of fat was determined by extracting ~1 g of dried sample in a fat extractor (Ankom XT-10, ANKOM Technology, Macedon, New York, USA) using petroleum ether (n = 3 trials; see Smith *et al.* 2015). Energy density (as kJ/g) was determined using ~1 g of dried pelleted sample combusted in a Parr 6100 bomb calorimeter and a Parr 1108 oxygen bomb vessel (Parr Instrument Company, Moline, Illinois, USA), and energy density was determined using a benzoic acid standard (n = 3 trials). Crude protein was determined using a modification of the micro-Kjeldahl analysis as described in Smith *et al.* (2015). Briefly, ~0.5 g of dried sample was digested and then distilled in a micro-Kjeldahl still (Labconco), then titrated against 0.01N HCl to calculate percentage nitrogen content, which was multiplied by a conversion factor of 4.4 (Witmer 1998) to obtain percentage protein content of the samples (n = 3 trials).

Thin-leaved Snowberry fruits from Montana were relatively low (mean ± SE) in energy density (16.65 ± 0.02 kJ/g dry mass), crude fat (0.99 ± 0.02% dry mass), crude protein (1.74 ± 0.01% dry mass), and high in water content (84.07 ± 0.17% wet mass) compared with many other native fall-ripening fruits consumed and disseminated by migratory birds (Stiles 1980; Smith *et al.* 2007, 2013, 2015; Cullen *et al.* 2020), some of which have energy densities exceeding 28.0 kJ/g dry mass, crude fat ranging from 6.0% to 49.0%, and crude protein usually exceeding 3.0%. Even low-quality fruits of some native fall-ripening boreal/low Arctic shrubs, such as bearberry (*Arctostaphylos*), crowberry (*Empetrum*), and blueberry (*Vaccinium*), which overwinter under snow and are important foods for migrant passerines when they first arrive on the breeding grounds in early summer (Norment and Fuller 1997), are generally of higher quality than Thin-leaved Snowberry fruit (Table 1). The

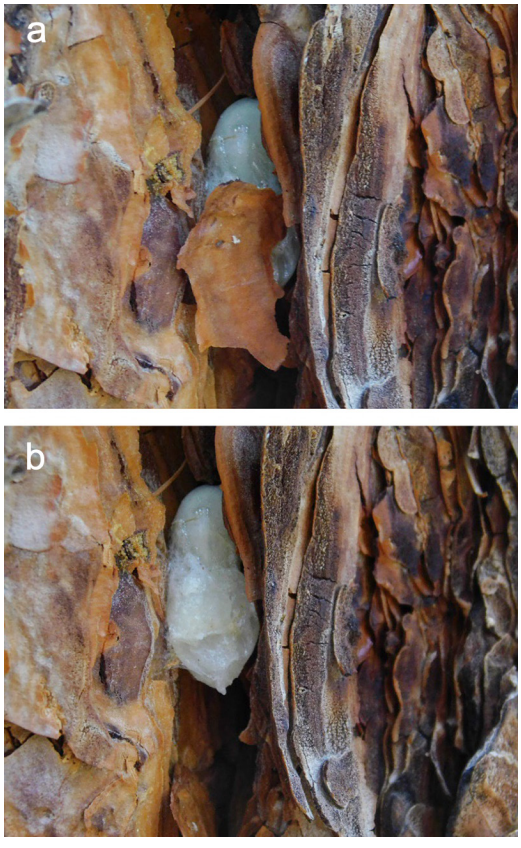

Figure 2. Closeup of the Canada Jay (*Perisoreus canadensis*) cache photographed in Figure 1, showing a. a flake of pine bark partly concealing the cache, and b. the flake removed to show the cached fruit of a Thin-leaved Snowberry (*Symphoricarpos albus*). The sticky saliva of the jay, to which the bark flake was attached, is visible coating the lower part of the cache bolus. Photos: P. Hendricks.

fruit quality of Thin-leaved Snowberry in Montana and New Jersey (Table 1; White 1989) was quite similar, indicating that the nutritional quality of snowberries is probably on the low end across its range. Further, fruit quality of Thin-leaved Snowberry is more similar to that of invasive non-native shrubs in eastern North America (Smith *et al.* 2013), with energy densities of ~16.3–17.2 kJ/g dry mass and crude fat content of ~0.5–1.0%.

A review of the published literature on fruits consumed by Canada Jays resulted in a list of at least 16 plant species in eight families (Table 1), typically harvested during late summer and autumn. At least some of these (e.g., *Arctostaphylos*, *Empetrum*, *Vaccinium,* native *Viburnum*; Norment and Fuller 1997; Smith *et al.* 2007, 2013) offer jays greater energy, fat, and protein rewards than Thin-leaved Snowberry. Neither Thin-leaved Snowberry nor any member of the genus *Symphoricarpos* appears to have been reported previously in the diet of Canada Jays. So, why would Canada Jays in Montana harvest and cache them?

Experimental evidence with artificial Canada Jay diets suggests that the energy density of Thin-leaved Snowberry fruits (16.65–17.43 kJ/g dry mass; Table 1) may be sufficient to meet maintenance energy targets of the jays (~15.97 kJ/g dry mass) during food-scarce periods (Martin *et al.* 2022) if the fruit is consumed in large quantities. Canada Jays require a daily energy intake of ~197 kJ (Shank 1986; Strickland and Ouellet 2020); thus, a jay would need to consume a minimum of 11.8 g dry mass of snowberries each day to meet daily energy needs, given an energy density of 16.6 kJ/g dry mass and without factoring in assimilation efficiency of snowberries by the jays. Average fresh weight of snowberries with seeds was ~0.2 g (20 fruits weighed 4.3 g), of which 84% was water and ~0.02 g was seed mass. Thus 1 g dry pulp mass of snowberries represents ~34 fruits, and ~404 fruits would be required to produce 197 kJ of energy. Even when snowberries are readily available and abundant for harvest and caching, as they were at the Montana site in September and October 2021 before being covered by winter snow, it is very unlikely that a Canada Jay could sustain itself through winter on a diet consisting largely of snowberries. It seems more probable that snowberries were harvested and cached by the jays because they were the most available fleshy fruits at the time and used to supplement other stored foods (e.g., meat, carrion, arthropods, fungi, other fruits) with higher energy, fat, and protein content, a conclusion analogous to that reached by Smith *et al.* (2007) on the needs of autumn migrant songbirds to consume insects as well as fruits to meet energy and protein requirements.

Author Contributions

Writing – Original Draft: P.H. and S.S.P.; Writing – Review & Editing: P.H. and S.S.P.; Investigation: P.H. and S.S.P.; Methodology: P.H. and S.S.P.; Formal Analysis: P.H. and S.S.P.

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TABLE 1. Fruits harvested by Canada Jay (*Perisoreus canadensis*). Mean nutritional values for native fruits are from localities other than where they were harvested by the jays.

Family	Species*	Energy, kJ/g dry mass†	% fat, dry mass (wet pulp)†	% protein, dry mass†
Anacardiaceae	Sumac (*Rhus*)[1]	26.18[d]	16.4[d]	2.4[d]
Caprifoliaceae	Elderberry (*Sambucus*)[1]	19.12[d]	4.9[d]	9.1[d]
	Thin-leaved Snowberry (*Symphoricarpos albus* (L.) S.F. Blake)[13]	17.43[d]	1.0[d]	2.6[d]
	Viburnum (*Viburnum*)[1]	27.40[c]	41.3[c]	2.6[c]
Elaeagnaceae	Soapberry (*Shepherdia canadensis* (L.) Nuttall)[9]		(1.7[b])	
Ericaceae	Bearberry (*Arctostaphylos*)[1, 10]	17.91[a]	3.1[a]	3.1[a]
	Black Crowberry (*Empetrum nigrum* L.)[6, 9]	18.90[a]	4.9[a]	2.5[a]
	Crowberry (*Empetrum*)[10]			
	Bog Bilberry (*Vaccinium uliginosum* L.)[9]		(6.0[b])	
	Mountain Cranberry (*Vaccinium vitis-idaea* L.)[9, 10]	16.38[a]	3.7[a]	2.5[a]
	Blueberry (*Vaccinium*)[3, 5, 8, 11]	17.51[d]	1.4[d]	3.3[d]
Liliaceae	Wild Lily-of-the-Valley (*Maianthemum canadense* Desfontaines)[8]		(1.4[b])	
	Solomon's Seal (*Maianthemum* (= *Smilacina*))[8]	20.12[d]	0.0[d]	3.0[d]
Rosaceae	Saskatoon (*Amelanchier alnifolia* (Nuttall) Nuttall ex Roemer)[12]			
	Serviceberry (*Amelanchier*)[2]	15.64[d]	1.2[d]	5.6[d]
	Chokecherry (*Prunus virginiana* L.)[7]	17.94[d]	0.7[d]	3.4[d]
	Arctic Raspberry (*Rubus arcticus* L.)[4]			
	American Mountain-ash (*Sorbus americana* Marshall)[5]	19.28[d]	1.7[d]	3.9[d]
Santalaceae	Northern Comandra (*Geocaulon lividum* (Richardson) Fernald)[9]		(1.1[b])	
Vitaceae	Virginia Creeper (*Parthenocissus quinquefolia* (L.) Planchon)[2]	22.30[c]	23.6[c]	6.0[c]

*Sources for fruits harvested by Canada Jays: 1. Bailey (1928), 2. Bent (1946), 3. Harper (1958), 4. Nelson (1983), 5. Ouellet (1970), 6. Preble (1908), 7. Rutter (1969), 8. Strickland and Ouellet (1993), 9. Swift *et al.* (2022), 10. Todd (1963), 11. Waite (1988), 12. P.H. pers. obs., and 13. this paper.
†Sources for fruit nutritional values: a. Norment and Fuller (1997), b. Traveset *et al*. (2004), c. Smith *et al.* (2007), and d. White (1989).

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