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The metabolizable energy of chicken scratch, the rhizomes of *Carex lyngbei*, and timothy grass to swans

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Introduction

The study reported here was undertaken as part of an investigation of the ecology of Trumpeter Swans (*Cygnus buccinator*) wintering at Comox, BC. The major components of that study have been reported in McKelvey (1981). One of the main objectives of that study was to determine the food habits of swans wintering on the estuaries at Comox and at Port Alberni. Food habits *per se*, however, say nothing of the relative nutritive or energy values of each food item (Sugden 1971). Metabolizable energy (*ME*), the amount of energy an animal extracts from its food, is a much better expression of the food value (Hill 1964, Sugden 1971).

In the spring of 1978, an opportunity became available to assess the digestive efficiency of several captive swans at the Animal Care Facility of the University of British Columbia (UBC). I encountered problems in working with the swans, but the data acquired may be of use to others engaged in or contemplating studies of feeding efficiency with captive swans.

Information is presented here on the metabolizable energy of the maintenance diet (chicken scratch) fed to the swans, and of rhizomes of *Carex lyngbei*, an emergent plant that forms part of the diet of Trumpeter Swans wintering at Comox and Port Alberni (McKelvey 1981). I also conducted tests using fresh timothy grass to simulate a recently acquired winter diet of pasture grass at Comox (McKelvey 1981).

Methods

The feeding trials involved captive, semi-tame swans at UBC in April and May 1978. Two adult Trumpeter Swans (one male and one female) andd one adult female Tundra Swan (*Cygnus columbianus*) were obtained from the George C. Reifel Migratory Bird Sanctuary, Delta, BC, and two immature female Trumpeter Swans from aviculturalist R.B. Trethewey. All swans were maintained on commercially available chicken scratch while not on feeding trails, with water and gravel continually available.

The feeding trials took place in "metabolic cages", constructed of 2.5 cm × 5.0 cm weldwire, measuring 1.2 m square by 2.4 m high. The cages were elevated 10 cm above the building floor on wooden blocks. Sheets of heavy waxed paper placed under the cages collected all spilled food and excreta. Trials lasted for 3 or 4 days. During each trial, I presented a measured amount of food, and the unused, spilled portions and excreta were collected once every 24 hours. Although water and gravel were freely available, I presented them in a manner that minimized contamination of the food source. I weighed unused portions of food after collection, and then subsampled them for later determination of water and ash content. All trials were conducted in an open-air building at ambient temperatures, which ranged from 5° to 15°C.

Gross energy (*GE*) and the ash content of droppings and food samples were measured on a Gallenkamp adiabatic bomb calorimeter. I calculated ash-free dry weights of droppings and food from the ash residue. Nitrogen for protein content determination of food and droppings was assessed with an HCN Auto-analyzer at Simon Fraser University, BC.

I calculated the *ME* of foods, corrected for nitrogen balance, by using the following formula (after Scott *et al.* 1969 and Sugden 1971), (N = nitrogen):

$$ME = GE\text{ food} - [(\text{dry-weight droppings}/\text{dry-weight food}) \times GE\text{ droppings}] + [(\text{weight N food} - \text{weight N droppings})/(\text{dry-weight food}) \times 8.22\text{ kcal/g}].$$

Feeding efficiency was calculated from:

$$[(\text{total energy in}) - (\text{total energy out})]/(\text{total energy in}) \times 100\%.$$

The chicken scratch came from a feed supplier in Vancouver; it consisted of a mixture of wheat (variety not reported) and cracked corn.

Rhizomes of *Carex lyngbei* were collected from a marsh on the Fraser River adjacent to the Alaksen National Wildlife Area. Quantities of rhizomes were dug from the marsh, washed on site to remove adhering mud, and stored refrigerated until used. Before the rhizome feeding trials, the swans were maintained on a mixture of rhizomes and grain, the amount of grain presented being decreased daily. Three days prior to the trial, rhizomes only were presented.

The timothy grass (leaves and stems) came from a hayfield on the Alaksen National Wildlife Area, and was stored refrigerated until used, usually within about 6 hours. Before being presented to the swans, the grass was chopped into lengths of approximately 5 to 10 cm. Subsamples were taken for water and ash content determination.

Results and discussion

The average *ME* and mean digestibility of chicken scratch, rhizomes of *Carex lyngbei*, and timothy grass to swans is shown in Table 1, and the nutritive composition of the tested foods in Table 2. All birds ate during the chicken-scratch trial, but only three swans ate the rhizomes, and only two ate the grass.

The dry weight of food consumed varied greatly, but was generally low, and all birds lost weight, except the Tundra

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Swan, which gained weight during the chicken-scratch feeding trial. Nitrogen balance was positive during feeding trials with chicken scratch, but negative for trials with rhizomes and grass.

The nitrogen-corrected *ME* of chicken scratch was just within the range of *ME* values (3.12 ± 0.01 to 3.60 ± 0.02) reported by Sugden (1971) for various grains fed to Mallards (*Anas platyrhynchos*). Swans probably digest grains with approximately the same efficiency as Mallards, and perhaps other waterfowl. Because the chicken scratch was a mixture of wheat and cracked corn, some differences in digestive efficiency might be expected. Swans may not metabolize wheat as well as Mallards, or the cracked corn may have lowered the apparent digestibility of the diet. The quality of chicken scratch can also vary, depending on how much grain dust and other waste it contains (L. Maltby, pers. commun.). The feed used in this study was of good quality, though by its nature it would probably contain more dust than the grains used by Sugden (1971).

The *ME* of rhizomes of *Carex* consumed by swans (2.48 ± 0.22 kcal/g) seemed to be high compared with Burton *et al.* (1979), who found the *ME* of *Scirpus americanus* rhizomes consumed by Lesser Snow Geese (*Anser caerulescens*) to be only 1.43 kcal/g. There are a number of possible reasons for this great difference in apparent metabolic efficiency of two similar species feeding on similar foods. One is the manner in which the swans consumed the *Carex* rhizomes during the feeding trial. They ingested large quantities of gravel with the rhizomes: after selecting a rhizome, the bird would select from the gravel supply, and then go back to the rhizomes. This procedure resulted in a high proportion of the dry weight of the droppings recovered in the rhizome feeding trial consisting of ash (29.6 ± 2.9%, n = 12). It is possible that with large quantities of gravel in the gizzard, the rhizome food was very finely pulverized, making the contents of a larger percentage of the plant cells available for digestion.

Another possible source of error, which may have caused an artificially high estimate of the *ME* of *Carex* rhizomes, was the length of time allowed the swans to adapt to the *Carex* diet. Calculated *ME*s of test foods can be adversely influenced by the preceding diet. However, it seems likely that a gut adapted to a relatively easily digested food, such as chicken scratch, would initially digest a lower quality diet with depressed efficiency. As the gut adapted to the new diet, the efficiency of digestion would be expected to rise, as would the *ME* of the diet. Although some of the swans in this study fed on rhizomes during the feeding trial, they consumed very little, and two swans would not take rhizomes at all.

Following the calculations of Burton *et al.* (1979), one can calculate the amount of *Carex* rhizomes a free-living swan might need to meet its existence-energy requirements. At 0°C, existence energy is calculated by $\log M = 0.6372 + 0.5300 \log W$, where M is the energy expenditure per bird per day and W is the weight of the bird in grams (Kendeigh 1970). The existence energy for a 10-kg swan would be 572 kcal/day. At 2.48 kcal/g, this energy requirement would be met by 230 g dry weight of rhizomes per day, or approximately 1.6 kg wet weight. That estimation falls within the range that McKelvey (1981) reported, where consumption was estimated by measuring changes in the area of emergent vegetation at Comox harbour after swans fed there. In that study, which measured only the disappearance of plants and could not account for wastage, dry-weight consumption varied from 155.1 g/bird/day in 1977–78 to 332.1 g/bird/day in 1978–79 (1.0 kg and 2.3 kg wet weight respectively).

The swans were apparently not able to extract much energy from the timothy grass. That was probably a result primarily of the rather coarse nature of the grass used. The original intention had been to simulate the quality of the grass that swans had recently begun to consume on dairy pastures at Comox (McKelvey 1981). That was not possible, however, because of the time of year at which this project was conducted. Higher *ME*s might be expected to result from a grass diet lower in fibre and higher in protein, although increased feeding efficiency might not. Trumpeter Swans grazing on dairy pastures at Comox have an almost unlimited food source of good quality, so that they need not digest the grass food with much efficiency to be able to extract an adequate amount of energy. The existence energy for a 10 kg swan feeding on timothy grass with a *ME* of 1.46 kcal/g would require the consumption of 392 g dry weight of grass per day, or 1.8 kg wet weight per day. McKelvey (1981) calculated a daily consumption of 4.5 to 5.5 kg wet weight of grass per bird per day from dairy pastures near Comox. Given that the swans grazing on pastures at Comox would use much more energy, through flight, than the existence energy calculated here, and that there could have been some wastage of the pasture grass, an *ME* of 1.46 kcal/g for timothy does not appear unreasonable.

Future studies would benefit from the use of hand-reared birds. The swans in this study, being used to the presence of people but not to the type of manipulations required for *ME* studies, did not adapt well to the confinement of the metabolic cages. I did not want to try forcing the swans to adapt to test diets over long periods, nor could I acquire more "co-operative" test subjects. The calculated *ME* values of *Carex* rhizomes and of timothy grass should be treated cautiously, because repetitive tests were not possible and adaptation periods to test diets were relatively short. However, the calculated standard errors for trials with chicken scratch and *Carex* rhizomes were less than 10% of the means. Those *ME* values should therefore be of some use as first estimates of the digestive efficiency of swans fed chicken scratch and *Carex* rhizomes. These data could be used for rough estimates of the capacity of estuaries to support wintering Trumpeter Swans, at least in terms of the biomass of available food.

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Table 1
Amount of food consumed, metabolic energy, and digestibility of chicken scratch, *Carex lyngbei* rhizomes, and timothy grass fed to captive swans. Values are ± one standard error

Food type	Amount consumed (g)	Mean weight* change (%)	*ME* (kcal/g, N corrected)	Digestibility (%)	N† correction (g)
Chicken scratch	226.7 ± 31.4 (n = 18 days)	−2.3 ± 0.14 (n = 5 birds)	3.06 ± 0.10 (n = 18 days)	75.8 ± 1.9 (n = 18 days)	+0.005 ± 0.016 (n = 18 days)
Rhizomes	25.2 ± 4.5 (n = 12 days)	−8.5 ± 0.32 (n = 2 birds)	2.48 ± 0.22 (n = 12 days)	56.3 ± 4.5 (n = 12 days)	−0.48 ± 0.11 (n = 12 days)
Grass	10.6 ± 1.4 (n = 5 days)	−7.9 ± 0.05 (n = 2 birds)	1.46 ± 0.42 (n = 5 days)	39.5 ± 8.5 (n = 5 days)	−0.44 ± 0.05 (n = 5 days)

* Calculated from weight before and after the trial.
† Weight loss data available for only two birds; three birds were used in the trial.

Table 2
Composition of foods used in metabolic energy trials with captive swans. Values are ± standard error

Food	Dry matter (%)	Crude protein (%)	Fibre (%)
Chicken scratch	86.0 ± 0.7 (n = 5)	12*	3.6*
Rhizomes	14.7 ± 0.6 (n = 11)	7.1 ± 0.3† (n = 45)	7.8 ± 1.7† (n = 7)
Grass	22.2 ± 0.1 (n = 4)	2.4 ± 0.1 (n = 2)	36.4‡

* Supplier's analysis.
† Based on data in McKelvey (1981) for *Carex* rhizomes from Port Alberni.
‡ Fibre content reported for alfalfa.