WINTER HABITAT AND FOOD OF *CYGNUS CYGNUS BUCCINATOR* IN BRITISH COLUMBIA, CANADA

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Introduction

The world population of *Cygnus cygnus buccinator* is thought to number about 5500 birds. One subpopulation of about 500 birds breeds in northwestern Alberta and in the tri-state area of Montana, Wyoming and Idaho and winters in the tri-state area. The larger subpopulation, of about 5000 birds, breeds mainly in Alaska and winters along the Pacific coast from Alaska to northern California.

At least 50% (approximately 2500 birds) of the Alaska subpopulation winters in British Columbia (McKelvey in press). Preferred winter habitats are the estuaries of the many creeks and rivers along the coast, while smaller groups of swans are found on inland water bodies which remain ice-free.

Until recently information on the ecology of swans wintering in British Columbia consisted only of winter surveys (Smith and Blood 1972; Davies in press; McKelvey 1979) and the casual observations of naturalists (Campbell *et al* 1979: 145). The importance of estuaries to wintering swans has long been recognized (Brooks 1923; Smith and Blood 1972) but the grazing of dairy pastures is a recent phenomenon (McKelvey 1979).

Coastal study areas

Comox Harbour: Comox Harbour is situated on the east coast of Vancouver Island (Fig 1). It has a southeast exposure, the direction of the prevailing winds during winter, and is characterized by above-freezing temperatures, frequent precipitation and moderate snowfall (Table 1).

Table 1. Winter climatic information for Comox Harbour and Port Alberni, British Columbia.

	Comox[1]	Port Alberni[2]
Lowest mean daily temperature	2.1°C	0.6°C
Month	January	January
Highest mean monthly precipitation	211.6 mm	313.4 mm
Month	December	November
Average annual snowfall	106.2 cm	81.0 cm
Month of peak snowfall	January	January

[1] Data source: Canada Dept of the Environment, 1971.
[2] Data source: Canada Dept of the Environment, 1972.

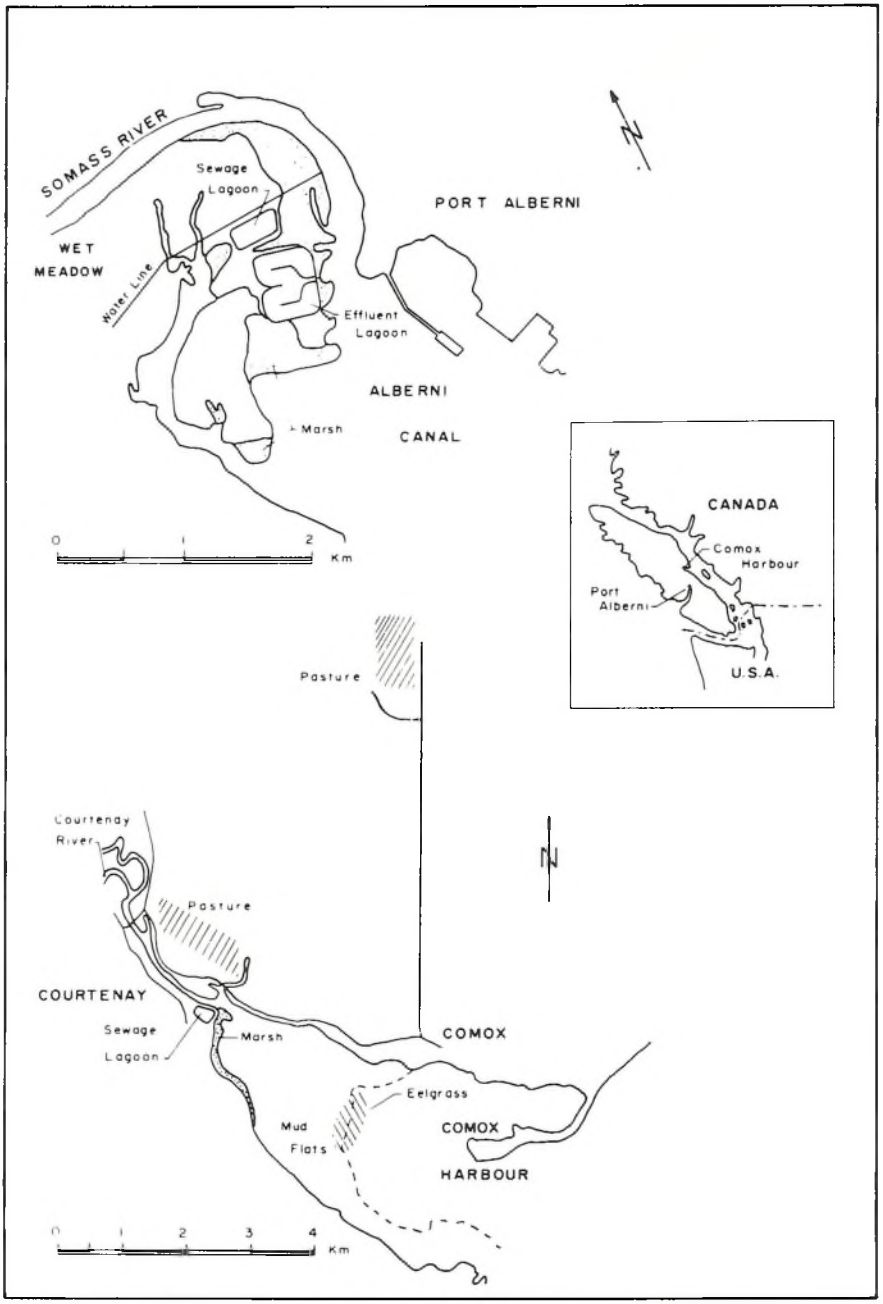

Fig 1. Location of estuarine study areas on Vancouver Island.

There is one major discharge of fresh water into the Harbour, and several smaller creeks. Most of the fresh water comes from the Courtenay River, which flows at a mean annual rate of 57.3 m^3/sec (Morris *et al* 1979). Tides are of the mixed semi-diurnal type (Canadian Hydrographic Service 1979) generally with highest tides in the early morning and lowest tides at midnight, during the winter (Fig 2).

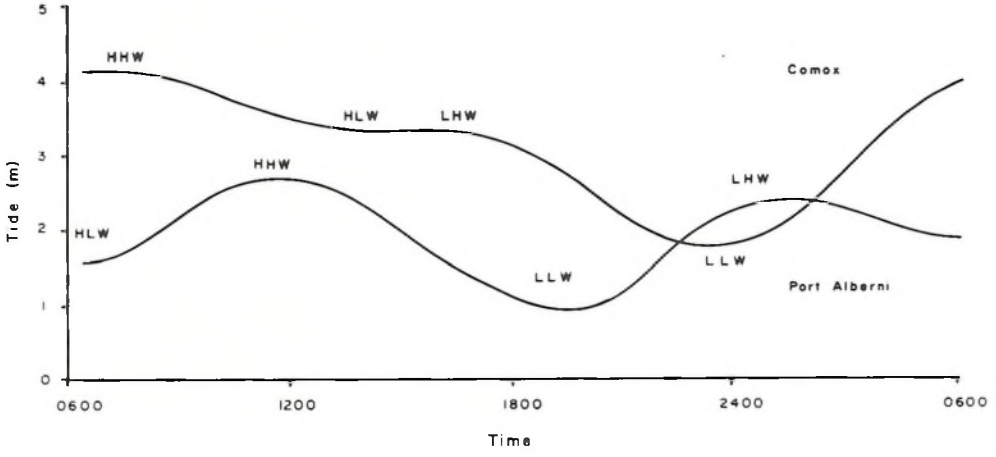

Fig 2. Composite tide cycles at Comox Harbour and Port Alberni, over the period November 1978 to March 1979.

Flood tides cause a counter-clockwise circulation of water, fresh water from the Courtenay River being deflected and mixed along the southeast side of the harbour.

Fields grazed by swans are dairy pastures which become too wet during the winter to be used by cattle. Field feeding occurs only on certain farms, generally the most productive in the area. The agricultural capability of the soil is moderate; high yields of forage crops are obtained only by heavy fertilization (R DeMong, pers comm). The fields most frequently used by swans are dominated by rye grass *Lolium perenne* and orchard grass *Dactylis glomerata.*

Port Alberni: Port Alberni is located at the head of the Alberni Canal, a fjord-like inlet on the west coast of Vancouver Island (Fig 1). The climate is similar to that of Comox Harbour but is slightly drier and cooler in the winter (Table 1).

The Somass River is the only major source of fresh water at the head of the Alberni Canal. Its flow is regulated by a dam on Sproat Lake, with a mean annual discharge of 84 m^3/sec (Canada Dept Fish & Env 1978). The tides during the winter are

lowest in the early evening with high tides of similar magnitude at midday and midnight (Fig 2). Freshwater–saltwater mixing occurs near the foot of the delta of the Somass River (Tully 1949), the result being weak tidal currents and very little saltwater influence on the vegetation of the delta (J Pogar, pers comm).

Methods

Vegetation structure, biomass and proximate analysis of potential foods, and food habits were assessed on the estuaries at Port Alberni and Comox Harbour. Food habits were analysed and food value assessed through proximate analysis on dairy pastures adjacent to the estuary at Comox Harbour (Fig 1).

A vegetation description was determined from literature sources for the estuary of the Somass River at Port Alberni and by the Braun-Blanquet plant releve technique (Muller-Dombois and Ellenberg 1974) for the Courtenay River Estuary at Comox Harbour. Biomass of below-ground plant material was estimated by core sampling a volume of 0.001 m^3 in standards of uniformly dense vegetation. Proximate analyses for fibre, fat and gross energy levels followed the methods of Horwitz (1965) and were performed by the Department of Animal Sciences, University of British Columbia, and by the Canadian Wildlife Service. Protein and carbohydrate levels were assessed using a Perkin Elmer Elemental Analyzer by the Department of Biological Sciences, Simon Fraser University.

Apparent food materials were collected from areas in which swans were observed feeding. Microscopical analyses of droppings were based on techniques reported by Baumgartner and Martin (1939), Stewart (1967) and Parker *et al* (1976).

Food habits were assessed visually at Nicomen Slough, 100 km east of Vancouver, (Fig 3) in January and November 1979. Plant materials were collected adjacent to feeding sites and analysed for protein content in November 1979.

Locations of active swan feeding were determined in February 1979 near Vanderhoof, in north central British Columbia (Fig 3). Identification of plants thought to be used as food was made in August 1979.

Results

Vegetation

The vegetation of both estuaries reflects the differences in the degree of mixing of salt and fresh water. At Comox Harbour little or no delta formation occurs; the river is somewhat channelized, and the original delta has been usurped for farmland. Much of the harbour is tidal flats, devoid of macrophytes above the eelgrass *Zostera* beds. Where the saltwater–freshwater mixing occurs, typical estuarine

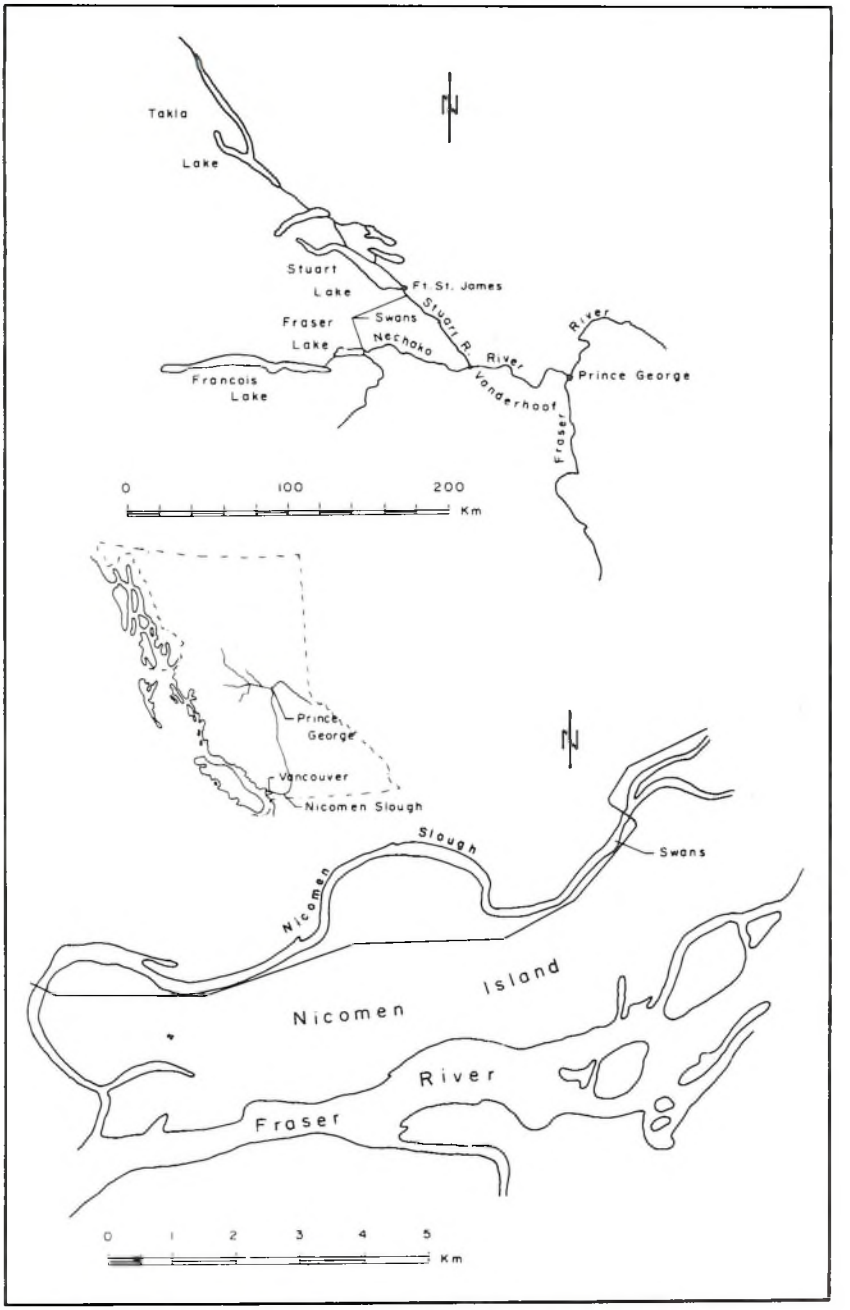

Fig 3. Location of study areas in interior British Columbia.

emergents have developed. They are confined to a narrow strip which tapers away from the Courtenay River mouth towards the southeast (Fig 1). The vegetation is characterized by only two plant associations, composed of 16 species. The associations are a *Scirpus americanus–S. cernuus–Triglochin maritimus* association and a *Carex lyngbyei–Potentilla pacifica–Deschampsia caespitosa* association. The *Scirpus* association is the more widespread, while the *Carex* association occurs between the *Scirpus* and the beach and on elevated portions of the substrate within the *Scirpus* association.

The strong influence of salt water at Comox Harbour is also reflected in plant vigour. The dominant *Scirpus americanus* seldom grows taller than 50 cm, while on estuaries more influenced by fresh water it reaches a height of over 100 cm.

The Somass River estuary at Port Alberni is more typically deltaic. Although parts of it have been developed for industrial use, sedimentation and mixing continue in their original patterns. The strong freshwater influence has resulted in a great diversity of vigorous plants. Over 60 species of emergent plants have been catalogued, and five vegetation types recognized (Paish *et al* 1973): a *Sidalcea canadensis–Fritillaria camschatensis–Solidago canadensis* type; a *Juncus balticus–Deschampsia caespitosa* type; a *Carex lyngbei* type; a *Scirpus acutus* variant of the *Carex* type; and a *Myriophyllum spicatum–Potamogeton natans* type.

Plant growth on the Somass River delta is exceptional. On average the *Carex* grows to a height of at least 100 cm and can be found in some locations over 200 cm high. Similarly *S. acutus* grows to heights above averages reported for the area (Hitchcock and Cronquist 1973).

Proximate analysis and biomass

The proximate analysis of below-ground plant materials showed them to be similar at both estuaries. In general, potential winter foods are moderate in protein (7%) and high in fibre (50% to 60%) (Table 2). The difference in fibre level of plants was highly significant ($p = 0.01$). The biomass per unit volume was significantly higher at Port Alberni ($p = 0.05$). The surface area of the estuary potentially available to swans wintering at Port Alberni was greater than at Comox Harbour with a correspondingly greater amount of food (Table 2). Proximate analysis of pasture grasses showed them to be of much higher food value than potential estuarine foods.

Food habits

C. c. buccinator was observed to feed by extracting the roots and rhizomes of the dominant emergent plants at both estuaries. At Port Alberni most feeding took place over *Carex* beds but also occurred in beds of *Scirpus acutus*. On one occasion, a characteristic swan-feeding crater was found along the edge of a bed of *Typha*

Table 2. Biomass estimate and proximate analysis of potential swan winter foods at Comox Harbour and Port Alberni, and proximate analysis of pasture grasses near Comox Harbour.

Values are ± one standard error; numbers in () are sample sizes.

Factor	Comox Harbour	Port Alberni	Pastures
Biomass (g/.001/m^3)	25.9 ± 2.1 (45)	31.9 ± 1.7 (49)	NA
Surface area (h)	8.26	22.94	NA
Food potentially available (m.t.)	115.6	401.4	NA
Protein (%)	7.0 ± .3 (45)	7.1 ± .3 (48)	22.9 ± 1.2 (14)
Fat (%)	1.2 ± .1 (39)	1.0 ± 2.6 (30)	0.4 ± .1 (4)
Carbohydrate (%)	46.8 ± 1.0 (46)	48.0 ± .3 (48)	44.0 ± .5 (14)
Fibre (%)	63.4 ± 1.2 (39)	47.8 ± 1.7 (7)	32.2 ± 1.4 (2.7)
Gross energy (Kcal/g)	4.76 ± .27 (9)	4.82 ± .16 (49)	NA

latifolia though there were no actual observations of the use of that species as food.

At Comox Harbour swan feeding was concentrated over the *Scirpus–Triglochin* association. Smaller numbers of birds were seen feeding on *Carex* beds and occasionally a swan was seen picking up a frond of *Zostera marina* drifted in by the tide. At night feeding activity was observed on *Zostera* beds exposed by low tides.

Animal matter appears to contribute very little to the winter diet of the swans. The dense growth of the plant rhizomes provides habitat only for microscopic animal forms. One source of animal protein, however, which may be used occasionally is to be found in the carcasses of spawned salmon *Oncorhynchus* sp. Butler (1973) recorded a swan picking at a dead salmon at the mouth of the Big Qualicum River, 80 km south of Comox Harbour. I have seen similar activity at the same river by a single family every winter since 1974/75; in January 1979 I saw a juvenile picking at a salmon in Comox Harbour.

The analysis of swan faeces for undigested plant fragments could not be used for quantitative measurements, because the differences between species in epidermal characteristics of roots and rhizomes were too subtle. Samples were analysed only for the presence or absence of four plant types: *Scirpus* sp, *Carex* sp, *Zostera marina* and grasses. Of the 59 droppings analysed, fronds of *Zostera* were seen in 22, *Scirpus* rhizomes in 20, grass parts in 12 and *Carex* rhizomes in 9; two had completely unidentifiable plant remains.

Interior wintering areas

The wintering area east of Vancouver is a small freshwater marsh on a side channel

of the Fraser River (Fig 3). Emergent vegetation consists predominantly of a *Carex* sp, probably *C. rostrata,* and horsetail *Equisetum* sp. The water is clear enough to support other aquatic plants as well, *Potamogeton* sp and *Eleocharis* sp being the most obvious. *Equisetum* sp and *Carex* sp, in that order, appear to be the preferred foods. Their protein contents were 5.0% and 4.4% respectively.

The climate in the lower Fraser Valley remains mild throughout the winter. When freezing conditions prevail, the slow river current and the turbulence caused by small creeks entering the marsh keep Nicomen Slough open for feeding.

Though climatic conditions in north central British Columbia are, by contrast, severe during the winter, certain wetland areas remain partially ice-free, particularly fast-flowing rivers and the outflows of large lakes. Their use by swans is traditional. Artifacts from the Hudson Bay Post at Fort St James indicate that swans have been found near the Fort since before settlement (about 1810).

Foods consumed in the northern interior areas are the leaves, tubers and rhizomes of emergent and floating leaved aquatic plants. Species found in areas known to have supported wintering swans included: *Scirpus* sp, *Elodea canadensis, Sagittaria latifolia, Potamogeton* sp and *Myriophyllum* sp.

Discussion

Vegetation

Studies of the vegetation of the numerous estuaries along the British Columbia coast have been confined to the larger and more accessible areas near Vancouver (Lim and Levings 1973; Yamanaka 1975; Dawe 1976). Plant species and associations seem to be similar from one estuary to another, the extent of mixing of salt water and fresh water being most important in determining final vegetation structure.

Vegetation patterns observed during aerial surveys of swans on Vancouver Island (McKelvey 1979) appeared to be similar to those seen at Comox Harbour and Port Alberni and to those reported by Lim and Levings (1973), Yamanaka (1975) and Dawe (1976). The most abundant plants in most estuaries, including estuaries used by swans, are *Carex* sp and *Scirpus* sp. Their importance to swans is undoubtedly as a food source.

Proximate analysis and biomass

Crude protein levels found in this study were similar to those reported in other studies of emergent plants. Burton (1977) measured protein levels of 7% to 14% in rhizomes of *Scirpus* sp consumed by *Anser caerulescens caerulescens* in the Fraser River Estuary. De la Cruz and Hackney (1977) reported crude protein

levels in below-ground parts of *Juncus* sp of between 4.0% and 5.4%. Similar ranges of crude protein have been reported for above-ground emergent plant parts by Boyd (1970a and 1970b) and Auclair (1978). Swans wintering on the estuaries at Comox Harbour and Port Alberni have available to them crude protein levels similar to those in many other emergent plant communities. It is difficult to say whether those levels of protein are adequate nutritionally, but as swans have always wintered on estuaries it must be concluded that they are.

High fibre content may reflect a low-quality diet or it may be an artifact of the sampling procedure. Cellulose, the major component of fibre, is not digested by geese (Mattocks 1972) and there is no evidence that swans digest it either. In mammals capable of cellulose digestion, winter diets high in fibre were thought to result in a negative energy balance (Gasaway and Coady 1974). Ingestion of high-fibre foods by birds may similarly lower the efficiency of digestion but high levels (30%) are tolerated by chickens (Bolton 1962).

Swans are probably more selective in their food habits than was the core sampling procedure of this study. Core samples often contained large quantities of roots attached to the rhizomes. The roots generally appeared to be dead; if so, they would be highly fibrous. Swans may be able to extract rhizomes only, leaving much of the root material behind and reducing the fibre levels of the actual diet.

Grazing of pastures

The much higher protein content of the grass on the pastures adjacent to Comox Harbour is the most likely reason for their attractiveness to swans. A popular belief is that when a species changes food habits, eg from emergent plants to pasture grasses, some catastrophe has befallen the natural food resource. My original hypothesis was that over-utilization of the estuary at Comox Harbour was forcing swans onto agricultural fields. However, Port Alberni, where there is abundant food, continues to receive less use while Comox Harbour may soon be over-utilized (McKelvey 1979). Swans attracted to the Comox area for the dairy pastures are still dependent on the estuary at night and during periods of snow when field feeding is not possible.

During the winter the Comox area supports nearly 5% of the world population (250 to 300 birds); it is a critical wintering area. Its popularity with swans is creating some management problems, complaints of depredation being the most obvious. There is direct evidence that limited waterfowl grazing may be beneficial to overwintering crops (Kear 1970; Marriott 1973; Clark and Jarvis 1978) and there is indirect evidence that swan grazing is generally not harmful. The owner of one farm near Comox claims not to have noticed yield changes since swan grazing began in 1974.

The manner in which the swans acquired the field feeding habit is unknown.

Because they are forced onto unfrozen coastal areas in severe weather, it cannot have occurred in response to weather as reported for other swan species (Owen and Kear 1972). The taste for high-nutrient grasses may have been acquired by chance, birds landing on rain-flooded fields then decoying other swans.

Reed (1976) speculated that goose species which have adapted to using agricultural crops may have lowered their reproductive output and shifted the age distribution through increased winter survival. There have been no studies yet of the reproductive success of swans feeding on grass compared with those feeding only on natural foods.

Feeding in fields has resulted in a rapid increase in the number of swans wintering at Comox (McKelvey 1979). The mechanism causing that increase could be a change in productivity or a decrease in winter mortality. Continued yearly observations on the productivity of those swans wintering at Comox would be useful.

Food habits

Winter food habits of *C. c. buccinator* are unlike those reported for other swans (Owen and Kear 1972; Owen and Cadbury 1975), the native foods on wintering areas in British Columbia appearing to be the roots and rhizomes of emergent plants. Other swan species seem to make more use of above-ground plant parts, on wetlands or fields, and of rooted aquatics. The use of *Zostera* has been reported in other swan species, but the extent of its use by *C. c. buccinator* is not known; *Zostera* does not occur at every wintering location, and its use at Comox may have been over-estimated. The rate of passage of food through the gut is unreported in swans but seems to be much slower than in other waterfowl (pers obs). *Zostera* is available only during the lowest daily tide, near midnight, and droppings collected during daylight on intermediate tides may have resulted in an over-estimation of the importance of *Zostera* in the diet.

Interior areas

Habitat and food habits of *C. c. buccinator* wintering in interior parts of British Columbia are similar to those reported for European swans (Owen and Kear 1972). Because there is indirect evidence of a long history of use of some areas, such as Fort St James, those areas may be traditional wintering areas. *C. c. buccinator* does not seem to be a flock bird in the sense that geese and even *Cygnus c. columbianus* are. They winter in small groups and do not migrate, some wintering as far north as Cordova, Alaska. It is possible that at least some of the birds wintering in north central British Columbia are also breeding nearby.

Acknowledgements

Dr N Verbeek has given much assistance in planning, interpretation of results and manuscript

review. N Perret assisted with early planning, H Boyd provided useful criticisms of the manuscript, and technical assistance was provided by K Simpson and M Wyborn.

Summary

During the winter British Columbia supports at least 50% of the world population of *Cygnus cygnus buccinator*. Habitat conditions and food habits are reported from estuaries at Port Alberni and Comox Harbour, from dairy pastures near Comox and from inland areas east of Vancouver and in north central British Columbia.

Vegetation varies between estuaries depending on freshwater influence. The protein content of below-ground plant parts was moderate (7%) and fibre levels were high (50% to 60%). Major food items include the roots and rhizomes of *Carex lyngbei* and *Scirpus americanus* and the leaves of *Zostera marina*.

Pasture grasses were found to be high in protein (23%) and low in fibre (32%). *Lolium* sp is the almost exclusive food item on pastures. The concentration of swans in the Comox area is thought to be the result of the availability of pastures and not the disappearance of the native estuarine food resource.

Food consumed on inland wintering areas include roots and rhizomes of *Carex* sp, *Equisetum* sp, *Scirpus* sp and roots or leaves of *Elodea canadensis, Sagittaria latifolia, Potamogeton* sp and *Myriophyllum* sp.

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