Activity budgets of Lesser Snow Geese wintering on the Fraser River Estuary, British Columbia

B. A. BURTON and R. J. HUDSON

Introduction

In the absence of disturbance the diurnal routine of waterfowl generally consists of a more or less regular pattern of feeding and resting, irregularly interspersed with less frequent flight, preening and alertness behaviour. Deviations from the normal activity budget may profoundly affect energy uptake and expenditure, and hence the welfare and productivity of the individual.

The balance between the ability to ingest large quantities of food and to select a relatively nutritious diet is very important for birds such as geese which, as a group, possess inefficient digestive systems (Mattocks 1971). Daily procurement of food is most often limited by the amount of light available (Bossenmaier & Marshall 1958). However, other factors such as disturbance and changes in food availability may alter the feeding routine markedly. One critical factor is the efficiency of feeding in relation to the amount of time available, and this, in turn, is directly related to the size, quality, and accessibility of the food resource.

Energy output is related to the level of daily activity, as well as the maintenance of homeothermy. Flight is the most energetically expensive activity, ranging from 5 to 14 times Standard Metabolic Rate (Utter & LeFebvre 1970).

In addition those areas most intensively utilized for feeding must be determined. Winter range usually includes a feeding site and a roosting or loafing site, and may also have separate drinking and grit-taking areas (Glazner 1946). The winter range is often disjointed, and different portions of the estuarine resource may be used more intensively for one activity than for others. Measurements of the dominant activity within each may indicate their relative importance in providing food, shelter, grit and sanctuary at different times of the year.

Methods

The activities of Lesser Snow Geese *Anser c. caerulescens* were observed on the Fraser River Estuary, British Columbia, from mid-November 1974 to mid-April 1975. The study area has been described in detail by Leach (1972). Five areas of the foreshore marsh were included in the study: Brunswick Point, Reifel Refuge, Outer Islands, Lulu Island, and Sea Island.

Regular observations were conducted between 0500 and 2400 hours using a spotting scope with a 20 × 40 power zoom ocular. Counts of the number of birds engaged in each of the four major activities of feeding, resting, preening or alert were recorded at half-hour intervals. Each count consisted of 200 birds. These sample groups were selected from four different segments of the flock, the better to represent the overall activity profile.

To obtain a measure of activity during the night, each marsh unit was visited at different times between sunset and sunrise. With the aid of a night-vision scope, the activity of birds within about 25 to 50 m could be determined, depending on weather, the dispersal of the birds and the ability of the observer to remain hidden. Unfortunately, the night-vision scope was not available before mid-December.

For each activity profile, the following were recorded: time, location, hunting pressure, tide height and state. Associations between major activities and each of these parameters were analyzed using the Osiris III statistical package (Andrews & Messenger 1973). Multiple Nominal Scale Analysis (MNA), the statistical routine adopted, was used to test for differences. Since behaviour was subject to numerous extraneous influences, the level of variance was high. An analysis of predominant activity would minimize these deviations, allowing a clearer expression of the controls exerted by independent variables on the two major activities, feeding and resting. Controls exerted on preening and alert behaviour were masked because these seldom constituted the predominant activity.

Results

Analysis of predominant activities

Snow Geese fed an average of 7·2 hours each day (Figure 1). Resting accounted for just over half of the diurnal activity budget, 12·4 hours. Preening and alert behaviours amounted to 1·4 and 2·8 hours, respectively. The time spent in flight, both disturbed and undisturbed, was estimated to be at least 0·25 hours. However, during periods of

Wildfowl 29(1978): 111–17

excessive wind or harassment this level could increase three-fold.

In general, location, tide height, time and tide state had only a moderate influence on predominant activities (Table 1). The complete model accounted for only 22% of the total variance. Location was the most important factor, followed by tide height, correlated with resting and feeding activity. The direction of tidal movements had only a minor effect. Feeding predominated under conditions where the tide was between 2·1 and 3·4 m (Figure 2) and was most intensive on Brunswick Point, Lulu Island and Sea Island. Although some feeding was observed on Reifel Refuge it was seldom predominant, the geese clearly being inclined to feed elsewhere whenever possible.

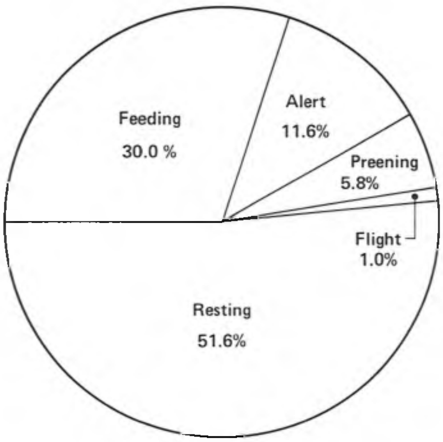

Figure 1. Proportions of time spent engaged in major activities by Lesser Snow Geese.

Resting was most prevalent when tide levels were either below 2·1 m or above 3·4 m and occurred most frequently at Reifel Refuge and least frequently at Brunswick Point. Activities on other parts of the foreshore were less clearly divided but levels of resting behaviour were not as high as on the refuge.

Preening tended to increase with water depth up to a maximum of 13% of the flock at the 3·7 m tide level with subsequent declines to 2% at 4·6 m. Alert behaviour gradually increased with tide height to a maximum at approximately 4·0 m, after which a small decline occurred.

Table 1. Relative contributions of factor variables to the probability that Snow Geese would be engaged in predominant activities.

Predictor variables (Generalized Eta²)	Categories	Activity: Feeding	Resting	Preening	Alert
Location (0·1248)	Brunswick Point	26·57	−32·08	−1·85	7·37
	Reifel Refuge	−15·70	15·13	1·21	−0·63
	Outer Islands	5·47	1·81	−1·75	−1·91
	Lulu Island	10·93	8·86	−0·29	−1·77
	Sea Island	4·52	−6·64	−1·67	3·79
Tide height (in m) (0·1049)	2·0–3·9	−35·83	36·17	0·38	−0·71
	4·0–5·9	−16·66	19·00	−0·54	−1·80
	6·0–7·9	−7·94	10·29	−1·39	−0·95
	8·0–9·9	12·85	−15·39	−0·17	2·71
	10·0–11·9	11·54	−12·16	−0·23	0·85
	12·0–13·9	−7·57	7·71	1·21	−1·34
	14·0–15·9	23·55	27·00	−2·60	−0·86
Time (in hr) (0·0514)	0300–0600	−10·16	13·53	−2·11	−1·27
	0600–0900	9·48	−10·55	1·06	0·01
	0900–1200	2·22	1·21	−1·73	−0·28
	1200–1500	−4·14	2·45	1·80	−0·11
	1500–1800	−9·75	10·59	−1·83	0·98
	1800–2100	25·29	−22·40	−0·76	−2·13
	2100–2400	4·53	−2·39	−2·53	0·39
Tide action (0·0024)	rising	−3·72	3·95	−0·99	0·76
	falling	2·76	−2·94	0·74	−0·56

Generalised $R^2 = 0·2188$.

Discussion

Feeding

Water levels are of major consequence to the daily activities of many species of waterfowl, including Snow Geese, through a direct effect on food availability. Wintering Snow Geese prefer to feed in water from 2–15 cm in depth (McIlhenney 1932; Soper 1942). In the present study approximately 83% of all feeding activity took place between the 2·0 and 3·7 m tide levels. *Scirpus americanus* and *S. paludosus*, the primary food plants of Snow Geese, grow between 2·1 and 3·5 m

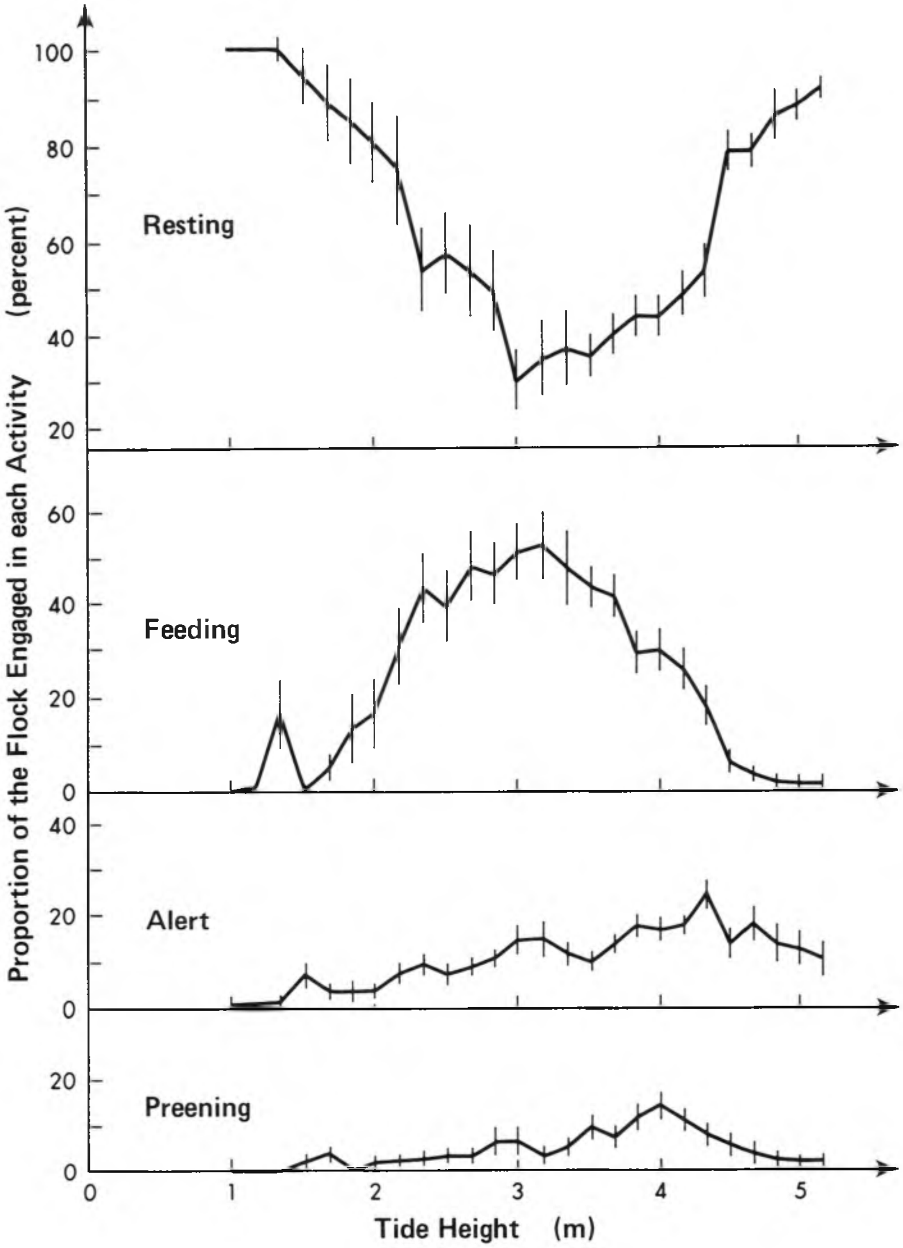

Figure 2. Proportion of Lesser Snow Geese engaged in various activities in relation to tide height. Vertical bars represent ± S.E.

(Burgess 1970) indicating that most feeding occurs when the water level is between 19 cm below the minimum and 20 cm above the maximum ranges of these plants.

If the water is deeper than 20 cm it is not possible for geese properly to brace themselves to excavate and extract the embedded rhizomes. If, on the other hand, the water is too shallow it is difficult for the geese to remove adhering silt and fibrous roots before swallowing.

An increase in feeding intensity occurred when the tide was between 2·0 and 2·2 m. Feeding activity is then almost entirely restricted to the sides of water-filled depressions, the abundance of which make feeding possible for a short time after level portions of the *Scirpus* zone had been exposed. However, the rhizome densities in the bottom of these depressions are significantly lower than in well-exposed stands.

Fluctuating water levels were believed responsible for changes in the wintering locations of Greater Snow Geese *A.c. atlanticus* along the east coast of the United States. Howard (1940) recorded that they changed their feeding grounds in response to unfavourable conditions created by storms or abnormally high tides. Dzubin (1965) implicated excessive flooding of feeding areas as a contributory factor in bringing forward the southward departure of migrating Ross's Geese *A. rossii.* In south-eastern Texas, Lesser Snow Geese responded to excessive flooding by altering their diet or by moving to areas with more favourable water regimes (Lynch *et al.* 1947). The geese also avoided otherwise excellent feeding areas until they had been inundated with a shallow covering of water.

Information on activity patterns usually consists of data collected only during daylight, and a more or less rigid diphasic pattern of activity, with peak feeding levels occurring in the early morning and the late afternoon is deduced (Bossenmaier & Marshall 1958), night-time feeding, except under abnormal circumstances, being thought negligible. Nocturnal feeding activity has, however, been recorded for several species of geese, when either the birds were highly visible on moonlit nights (Howard 1940; Boyd 1955; Marriott 1970; Owen 1972) or when movements of large numbers of birds are most conspicuous, such as during periods of excessive hunting pressure (Racey 1924; McIlhenney 1932; Glazner 1946).

Marriott (1970) did not observe free-ranging Cape Barren Geese *Cereopsis novaehollandiae* feeding at night (except by moonlight when the birds would be most visible). However, during experimental trials on caged birds he noted that at least one-third of the total daily intake was during the hours of darkness. Utilizing image intensification equipment, Swanson and Sargeant (1972) observed adult and immature ducks of several species feeding intensively between the hours of 2100 and 0400 during the summer. The major factor influencing the nocturnal feeding of these birds was food availability, an abundance of midges (*Chironomidae*) and mayflies (*Ephemeroptera*).

The present study clearly established that Snow Geese do in fact feed at all hours, regardless of the light intensity. Nocturnal feeding occurred both in and out of the hunting season, further indicating that fluctuating food availability (due to changing tide levels) is more important than hunter harassment.

Assuming that feeding intensity of Snow Geese is controlled to a large extent by tide height, it is possible to calculate the duration and occurrence of the effective feeding periods. From the end of October to the middle of April the tide was between 2·0 and 3·7 m for an average of 14 hours per day. Although shorter periods did occur in December and January the average was still 12 hours. Feeding between these tide levels accounted for an average of only 29% of the total activity in 24 hours. This figure is relatively low compared to the estimate for European White-fronted Geese *Anser a. albifrons* which fed for a mean of 9·4 hours of a possible 10 hours on two days of observation (Owen 1972). Since nocturnal feeding was known not to have occurred among the Whitefronts, 39% of the 24-hour day was spent feeding.

Locality was a major factor determining the predominant flock activity and had a considerable effect on the intensity of feeding. Reifel Refuge, along with the Outer Islands, possessed the lowest rhizome densities on the foreshore (Burton 1977). Preferred feeding areas were those with comparatively high rhizome densities.

Bossenmaier & Marshall (1958) stated that feeding site preferences of waterfowl are based primarily on food density and accessibility, including water levels in the fields, and their proximity to the roosts. Once a feeding site was selected the birds, with rare exception, returned to the same place each day.

Certainly other habitat factors such as the structural and chemical characteristics of the vegetation, root to rhizome ratios, relative amounts of pothole and channel edge and ease of extraction, along with environmental factors like wind, precipitation, and temperature must influence levels of feeding differently at different locations. Lulu and Sea Islands appeared to have similar rhizome densities to Brunswick Point. However, Snow Geese were not observed to use these areas at all during November and December. The early autumn migrants invariably first settled at Brusnwick Point in October. This marsh was used both day and night for a short time, but hunting pressure during the day soon forced the geese on to Reifel refuge. The suitable conditions encountered at Brunswick apparently committed them to return each night. Reinforced by successful foraging, geese maintained this regular flight pattern until January when all birds departed for the Skagit River Estuary, 50 km to the south.

Upon their return to the Fraser Delta in March, Brunswick Point and Sea Island were chosen by the first arrivals. However, at this time there was no hunting, thus allowing a fuller expression of innate preferences.

Tidal movements exerted little, if any, control on the feeding intensity and periodicity of Snow Geese. White & Lewis (1937) reported that Greater Snow Geese fed with equal frequency on rising and falling tides. However, Soviet work indicated that Lesser Snow Geese preferred to feed on an incoming tide (Telpov & Shevareva 1963). Hunters on the Fraser Delta, on the other hand, suggest that feeding is most common on a falling tide, since they shoot most geese as they fly in to feed in the early morning and late afternoon. During the hunting season minimum low tide occurs at night and feeding by geese on falling tides therefore occurs twice during daylight. Flight activity increases with an increase in feeding activity therefore geese are then more vulnerable to hunters. The deductions of the hunters are thus somewhat incomplete. From night-time and post-hunting season data it is now clear that absolute tide height rather than its movement is most important in regulating feeding activity.

Time of day was of surprisingly minor importance in feeding activity. Many other bird species are directly controlled by light intensity and diphasic feeding flights have been recorded for most species of waterfowl, including Snow Geese, when food availability is stable. Markgren (1963) stated that an endogenous 24-hour metabolic rhythm in Bean Geese *Anser fabalis* determines the pattern of their daily activities. He also suggested that light intensity, since it affects visibility and other environmental factors such as temperature and food availability, regulates the expression of this rhythm. Other studies point out that nocturnal behaviour in waterfowl is common and that the 24-hour rhythm of most birds may actually consist of several smaller cycles (Swanson & Sargeant 1972). Siegfried (1974) proposed just such a polyphasic rhythmicity for mated female Lesser Scaup *Aythya affinis*.

Resting

Resting constituted a major portion of flock activity at all times. Since Snow Geese are observed to sleep with equal facility on land and water it is likely that tide height regulates resting behaviour indirectly through its effect on food availability. However, control of resting behaviour by fluctuations in tide height was not absolute. A large percentage of geese was asleep at any one time. When rhizomes were readily available an unexpectedly high proportion of sleeping activity was recorded. It may be that the geese had filled their gastro-intestinal tracts. Considering that an average of 29% of the flock was asleep between the 2·0 and 3·6 m tide levels a high degree of feeding efficiency is indicated. Even among the more nearly diphasic Bean Geese, which usually slept at night and fed during the day, there was always a relatively large number of birds resting. (Markgren 1963.)

During winter, the high relative humidity, with the low ambient temperature amplified by the almost constant winds, emphasized the need to conserve body heat. Under normal conditions sleeping follows completion of feeding and preening. However, during extreme weather conditions and periods of restricted food availability the regular diurnal feeding habits of waterfowl may be abandoned in order to maintain body heat.

Bean Geese displayed prolonged bouts of daytime resting in unseasonably cold weather and light snow cover on the feeding grounds (Markgren 1963). Although snow did not physically prevent feeding, efficiency may have been reduced to a point where it would not have been economical of energy to continue. When a bird assumed a sleeping position with the bill tucked under one wing, metabolic activity dropped 50 to 60% below that when standing with the head held erect.

During the hunting season Reifel Refuge

provided the only safe base available to Snow Geese. Tidal conditions at this time of year limit the amount of daytime feeding, and rhizome densities in this marsh are low. Feeding would then appear to be inefficient and sleeping would increase.

Geese display a preference for areas providing unhindered visibility (Markgren 1963). Even though the lower reaches of the Outer Islands, Brunswick Point and Lulu Island offer little protection from weather, they do provide an unobstructed panoramic view. Reifel Refuge, on the other hand, is relatively well sheltered from wind but is in the centre of a complex of intertidal islands covered with water, and when the islands are exposed by the falling tide, the geese are left essentially surrounded by land.

Neither tidal state nor time of day influence the level and periodicity of resting behaviour. The dependence of feeding on tide height meant that no regular mid-day sleeping behaviour was observed as had been recorded for Snow Geese wintering in Louisiana (McAtte 1910; McIlhenney 1932).

Preening

Included within preening were all of the comfort movements related to cleaning and grooming listed by McKinney (1965). Neither time of day, direction of tidal movement, hunting season nor location were of consequence in explaining the level and periodicity of preening behaviour, which is directly related to feeding intensity and, therefore, to food availability.

White-fronted Geese were reported to spend an average of 2·4% of an 8-hour day in active preening (Owen 1972). McKinney (1965) reported that a single captive, blue-phase Snow Goose preened six times during daylight hours. Since each preening sequence lasted an average of four minutes, this represents 24 minutes of preening. If preening occurs as frequently at night as it does during daylight, another five bouts may be expected, giving a total of 44 minutes, half that estimated in the present study. Presumably the rigours of flight, wind and intensive feeding explain the higher levels of preening observed in free-ranging Snow Geese.

Alert behaviour

Alert behaviour is a deliberately broad category encompassing such activities as walking, swimming, fighting and standing.

No correlation was established between time of day, hunting season or direction of tidal movement and the level of alert behaviour. Owen (1972) could demonstrate no relation between the level of alertness in undisturbed flocks and time of day.

When rafts of sleeping geese began to form on the incoming tide many swim towards shore, especially after others had begun intensive feeding. As appetites become satisfied, more time is devoted to interactions with other geese and to 'aimless' walking.

Maximum levels of alert activity occur immediately following the high-tide drop in feeding activity. Above 3·7 m there exist few exposed surfaces on which they are able to stand. Under these conditions many geese float close to the shoreline and go to sleep. However, proximity to tall vegetation maintains alert behaviour above the levels observed when geese rest in more open and therefore secure areas at low tide.

Owen (1972) recorded that during daylight, approximately 3·0% of White-fronted Geese were alert during periods of intensive feeding. In the present study alert behaviour amounted to approximately 11·5% of the activity profile during similar periods. This discrepancy may, in part, reflect the relative amount of foraging time required to obtain an adequate diet.

Acknowledgements

This study was conducted by the senior author in partial fulfilment for the degree of M.Sc. at the University of British Columbia. Grateful recognition is made to the British Columbia Fish and Wildlife Branch for financial and logistic support.

Summary

Diurnal activity profiles of Lesser Snow Geese *Anser c. caerulescens* were recorded between 0500 and 2400 hours from late autumn to early spring to identify areas of greatest importance for feeding and resting. Access to food supply, regulated by changes in tide height and flock location, was the most influential determinant of feeding and sleeping periodicity. Because of tidal fluctuations, a polyphasic rhythmicity was displayed by Snow Geese rather than the more common light-controlled, diphasic routine. Nocturnal feeding occurred regularly in and out of the hunting season. The mean proportion of each day engaged in feeding was 29%, but even during periods of optimal food accessibility, it amounted to only 52% of the total activity profile. This indicated a combination of efficient feeding techniques and a nutritious diet.

References

Bossenmaier, E. F. & Marshall, W. H. 1958. Field feeding by waterfowl in south western Manitoba. *Wildl. Monog.* 1: 1–32.
Boyd, H. 1955. The role of tradition in determining the winter distribution of Pinkfeet Geese in Britain. *Wildfowl Trust Ann. Rep.* 7: 107–22.
Burgess, T. E. 1970. Foods and habitat of four Anatinids wintering on the Fraser Delta tidal marshes. M.Sc. Thesis, Univ. Brit. Col., Vancouver.
Dzubin, A. 1965. A study of migrating Ross geese in western Saskatchewan. *Condor* 67: 511–35.
Glazner, W. C. 1946. Food habits of wild geese on the Gulf coast of Texas. *J. Wildl. Mgmt.* 10: 322–9.
Howard, W. J. 1940. Wintering of the greater Snow Goose. *Auk* 57: 523–31.
Klopfer, P. H. & Hailman, J. P. 1965. Habitat selection in birds. *Advances in the Study of Bird Behav.* 1: 279–303.
Leach, B. A. 1972. The waterfowl of the Fraser Delta, British Columbia. *Wildfowl* 23: 45–55.
Lynch, J. J., O'Niel, T. & Lay, D. W. 1947. Management significance of damage by geese and muskrats of Gulf coast marshes. *J. Wildl. Mgmt.* 11: 50–76.
Markgren, G. 1963. Migrating and wintering geese in southern Sweden. *Acta Vertebratica* 2: 297–418.
Marriott, R. W. 1970. The food and water requirements of Cape Barren Geese. Ph.D. Thesis, Monash Univ.
Mattocks, G. 1971. Goose feeding and cellulose digestion. *Wildfowl* 22: 107–13.
McAtee, G. E. 1910. Notes on *Chen caerulescens, C. rossi* and other waterfowl. *Auk* 27: 337–9.
McIllhenny, E. A. 1932. The Blue goose in its winter habitat. *Auk* 49: 279–306.
McKinney, F. 1965. The comfort movements of Anatidae. *Behav.* 25: 120–220.
Owen, M. 1972. Some factors affecting food intake and selection in White-fronted geese. *J. Anim. Ecol.* 41: 79–92.
Racey, K. 1924. Snow Goose near Vancouver, B.C. *Murrelet* 5: 10–11.
Siefried, W. R. 1974. Time budget of behaviour among Lesser Scaups on Delta marsh. *J. Wildl. Mgmt.* 38: 708–13.
Soper, J. D. 1942. The life history of the Blue Goose. *Proc. Boston Soc. Nat. Hist.* 42: 121–225.
Swanson, G. A. & Sargeant, A. B. 1972. Observations of night-time feeding behaviour of ducks. *J. Wildl. Mgmt.* 36: 959–61.
Telpov, V. P. & Shevareva, T. P. 1965. (On seasonal movements and the bag of Snow Geese.) Pp. 23–38 in *The Migrations of Birds and Mammals*. Moscow: Publishing House Nauka. (trans. from Russian).
Utter, J. M. & LeFebvre, E. A. 1970. Energy expenditure for free flight by the Purple Martin. *Comp. Biochem. Physiol.* 35: 713–9.
White, E. F. G. & Lewis, H. F. 1973. The Greater Snow Geese in Canada. *Auk* 54: 440–4.

B. A. Burton, Department of Animal Science, University of British Columbia, Vancouver. Present address: Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon S7N 0W0.

R. J. Hudson, Department of Animal Science, University of Alberta, Edmonton, Canada T6G 2E3.