Diurnal time-activity budgets and habitat use of Lesser Snow Geese *Anser caerulescens* in the middle Missouri River valley during winter and spring

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Diurnal time activity and habitat use of wintering and spring-migrating Lesser Snow Geese were studied in the middle Missouri River valley during 1983 and 1984. Geese spent the majority of daylight hours sleeping and loafing. During winter and spring migration, geese spent 17.5% and 24.0% of a 12-h day feeding, respectively. Geese primarily fed in corn stubble fields; they also fed on winter wheat and bromegrass. The availability of waste corn in the middle Missouri River valley presumably influences the winter distribution of Snow Geese.

Historically, the mid-continental population of Lesser Snow Geese *Anser (Chen) caerluscens caerluscens* has wintered on the Gulf Coast of Texas and Louisiana (Bellrose 1976). Over the past 20 years, however, increasing numbers of Snow Geese have wintered along the middle Missouri River valley. Both the number of geese that remain at mid-latitude roosting areas and the length of time they stay have varied; in recent years, flocks of a few thousand to 100,000 have remained through the winter. In addition, Snow Geese concentrate in large numbers in the middle Missouri River valley during spring migration. A number of potential problems are associated with these concentrations of geese, including crop depredation and disease outbreaks.

The increased number of Snow Geese wintering at mid-latitudes reflects the overall increase in the mid-continental Lesser Snow Goose population over the past 30 years (Boyd *et al.* 1982). However, this change in the winter distribution pattern of Snow Geese may also be related to the increased availability of waste maize or corn in the middle Missouri River valley owing to the advent of mechanical corn pickers, increased acreages planted, and increased crop yields. More recently, in an effort to reduce soil erosion, there has been a reduction in autumn or fall ploughing and in the use of the moldboard plough. Increasingly, harvested cornfields are either lightly disked, chisel-ploughed, or left unploughed until spring, thus increasing the amount of waste corn available to Snow Geese in winter.

The abundance of a high-energy food, such as corn, presumably allows Snow Geese to stay north of their traditional wintering grounds in spite of more severe weather conditions. Wintering geese feeding on corn would need to spend less time, and possibly less energy, obtaining food than geese feeding on grass and rhizomes in rice fields and saltmarshes along the Gulf Coast.

Fall-migrating Snow Geese in the middle Missouri River valley have been studied (Frederick & Klaas 1982), but little was known of the behaviour and ecology of wintering and spring-migrating Snow Geese in this area. The objectives of this study were to determine diurnal time-activity budgets for wintering and spring-migrating Lesser Snow Geese, their daily and seasonal patterns of feeding activity, and habitat use during winter and spring.

Study Area and Methods

The study area included the floodplain of the Missouri River from Omaha, Nebraska, to Iatan, Missouri, and the adjacent uplands of Iowa, Nebraska, Missouri, and Kansas (an area of 12,600 km^2) (Fig. 1). The area is farmed intensively; major crops

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Figure 1. Location of general study area in middle Missouri River valley showing Snow Goose roosts: (1) Riverton, Iowa; (2) Squaw Creek National Wildlife Refuge, Missouri; (3) Iatan, Missouri.

are corn and soybeans. Specific observation sites were determined by the movements of the geese. Winter (defined here as late December to the onset of spring migration) observations were made on the northernmost flock of Snow Geese, the location of which varied within the season and between years. In 1983, winter observations were made of flocks roosting in Fremont County, Iowa, at Squaw Creek National Wildlife Refuge, Missouri, and at the Kansas City Power and Light Electric Generating Plant, Iatan, Missouri (herein referred to as Iatan). In 1984, all winter observations were made of the flock roosting on the fly-ash ponds at Iatan. Observations of geese migrating in spring were made at Iatan and in south-western Iowa in both years.

Behaviour of Snow Geese was monitored in January, February and March of 1983 and 1984 and during the last week of December 1983. Snow Goose activity was sampled during all daylight hours. Although observations were not made during every hour of a single day, observations were conducted so that over two to three consecutive days, activity was sampled during all hours. Observations were made from a vehicle with the aid of binoculars and a 10-60X spotting scope. Most observation days began at the roost, where data were collected until geese began leaving for surrounding cropland. The choice of a flock to observe away from the roost was made as randomly as possible, but was influenced by the ease with which a flock could be followed and by its accessibility for observation from the road. Geese usually remained in large groups (30–100% of the total roosting flock) after leaving the roost; thus, observations are believed representative of the geese in the area. Generally, it was possible to remain with a single flock throughout the day. Night-time observations of geese roosting on water or on ice was attempted, but because the birds roosted too far from land, it was not possible to observe a sufficiently large proportion.

To quantify the time that Snow Geese spent in flight, a flock was observed for 30 minutes during each hour of daylight. The flock was observed as a whole at 30 second intervals, the percentage of the flock in flight was estimated and recorded, and the cause of flight was noted. Flight activity was summarised as the mean percentage of a flock in flight per hour; hourly and daily means were computed. The daily mean percentage of geese observed flying was used to estimate the average number of daylight hours Snow Geese spent flying per day. Flight paths to and from the roosts were recorded, as was the straight-line distance of feeding areas from the roost.

Scan sampling (Altman 1974) was used to collect time-activity data from flocks of Snow Geese on land and on water. A flock was sampled only if at least 90% of the birds could be observed. In 1984, separate scans were made of adult and juvenile geese, whereas adults and juveniles were sampled together in 1983. A scan was begun by the observer directing the spotting scope at one end of the flock and, after looking away briefly, choosing the individual in the centre of the field of view. From the initial goose, a scan was made in a zig-zag pattern across the flock so that geese in all portions of the flock were sampled. The behaviour, at the instant of observation, of each goose in turn was recorded on a cassette tape. Seven activities were recognised: loafing – engaged in no activity other than standing or sitting; sleeping – still, with eyes closed or bill tucked under wing feathers; feeding –

ingesting or actively searching for food (pecking or grubbing on land, dabbling or tipping on water); comfort movements – as described by McKinney (1965); alert – calling or head up, neck extended; agonistic – intraspecific aggression or retreat from an aggressor; and other – including mating behaviour, drinking, and "eating" snow or grit.

In 1983, a single scan consisted of 600 geese, although scans of fewer geese were made occasionally when the flock flushed or moved out of observation range. Analysis of the 1983 scan data revealed that activity budgets determined from samples of 100, 300 and 500 geese from the same flock did not vary significantly ($P>0.05$). Consequently, in 1984 a maximum of 300 adult geese was included in a scan. Samples of fewer than 100 adults were not used in the analyses. Scan samples of juvenile geese averaged 100 individuals, reflecting the smaller proportion of juvenile birds in the flock.

The percentage of geese observed in each activity was calculated for each scan. Means were computed for each hour to determine the diurnal pattern of activity. Initial analysis demonstrated high correlations among hourly samples within a day; therefore, daily means were calculated and used to estimate diurnal activity budgets. Adult and juvenile activity data from 1984 were analysed separately, and daily mean percentages of geese observed in each activity were compared by using the Wilcoxon Signed Ranks Test for paired data (Conover 1971). The adult and juvenile data were then combined so that they conformed with 1983 data. Activity budgets were computed for the two years separately and compared by using the Mann-Whitney Test (Conover 1971). Yearly differences were not significant ($P>0.05$); therefore, the data were combined for further analysis. To determine activity budgets, on-water and on-land observations were analysed together. Diurnal time budgets were estimated, given that the mean percentage of geese observed in the various activities represents the average amount of time Snow Geese spent in each activity. Time budgets were based on 12-h of daylight rather than a 24-h period because the few observations made at night revealed that roosting Snow Geese engage in activities other than sleeping or loafing (e.g. alert and agonistic behaviours, comfort movements, and flying).

The type of field or area being used by the flock was recorded at the beginning of each hourly observation. A total of 16 different habitat types was recognised initially; however, where preliminary analysis demonstrated no significant difference ($P>0.05$) in Snow Goose activity between habitats, data were combined. The following habitat types were used in subsequent analyses: corn *Zea mays* stubble – including untilled and burned stubble; disked corn stubble; soybean *Glycine max* stubble – including untilled, disked and ploughed stubble; winter wheat *Triticum* sp.; pasture – bromegrass *Bromus* sp.; lake – including fly-ash ponds at the power plant, farm ponds, and ice and grit banks; and other – including fallow fields, ploughed corn stubble and mudflats. These data were used to estimate habitat use by Snow Geese by computing the percentage of observations made on the various habitat types. Because observations were made during all daylight hours, the percentage of observations made on each habitat was used to estimate the number of daylight hours spent by Snow Geese on the various habitats. G-statistics (Sokal & Rohlf 1969) were used to test independence and goodness of fit; i.e. to determine patterns of habitat use, as well as whether observed use of corn stubble, soybean stubble, and winter wheat was random or showed resource preference. The availabilities of corn stubble, soybean stubble, and winter wheat were determined on the basis of data obtained from Iowa Crop and Livestock Reporting Service (1984), Missouri Crop and Livestock Reporting Service (1984), and the Kansas Crop and Livestock Reporting Service, Topeka, Kansas (pers. comm. 1984). Data on the availability of pasture were not available. Scan data were analysed by each of the defined habitat types to determine the magnitude of the differences in activity on those habitats. Comparisons were made by using the Mann-Whitney Test (Conover 1971).

All data were analysed by seasonal period, in addition to the overall three month period. Three seasonal periods were determined on the basis of Snow Goose activity and are defined as: winter – pre-spring migration (10 January–12 February 1983, 20 December 1983–4 February 1984); early migration – the beginning of migration to peak migration (17 February–11 March 1983, 5 February–29 February 1984); and late migration – peak migration to the end of migration (12 March–31 March 1983, 1 March–20 March 1984). Peak migration is defined here as the date when the maximum number of Snow Geese was observed in Fremont County, Iowa; the end of migration was the date when no large numbers (<5000) of Snow Geese were reported south of Iowa and when the flocks remaining in Iowa were composed predominantly of orphaned juveniles and crippled birds. Where early and late migration data did not differ significantly ($P>0.05$), they were combined.

Results

General behaviour and movements

The numbers and movements of Snow Geese in the middle Missouri River valley during winter and spring migration varied. On 6 January 1983, an estimated 100,000 Snow Geese were concentrated on three small farm ponds in Fremont County, Iowa. By 24 January 1983, fewer than 2500 geese remained in Iowa and, after a snowstorm on 1 February 1983, no geese were observed in south-western Iowa. From 1 February to 13 February 1983, the northernmost flock of Snow Geese was located at Iatan, Missouri (estimated flock size 35,000). In 1984, no geese were seen north of Iatan. On 18 December 1983, 1200 geese roosted on the Iatan fly-ash pond. This flock increased to 7500 birds on 1 January 1984 and to 12,000 birds on 2 February 1984.

Although the beginning of the northward migration movement could not be determined precisely, a marked increase in the size of the Iatan flock and the appearance of "rust-headed geese" indicated that movement of geese from more southern latitudes had begun (the head and neck feathers of geese feeding in Gulf Coast saltmarshes become stained rust colour (Alisauskas pers. comm.). Flocks of geese observed in the middle Missouri River valley in winter included no individuals with such marking. The first "rust-headed" geese appeared in the Iatan flock on 13 February 1983 and 9 February 1984.

Flight activity

A total of 250 observations of flight activity was made on 51 days in 1983 and 56 days in 1984. All observations were made between 0600 and 1900 h. The daily mean percentage (± SE) of Snow Geese observed flying was 10.9 ± 2.5 in winter and 12.9 ± 1.4 in the migration periods. Expressed in terms of the number of daylight hours that geese spent in flight per day, these values represent 1.3 h and 1.5 h respectively. The increase in flight activity during migration was significant ($P<0.05$). Apart from flights made between feeding areas and loafing or roosting areas, the primary cause of flight was disturbance from Bald Eagles *Haliaeetus leucocephalus* and aircraft. Eagles and aircraft were responsible for 47.9% and 24.9% of the disturbances of known cause that flushed ⩾-5% of the observed flock. The percentage of geese observed flying varied with time of day, and the daily pattern of flight activity varied between seasons (Fig. 2).

Snow Geese flew an average of 11.5 km from the roost to feed each day. Significant differences ($P<0.05$) in the average distance flown to feed between seasons are related, at least in part, to differences in the location of the roosts. In winter, geese roosting at Iatan flew an average of 23.8 km to feed daily, whereas during migration geese roosting in south-western Iowa flew an average of 9.7 km from the roost.

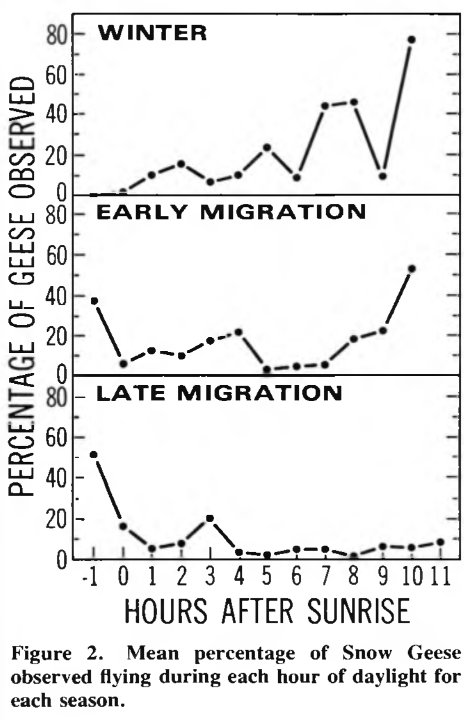

Figure 2. Mean percentage of Snow Geese observed flying during each hour of daylight for each season.

Activity on land and water

There were 602 scans made on 63 days in 1983 and 68 days in 1984; 540 and 62 observations were made of flocks of Snow Geese on land and on water, respectively. All scans were made between 0700 and 1800 h. The most common activities performed by geese on land and on water were loafing and sleeping; 50.8% and 75.7% of the birds observed on land and on water were loafing or sleeping (Table 1). Most feeding occurred on land; however, geese occasionally were observed dabbling or tipping while on water. Comfort movements and alert and agonistic behaviours occurred with equal frequency ($P>0.05$) on land and on water.

Table 1. Percentage of Snow Geese observed in each activity during daylight hours (n = number of days). Asterisks denote a significant difference ($P<0.05$) between on-land and on-water activity; Mann-Whitney Test.

Activity	On land (n = 115) $\bar{x}$	(SE)	On water (n = 23) $\bar{x}$	(SE)
Sleeping	28.1	(2.1)	22.3	(0.8)*
Loafing	22.7	(0.8)	53.4	(3.6)*
Feeding	22.7	(1.3)	0.2	(0.1)*
Alert	18.9	(0.8)	16.3	(1.9)
Comfort	6.6	(0.5)	4.6	(0.6)
Agonistic	0.6	(0.1)	0.6	(0.2)
Other	0.4	(0.1)	2.6	(0.1)

The behaviour of adult and juvenile Snow Geese on land differed. A significantly ($P<0.05$) greater percentage of juveniles was observed loafing (31.6% *v* 22.6%), feeding (21.5% *v* 19.5%), and in comfort movements (8.9% *v* 6.7%), whereas a larger percentage ($P<0.05$) of adult geese was observed in alert (19.9% *v* 6.7%) and agonistic (0.7% *v* 0.5%) postures. With the exception of alert behaviour, which occurred more frequently among adult geese ($P<0.05$), adult and juvenile activities on water were not significantly different ($P>0.05$).

Diurnal activity of Snow Geese varied among seasons. A greater percentage of geese was observed resting (sleeping or loafing) in winter than during either migration period (61.7% *v* 49.8% and 46.1%, $P<0.05$). Geese fed more frequently during migration (21.6% and 26.7% in early and late migration *v* 17.5% in winter, $P<0.05$). Alert behaviour occurred most frequently in early migration (22.2% *v* 15.0% in winter and 18.4% in late migration, $P<0.05$). The frequency of feeding and resting varied with the time of day, and the diurnal pattern of these activities varied seasonally (Fig. 3). In all seasons, the general pattern was characterised by alternating periods of feeding and resting, but the timing of peak feeding and resting activity varied with respect to sunrise.

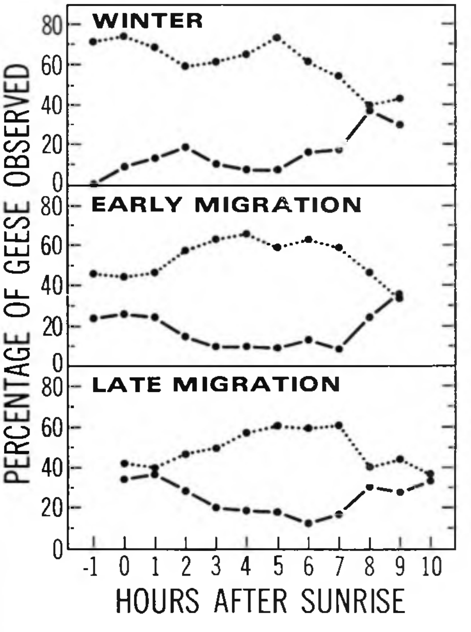

Figure 3. Mean percentage of Snow Geese observed feeding (solid line) and sleeping or loafing (dotted line) during each hour of daylight for each season.

Time-activity budgets

The diurnal activity budgets of Snow Geese in winter differed significantly ($P<0.05$) from those in spring. Geese spent half as much time sleeping during spring, and spent more time loafing, feeding, alert, flying and in comfort movements (Fig. 4).

Habitat use

Habitat use by Snow Geese varied seasonally. In winter, geese spent more than half of the daylight hours at roost sites (i.e. lake), either on water or on ice or grit banks (Table 2). On land, during all seasons, they spent the most time in untilled corn stubble and soybean stubble. Geese were observed in standing corn twice and once in standing soybeans. Snow Goose activity varied on the different habitat types (Fig. 5). Feeding activity was greater ($P<0.05$) on corn stubble, pasture and winter wheat than on soybean stubble or lake habitat. Sleeping and loafing occurred less frequently ($P<0.05$) on corn stubble, pasture and winter wheat than on other habitats.

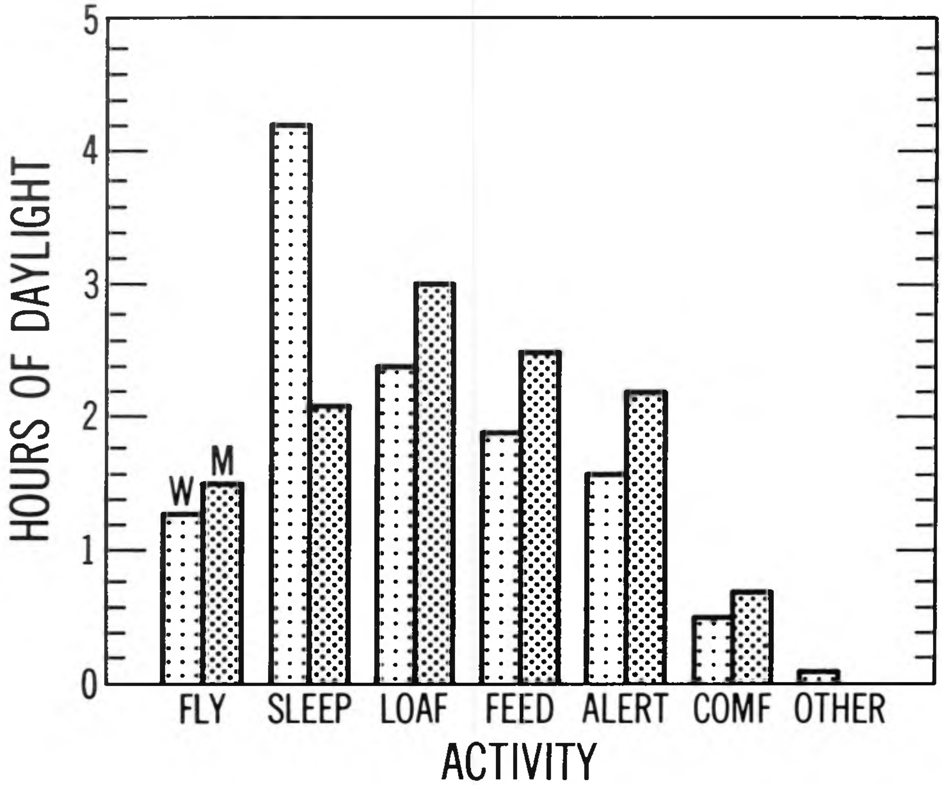

Figure 4. Diurnal time-activity budgets of Snow Geese for winter and spring migration. W = winter, M = migration. All comparisons between seasons, except "other", differed significantly at $P<0.05$ (Mann-Whitney Test).

Table 2. Number of daylight hours spent by Snow Geese on various habitats during winter and spring migration as estimated from percentage of observations made on each habitat (n = number of observations). Asterisks denote a significant difference ($P<0.001$) between seasons; Mann-Whitney Test.

Habitat	Winter Hours	(n)	Migration Hours	(n)
Lake	7.2	(137)	2.0	(95) *
Untilled corn stubble	3.1	(60)	5.3	(244) *
Disked corn stubble	0.0	(0)	1.0	(45) *
Soybean stubble	1.1	(20)	2.2	(103) *
Pasture	0.1	(1)	0.8	(35) *
Winter wheat	0.2	(4)	0.5	(23)
Other	0.3	(6)	0.2	(9)

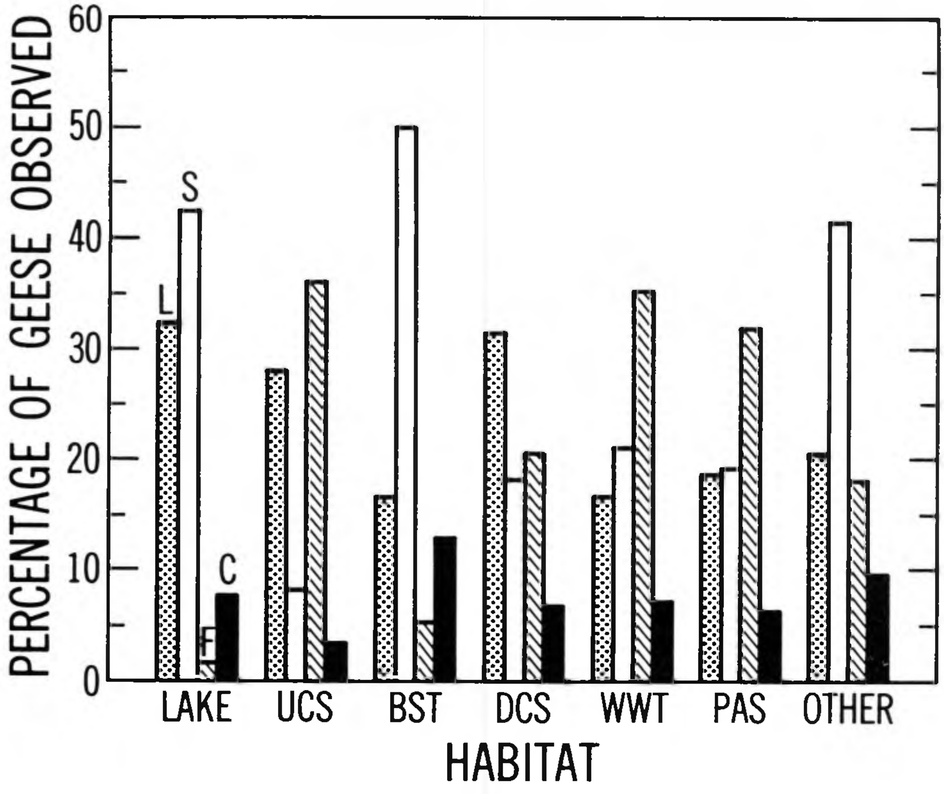

Figure 5. Mean percentage of Snow Geese observed in various activities during daylight hours on different habitat types. L = loafing, S = sleeping, F = feeding, C = comfort. LAKE = roost sites, including ice and grit banks, UCS = untilled corn stubble, BST = soybean stubble, DCS = disked corn stubble, WWT = winter wheat, PAS = pasture.

Table 3. Availabilities of corn stubble, soybean stubble and winter wheat and percentage use of each habitat by Snow Geese.

	1983						1984					
	Winter		Early Migration		Late Migration		Winter		Early Migration		Late Migration	
Habitat	% Area[ac]	% Use[b]	% Area[c]	% Use	% Area[c]	% Use	% Area[d]	% Use	% Area[e]	% Use	% Area[c]	% Use
Corn stubble[f]	46.2	75.5	46.2	75.5	46.2	67.7	17.8	65.7	27.9	66.7	41.8	66.2
Soybean stubble	52.0	24.5	52.0	18.9	52.0	26.1	56.2	22.9	56.5	30.2	57.0	26.0
Winter wheat	1.8	0	1.8	5.6	1.8	6.2	26.0	11.4	15.5	3.1	1.2	7.8

[a] % area is % of total acres of corn, soybeans and wheat harvested.
[b] % use was estimated from % observations on each habitat.
[c] Fremont Co., IA.
[d] Buchanan Co. and Platte Co., MO; Atchison Co., KS.
[e] Buchanan Co. and Platte Co., MO; Atchison Co., KS; Fremont Co., IA.
[f] Data for untilled and disked corn stubble were combined.

The availabilities of corn stubble, soybean stubble and winter wheat varied among locations and between years (Table 3). In 1983, the availability of these habitats remained constant because all observations were made in Fremont County, Iowa, whereas in 1984, there is a marked change in the availability of corn stubble and winter wheat because observations were made at different locations. Although the availability of the three habitats varied, their use by Snow Geese followed a similar pattern during all periods; i.e. use of corn stubble exceeded use of soybean stubble exceeded use of winter wheat. The observed usage varied significantly from the expected usage given the availability of these habitats ($P<0.05$).

Discussion

Seasonal and yearly differences in Snow Goose flight activity were observed. Although the distance geese fly from the roost to feed is a major factor determining the amount of time they spend in flight, it does not explain the observed variation in flight activity. For example, in 1984, geese roosting at the Iatan power plant in winter flew twice as far to feed as did geese roosting in Fremont County, Iowa, during late migration, yet flight activity was greater during the migration period.

Weather conditions affect the flight activity of geese. Raveling *et al.* (1972) reported that wintering Canada Geese *Branta canadensis* flew less when temperatures were below −6.7°C, and they ceased flight completely below −9.5°C; temperatures above −6.7°C did not affect the amount of time Canada Geese spent in flight. Snow Geese exhibited a similar response to low temperatures, however the temperature at which flight ceased completely was lower (−23.3°C). Geese did not feed on extremely cold days, but remained at the roost sleeping or loafing. In spite of this effect of temperature on flight activity, it does not account for the seasonal and yearly variation observed in this study. The average daily temperature rarely fell below −6.7°C (9% of the observation days), and temperatures above −6.7°C had no observable effect on Snow Goose flight activity.

Yearly differences in flight activity may be related to the availability of corn stubble fields. Geese primarily fed on waste corn. The number of cornfields and the amount of waste corn available presumably influence the amount of time geese must spend flying in search of food. The lack of a significant increase in flight activity over seasonal periods in 1983 suggests a plentiful food supply. However, implementation of the U.S. Department of Agriculture's Payment in Kind (PIK) programme in 1983 reduced harvested corn acreage in Fremont County, Iowa, in 1984. Although the straight-line distance flown to feed during the migration periods did not vary between years, geese may have spent more time searching for food in 1984 because of the reduced number of stubble fields with available corn.

Bald Eagles were a regular disturbance to flocks of Snow Geese. Flocks responded to eagles by flushing from the water or the fields and circling the area from several seconds to a number of minutes before landing. Yearly differences in Bald Eagle activity can explain, in part, the observed variation in Snow Goose flight activity; for example, during late migration the frequency of Bald Eagle disturbance was 1.5 times greater in 1984 than in 1983.

The diurnal pattern of flight activity is related to the diurnal feeding cycle; i.e. periods of peak flying activity corresponded with peak feeding periods. Snow Geese used different habitats for feeding and resting (Fig. 5); consequently, flight activity generally was greater immediately before and after a feeding period as geese flew between feeding and resting areas.

The activity of adult and juvenile Snow Geese on land differed for all behaviours; however, with the exception of loafing and alert behaviour, the differences were small and probably do not represent important variation in the behaviour of adult and juvenile birds. Assuming that most of the juvenile geese were members of a family group, the differences in the frequency of alert and loafing behaviours illustrate the advantage gained by juveniles that remain with their parents; i.e. if the parent bird "keeps watch" for potential danger, the juvenile is able to spend more time loafing. The small difference in feeding activity observed in this study is in contrast to the 17% difference reported by Frederick and Klaas (1982) for fall-migrating Snow Geese (juveniles spent more time feeding than adults).

During winter and spring migration, Snow Geese spent most daylight hours sleeping and loafing (Fig. 4). Seasonal variation in the diurnal activity budgets of Snow Geese presumably is related to weather conditions and the annual cycle of the birds. Geese spent a greater proportion of the day sleeping and loafing in winter, when no increase in body weight occurs (Alisauskas 1988) and when there is a need to conserve energy to withstand periods of harsh weather. With the onset of spring migration, geese must begin to accumulate nutrient reserves (fat and protein) necessary for completing migration and for breeding. Furthermore, there is a trend toward milder weather during spring. Thus, during the migration periods, feeding activity would increase while the frequency of resting behaviours decreased.

The diurnal pattern of Snow Goose activity reported here is consistent with that reported for fall-migrating Snow Geese (Frederick & Klaas 1982), as well as for other goose species feeding on waste grain; e.g. Canada Geese (Bossenmaier & Marshall 1958, Raveling *et al.* 1972), Greylag Geese *Anser anser* and Pink-footed Geese *Anser brachyrynchus* (Newton *et al.* 1973). The pattern generally is bimodal, with early morning and late afternoon peaks in feeding activity, and a mid-day resting period.

Snow Geese used a number of different habitats in the middle Missouri River valley, but they spent most of the day on untilled corn stubble and soybean stubble and at roost sites. Seasonal differences in habitat use are related to differences in Snow Goose activity on the various habitats and, therefore, correspond to seasonal differences in the diurnal activity budget. The use of roost sites was greatest during winter when sleeping and loafing activities occurred most frequently. Furthermore, the use of roost sites decreased during the migration period as geese spent more time sleeping and loafing in fields, particularly soybean stubble. The increased use of feeding areas (corn stubble, pasture and winter wheat) during the migration period reflects increased feeding activity.

The amount of time geese spent in pasture and winter wheat fields was relatively low, but this does not necessarily indicate that these habitats are not important to Snow Geese. Heavy feeding did occur in pasture and winter wheat fields when they were used (Fig. 5). Geese possibly feed on these grasses to acquire essential nutrients not available from corn. For example, corn protein lacks the essential amino acids tryptophan and lysine, as well as an adequate amount of methionine (McDonald *et al.* 1973). McLandress and Raveling (1981) suggested that corn carbohydrate may not be assimilated completely by geese on an exclusive corn diet. Bromegrass and winter wheat may provide proteins necessary for the enzymatic activity required for more complete conversion of corn carbohydrate to fat. If the requirement for such essential nutrients is low, the amount of time spent on these habitats also would be low.

Clearly, the primary food consumed by wintering and spring migrating Snow Geese was corn. The data support the hypothesis that the availability of waste corn in the middle Missouri River valley influences the winter distribution of Snow Geese. The number of geese that remain and the length of time they stay at mid-latitude wintering areas are influenced by weather conditions, particularly snow cover. Snow Geese can withstand extremely low temperatures, but will do so only so long as waste corn is accessible. When snow cover reaches 15 cm or more, geese are unable to feed and move south. It seems, however, that a portion of the mid-continental Snow Goose population never reeaches the Gulf Coast during winter. That is, a considerable number of geese winter at the snow line. Heavy snow cover may cause geese to move out of the middle Missouri River valley, but only temporarily; with a change to milder weather, geese promptly return to mid-latitude wintering areas.

Why do some Snow Geese winter at mid-latitudes where weather conditions are unpredictable and, at times, may be severe? Drent *et al.* (in Owen 1980:134) suggested that "the movements of geese during . . . the year were determined by the profitability of feeding in terms of net energy intake". Corn is a very high-energy food compared with that available in Gulf Coast feeding areas (rice fields and saltmarshes). In addition, corn is easy to collect and geese are able to gather their daily food requirement in a relatively short time. Geese that graze on grass or dig up rhizomes of saltmarsh plants spend considerably more time per day feeding (Burton & Hudson 1978, Owen 1980). Snow Geese wintering in the middle

Missouri River valley spent an average 2 h per day feeding. This is in sharp contrast to the feeding activity of Snow Geese observed in Texas and Louisiana; Alisauskas (pers. comm.) estimated that Snow Geese feeding in rice fields and saltmarshes spent approximately 9.0 h and 5.4 h, respectively, obtaining their daily food requirements.

Although a harsher climate places greater energy demands on geese wintering in the middle Missouri River valley, by feeding on corn, geese are free to spend most of the day in energetically inexpensive activities such as loafing and sleeping. If geese are able to maintain good body condition through the winter, there may be an advantage to wintering at mid-latitudes. In addition to conserving the energy that would be expended by flying to the Gulf Coast, geese wintering in the middle Missouri River valley are at the leading edge of the wave of spring migration and may be among the first birds to arrive at the breeding grounds, a position that could afford those geese a reproductive advantage.

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