ACTIVITY BUDGETS OF CANADA GEESE DURING BROOD REARING

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ABSTRACT.—We studied the diurnal activity budgets of adult female Great Basin Canada Geese (*Branta canadensis moffitti*) and their broods during the rearing seasons of 1983–1984 on the Columbia River in south-central Washington. During the prefledging period, broods and adult females spent ca. 50% of daylight hours foraging. The activity budgets of both adult females and their broods changed dramatically at fledging. Time spent resting and preening increased, while movement and foraging activities decreased. The habitat type used seemed to influence the activity budgets of Canada Geese. Broods that foraged in a fertilized pasture spent less time moving and more time resting than did broods that used only native plant communities. These differences might be related to the increased time required for broods in native habitats to search for adequate foraging sites. However, total time spent foraging and growth rates of broods in the two habitats were similar. *Received 12 April 1988, accepted 4 November 1988.*

ALTHOUGH nesting populations of Great Basin Canada Geese (*Branta canadensis moffitti*) in south-central Washington have been studied in detail (Hanson and Eberhardt 1971, Fitzner and Rickard 1983), the behavior of broods between hatching and fledging remains essentially unknown. Ball et al. (1981: 17) claimed that "biologists know less about the brood-rearing phase than about any other stage of the life cycle of geese in Washington." Furthermore, quantitative data are lacking on the activity budgets of Canada Geese that breed in the lower 48 states. Lieff (1973) and Sedinger and Raveling (1988) provide information on the behavioral activities of smaller subspecies of Canada Goose broods in Canada and Alaska.

Our main objective was to document the activity budgets of adult female Great Basin Canada Geese and their broods on the Columbia River in south-central Washington.

STUDY AREA AND METHODS

Study area.—We studied geese between April and September, 1983–1984, on an 88-km section of the Columbia River (Hanford Reach) that flows through, and is adjacent to, portions of the U.S. Department of Energy's (DOE) Hanford site in south-central Washington. This is the last free-flowing stretch of the Columbia River in the U.S. upstream from Bonneville Dam. The region is characterized by a semiarid climate (16-cm annual precipitation) and steppe vegetation (sagebrush [*Artemisia tridentata*]-grass; Daubenmire 1970).

Twenty-one islands that range from 2.7–135.0 ha occur in the Hanford Reach and provide important nesting and brood-rearing habitat for geese. Most of the shoreline supports natural plant communities dominated by various species of forbs, grasses, and shrub willows (*Salix* spp.). Other trees are scarce. The only agricultural land that adjoins the river is a 4-km section of pasture, orchard, and small grains. This pasture, the Ringold Ranch, has been used as a brood-rearing area for at least 30 yr (Hanson and Eberhardt 1971).

Most of the northern and eastern shoreline is open to the public. However, DOE restricts public access by land on the southern and western shoreline on this section of the river and on the northern 11 islands. Public access is also prohibited on the southern 10 islands during goose nesting season (March–May). The entire Hanford Reach is open to boat traffic, but most boating occurs on the southern 30 km of the study area. Comparatively little human-induced disturbance of broods occurs upstream from Ringold Ranch.

Approximately 200 pairs of geese nest on the islands in the Hanford Reach between March and May (Fitzner and Rickard 1983). Hatching begins in early April and extends through mid-May. Goslings fledge ca. 70 days later (Yocom and Harris 1965).

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Methods.—We captured adult female geese on their nests with a drop net immediately before or during hatching (Eberhardt et al. 1986). Captured adults were fitted with a back-mounted radio transmitter (Dwyer 1972) weighing 40 g (ca. 1% of body mass), a 6.5-cm plastic neck collar, and a metal USFWS leg band. Fingerling tags were placed in the webs of both feet of recently hatched goslings found in nests (Haramis and Nice 1980). Some marked adults and their broods were recaptured in drive traps when the young were 6–8 weeks old.

We relocated radio-equipped adults with broods at least twice a week throughout the rearing season to document general movement patterns. Most geese were located from a boat, although a fixed-wing aircraft was occasionally used when marked adults had made a long or unusual movement. In 1984, we recorded movements and activities of selected broods of radio-equipped adults ($n = 18$) instantaneously at 5-min intervals for periods of 3–8 h. These observation periods began randomly during daylight hours. We selected broods for intensive monitoring so that the activity budgets of all age classes were sampled. An activity category was assigned to each brood based on the behavior of the majority of the brood at a given time. We recorded moving (walking and swimming while not engaging in any other behavior, such as foraging); preening; foraging (aquatic and terrestrial); and resting (inactive or sleeping). We also recorded drinking and brooding; however, because of the short duration of these activities and comparatively long periods between samples, these activities were excluded from our analysis. Behavioral observations were not made on adult females or goslings after fledging while they foraged in agricultural fields located away from the river. Hourly averages of wind speed, barometric pressure, temperature, relative humidity, precipitation, and cloud cover were calculated for comparison with brood activities from a meteorological station located on the Hanford site ca. 20 km from the center of the study area.

Analysis.—We assumed that the instantaneous activity samples obtained at 5-min intervals adequately represented the actual proportion of time-in-activity (TIA) of the adult females and broods: TIA $= x/n$, where x was the number of observations in a given activity and n was the total number of observations. Time sampling at 5-min intervals provided an unbiased estimate of the actual TIA of captive white-tailed deer (*Odocoileus virginianus*) (Jacobsen and Wiggins 1982).

The percentage of TIA and duration of activity bouts were summarized by 10-day age intervals beginning with hatching. Because sampling was not distributed equally among gosling age classes, we calculated unweighted means for most measurements made on marked adults and their broods. In calculating the duration of activity, we assumed that each instantaneous 5-min observation represented the type of activity that had occurred during a 5-min period centered on the observation time. Duration of activity was estimated only for the major time-consuming activity, foraging, because of the relatively long time interval between observations.

Repeated observations on the same group of marked adults and their broods over time leads to some complications in analysis, because of a lack of statistical independence. This lack of independence complicated statistical analyses. During the prefledging period, the estimated proportion of time spent in a given activity and the duration of that activity for each brood and adult female were regressed separately on age (number of days since hatching) if more than two observation periods of ≥ 1 h in length were made. We pooled the slopes of these regressions for each activity and age category (adult female or brood) and tested (t-test) to determine if the population of slopes differed significantly from zero (i.e. whether the proportion of time spent in a given activity or the duration of that activity increased, decreased, or stayed the same during the prefledging period). Contingency table analyses were used to determine if the distribution of TIA or duration of activities changed significantly between the pre- and postfledging periods for adult females and broods. Data expressed as proportions were transformed (2 arcsin $\sqrt{Y}$) before performing parametric statistical analyses (Neter et al. 1983).

Results

Forty-one adult female geese were captured and equipped with radio transmitters, 10 in 1983 and 31 in 1984. Ten females either deserted their nests as a result of our activities or lost their broods within 1–3 days of capture. Fifteen females fledged at least one young. The activity budgets of marked adult females and their broods were monitored for 215 and 244 h, respectively. Because of the gradual loss of broods during the rearing season, sampling was not distributed evenly across all brood age classes.

Juvenile activity budgets.—The activity budgets of juvenile geese were significantly different ($\chi^2 = 140.2$, $P < 0.001$) between the pre- and postfledging periods while the geese were on the river. Changes in activities of broods were most apparent at or near fledging (Table 1).

Foraging was the predominant diurnal activity of juvenile geese (Table 1). During prefledging, broods foraged between 28–61% of the time. The proportion of time foraging decreased ($t = -2.50$, $P = 0.03$) between hatching and fledging. Foraging activity by goslings was highest in the morning and lowest in the late evening (Fig. 1). During prefledging, the average duration of a foraging bout ($\bar{x}$ = 15 ± 3 min) did not change significantly (t = −0.52, P = 0.61) with gosling age (Fig. 2). Both the percentage of time goslings spent foraging (Table 1) and the average length of a foraging bout (Fig. 2) seemed to decrease substantially for a short period of time at fledging. Most foraging by broods (96% of 1,404 observations of foraging goslings) took place on the river shoreline rather than in water. After fledging, juveniles began to fly to and forage in agricultural fields near the river.

Before fledging, goslings spent from 25–38% of the diurnal hours moving, generally from one foraging site to another (Table 1). The proportion of time devoted to movement did not change significantly (t = 1.11, P = 0.29) during prefledging. A substantial drop in movements (excluding flying) by juvenile geese while on the river followed fledging (Table 1). Gosling movements were highest during midday and late evening (Fig. 1). There was no relation between gosling age and time spent moving (Table 1). Although goslings spent more time foraging on land than in water, they used the river more frequently (64% of 753 observations) than land for moving. An apparent relation existed between gosling age and type of locomotion (walking or swimming) used (Fig. 3). When moving between sites, goslings ≤20 days old swam less than did older goslings (Fig. 3). Swimming and walking decreased five- to sixfold once juvenile geese could fly (Table 1). Ju-

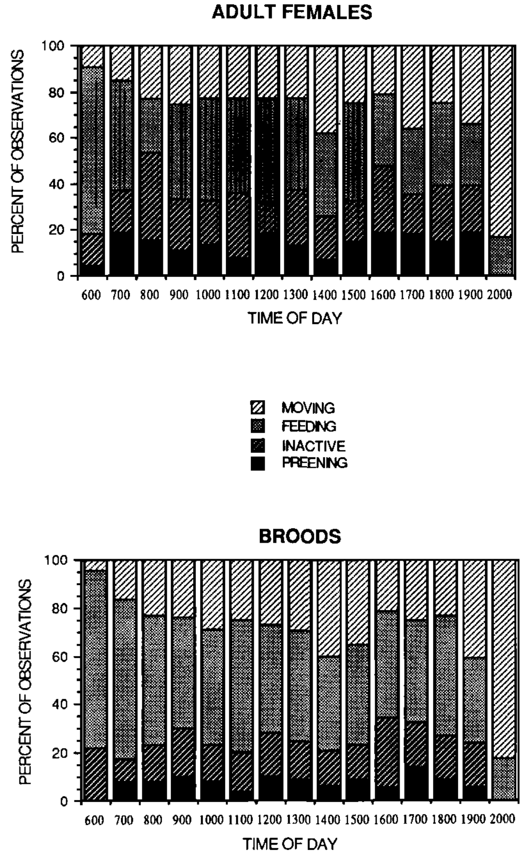

Fig. 1. Percentage of time (unweighted mean) spent by adult females and their broods in various behavioral activities relative to time of day.

TABLE 1. Percentage of time (unweighted mean)[a] spent by adult female Canada Geese and their goslings in various activities relative to age of brood.

Age (days)	No. observed[b]		Feeding[c]		Moving[c]		Resting[c]		Preening[c]	
	Broods	Adult	Gos.	Adult	Gos.	Adult	Gos.	Adult	Gos.	Adult
0–10	11 (63)	7 (39)	64 (6)	57 (5)	25 (6)	27 (5)	6 (1)	8 (2)	3 (1)	8 (2)
11–20	8 (44)	6 (34)	61 (4)	57 (3)	30 (4)	26 (5)	6 (2)	10 (4)	3 (1)	7 (1)
21–30	4 (22)	4 (21)	49 (9)	42 (8)	28 (6)	28 (7)	18 (6)	22 (5)	5 (1)	8 (2)
31–40	6 (18)	6 (18)	50 (5)	39 (6)	38 (8)	39 (7)	9 (5)	13 (3)	3 (2)	9 (3)
41–50	7 (32)	7 (32)	53 (5)	38 (7)	21 (4)	21 (4)	20 (5)	29 (6)	6 (2)	12 (3)
51–60	1 (5)	1 (5)	51	34	29	28	19	31	2	6
61–70	6 (35)	6 (37)	28 (7)	21 (7)	25 (7)	23 (8)	35 (7)	32 (4)	13 (3)	24 (5)
71–80	1 (5)	1 (5)	66	46	2	2	18	28	15	25
81–90	1 (5)	1 (6)	44	33	7	7	44	44	7	16

[a] Mean percent time in activity estimated for each brood or adult female of a given age class observed for >1 h, then overall mean of the means calculated for each age class.

[b] Total number of hours observed are in parentheses.

[c] SE are in parentheses.

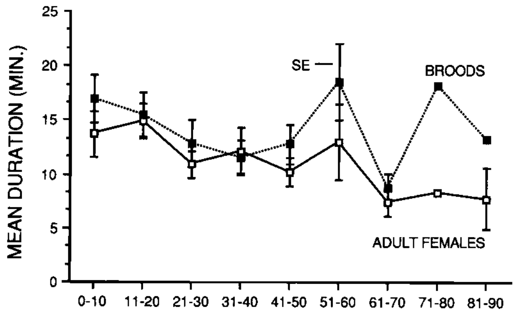

Fig. 2. Duration of foraging bouts (unweighted mean) for adult females and their broods by age of brood.

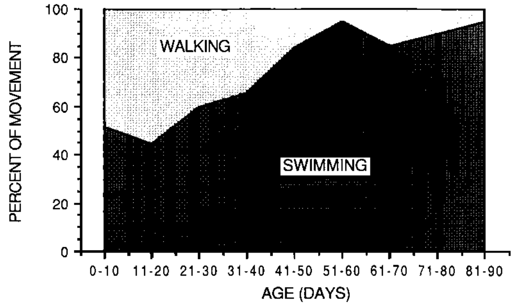

Fig. 3. Percentage of movements by broods that involved walking and swimming relative to brood age.

venile geese were first observed flying during the last week of June at the earliest known age of 75 days post-hatch.

Goslings spent from 6–35% of their prefledging time resting. During prefledging, the proportion of time goslings rested increased significantly (t = 3.17, P = 0.02) with age (Table 1). Juvenile geese spent comparatively little time preening before fledging. Preening activity increased almost threefold following fledging (Table 1). Preening frequency (Table 1) did not change significantly (t = 0.70, P = 0.50) with age during prefledging. Gosling preening occurred throughout the day except during early morning and late evening (Fig. 1).

At any given time, the behavioral activity of the brood generally reflected that of the adult female. In only 22.2% of the 5-min observations (n = 2,360) did brood behavior differ from that of the adult female.

Brood activities were correlated with barometric pressure and degree of cloudiness (Table 2). In general, little or no relation was found between the time spent in various activities by broods and either temperature or relative humidity. Rain and wind also correlated poorly with brood activities, but brood observations were often precluded on days of high winds or heavy rainfall.

Adult female activity budgets.—The activity budgets of adult females with broods were significantly different (χ^2 = 98.9, P < 0.001) between the pre- and postfledging stages of their young. Early in the brood-rearing season, adult females spent a large proportion of their time foraging, but foraging decreased significantly (t = −5.2, P = 0.01) with increasing age of the goslings (Table 1). During prefledging, adult females foraged from 21–56% of daylight hours. The average duration of a foraging bout by adult females (Fig. 2) during this period (13 ± 2 min) did not change with the age of their broods (t = −1.67, P = 0.12). Adult female diurnal foraging was highest in early morning and midday, and lowest in late evening (Fig. 1).

The percentage of time adult females spent moving remained relatively constant (t = −0.10, P = 0.92) during prefledging. At fledging, adult movement substantially decreased (Table 1). Diurnal movement of adults was lowest during early morning and highest in late evening (Fig. 1).

The percentage of time adults spent resting seemed to increase during prefledging (Table 1), although this change was not statistically significant (t = 2.45, P = 0.09). The level of diurnal resting demonstrated by adults was highly variable with time of day, although females appeared to be most active during early morning and late evening (Fig. 1).

Preening activity by females was approximately twice that of their broods (Table 1), but was still comparatively low during prefledging. When their broods fledged, however, females preened more (Table 1). The time females preened did not change with gosling age during prefledging (t = 1.49, P = 0.23). Preening was most frequent in the morning and evening (Fig. 1).

As noted with broods, the time spent by females in various activities was most highly correlated with barometric pressure and cloud cover (Table 2). In contrast to their broods, significant correlations also were noted between adult female foraging, and temperature and wind. The time spent foraging was corre-

TABLE 2. Spearman-rank correlations between percentage time-in-activity and environmental parameters for adult female Canada Geese and their broods. * = $P < 0.05$, ** = $P < 0.01$.

Environmental parameter[a]	Adult females		Broods	
	Prefledge	Postfledge	Prefledge	Postfledge
		Foraging		
TEMP	−0.21*	0.04	−0.09	0.07
RHUM	−0.02	−0.09	0.03	−0.01
BPRES	0.17	−0.60**	0.12	−0.65**
SKCOV	0.11	−0.16	0.20**	−0.32*
RAIN	−0.02		0.07	
WIND	0.24**	0.29	0.07	0.18
		Moving		
TEMP	0.14	0.04	−0.02	0.00
RHUM	−0.03	−0.12	0.00	−0.10
BPRES	−0.18*	0.36*	−0.14	0.38*
SKCOV	0.00	−0.10	−0.10	−0.14
RAIN	−0.03		−0.04	
WIND	−0.16	−0.01	0.01	0.02
		Inactive		
TEMP	0.03	−0.01	0.18*	−0.03
RHUM	0.05	0.16	−0.04	0.11
BPRES	−0.08	0.06	0.13	0.24
SKCOV	−0.04	0.35*	−0.14	0.51**
RAIN	0.07		−0.12	
WIND	−0.07	−0.22	−0.13	−0.27
		Preening		
TEMP	−0.02	−0.11	0.02	−0.08
RHUM	0.06	0.08	0.13	0.04
BPRES	−0.07	0.32*	0.00	0.21
SKCOV	0.10	0.03	−0.02	0.15
RAIN	0.05		0.03	
WIND	−0.06	−0.09	−0.12	0.05

[a] TEMP = temperature, RHUM = relative humidity, BPRES = barometric pressure, SKCOV = sky cover.

lated negatively with temperature and positively with wind (Table 2).

Influence of habitat on activity budgets.—The time allocated to various activities differed significantly ($\chi^2 = 21.1$, $P < 0.001$) during prefledging between broods that had access to the grazed pasture at Ringold Ranch and those that did not (Fig. 4). The percentage of time devoted to foraging and preening was identical in the two areas (Fig. 4). In addition, the duration of preening and foraging bouts by broods in the two areas was not different (Wilcoxon two-sample test; $P = 0.48$ and 0.66, respectively). However, broods that foraged in the pasture spent less time moving and more time resting than broods that used only native habitats (Fig. 4). The duration of moving bouts was also significantly shorter (Wilcoxon two-sample test, $P = 0.05$) for broods that used the pasture, but the duration of inactivity bouts between the two areas did not differ ($P = 0.07$).

We found significant differences ($\chi^2 = 69.3$, $P < 0.001$) in the time broods near Ringold Ranch devoted to various activities when they used the pasture and when they used surrounding native habitats (Fig. 5). These resident broods spent nearly twice as much time foraging in the pasture than when they foraged elsewhere (Fig. 5). In addition, they devoted less time to moving and resting states when the broods were using the pasture (Fig. 5). Preening activity was approximately the same whether the broods were on or off the pasture (Fig. 5).

DISCUSSION

Activity budgets.—Dramatic changes in the activities of both adult Canada Geese and their broods occurred when the young fledged (ca. mid-July). Resting and preening increased, while movement and foraging decreased. The substantial increase in preening by both adult

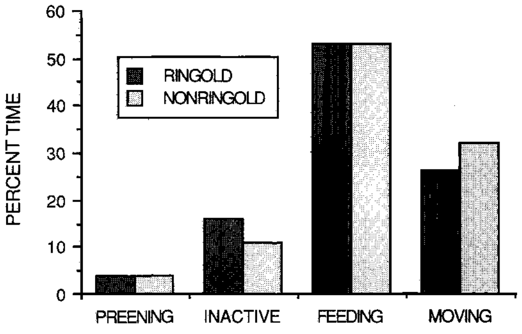

Fig. 4. Percentage of time spent in various activities by broods that used the Ringold Ranch pasture and those that did not.

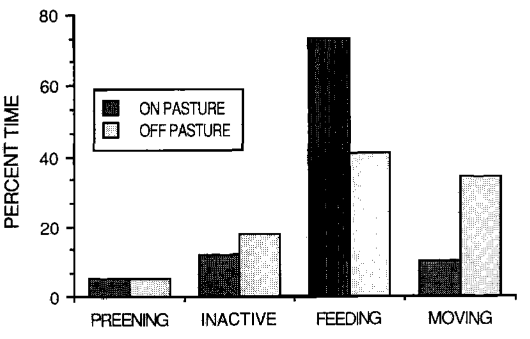

Fig. 5. Percentage of time spent in various activities by resident broods in the vicinity of the Ringold pasture when on and off the pasture.

and juvenile geese was probably related to the nearly complete growth of new feathers and increased use of flight feathers. The initiation or regaining of flight capabilities apparently resulted in a temporary decrease in diurnal foraging by both broods and adult females.

Yocom and Harris (1965) reported that young captive Great Basin Canada Geese began to fly when they were 65–70 days old. We did not observe wild goslings flying until they were at least 70 days old. The primaries of recaptured, web-tagged goslings ($n = 9$) between the ages of 60–64 days were <50% fully grown. Known-age juvenile geese were first observed to fly between the ages of 75 and 80 days. Hanson (1965) reported that molting adult geese could begin flying when the primaries had reached ca. 85% of full length. A higher quality diet for captive geese may account for differences in fledging times.

Foraging dominated the diurnal activities of Canada Geese during brood-rearing, which reflects both the relative inefficiency of their digestive system (Harwood 1977) and special seasonal energy requirements. After incubation, when birds foraged sparsely, the body reserves of adult females were severely depleted (Raveling 1979). In some Arctic-nesting geese, this depletion was so severe that females occasionally died from starvation during the latter stages of incubation (Ankney and MacInnes 1978). As a result, adult females must feed heavily after their young hatch. Goslings, especially among the more northerly subspecies of nesting Canada Goose, must grow rapidly to be prepared for subsequent migration.

The geese we observed appeared to spend less time foraging than other species or subspecies of geese that nest in more northern areas. On our study area (46°N) adult females and their young spend ca. 7–8 h/day foraging. At 61°N, Cackling Canada Goose (*B. c. minima*) broods foraged ca. 12 h/day (Sedinger and Raveling 1988), Richardson's Canada Geese (*B. c. hutchinsii*) ca. 15–16 h/day (Lieff 1973), and Lesser Snow Geese (*Chen c. caerulescens*) ca. 17 h/day (Harwood 1977). We do not know why foraging times differ between southern and northern nesting species of geese. The climatic differences between the regions and substantial physical contrast between northern and southern nesting geese undoubtedly influence behavior.

Sedinger and Raveling (1988) observed that the length of foraging periods increased with gosling age for Cackling Canada Geese in Alaska. They attributed this to a gradual seasonal reduction in the availability and quality of food. This was not the case for goslings in Washington, because both time spent foraging and duration of foraging bouts for 1–10-day-old goslings were near the maximum observed during the brood-rearing period. Differences in sampling techniques may, at least partially, explain the disparity between our results and those of Sedinger and Raveling (1988). We used instantaneous sampling at 5-min intervals which was less precise than continuous observation (Sedinger and Raveling 1988). Other possible influences include differences in the quantity, quality, or phenology of forage between the two study areas.

Influence of habitat on activity budgets.—Lieff (1973) found that wild Canada Geese strongly preferred to forage in artificially fertilized areas in northern Canada and that captive goslings that fed on fertilized tracts grew faster than those that fed on unfertilized tracts. In addition, Harwood (1977) found a positive correlation between the foraging rate of Lesser Snow Geese and the protein content of their forage. The percentage of time spent foraging by Canada Geese was substantially higher when they foraged on the fertilized pasture, where the protein content of the forage was significantly higher (Eberhardt 1987), than when they foraged in natural habitats. When these geese foraged on native plants, however, the total time spent foraging was less than for birds that used only natural forage throughout the rearing season. We noticed no difference between the overall percentage of time spent foraging during the prefledging stage for broods that used the pasture and those that did not (Fig. 5). No evidence of a weight difference between goslings that used the pasture and those that did not (Eberhardt 1987) was found. This implies that the quantity and quality of natural forage on the study area were adequate to meet the nutritional needs of goslings. Natural food sources were more patchy in distribution, which might account for the fact that broods without access to the pasture spent more time moving than broods with access (Fig. 5). The preference demonstrated by resident broods to forage in the pasture (Eberhardt 1987) was probably related to the higher protein content of the forage. An alternative is that it was due to the openness of the pasture and an increased sense of security. However, we made no direct measure of viligance.

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