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Comparison of activities within families and pairs of wintering Canada Geese.—Canada Geese (*Branta canadensis*) have strong family bonds and social hierarchies. Interactions within and among families of geese and dominance relationships have been described in many earlier studies (e.g., Raveling 1969, 1970; Prevett and MacInnes 1980; Lamprecht 1986; Black and Owen 1989b). Few studies have examined the effect of such social structure on the allocation of time among activities, such as foraging, resting, and vigilance. These studies usually have addressed parental investment during the breeding season (Lazarus and Inglis 1978, Giroux et al. 1986, Eberhardt et al. 1989). Most families remain intact through the winter (Elder and Elder 1949, Sherwood 1967, Raveling 1969), and adults may continue protective parental behaviors such as vigilance and defense of young. The allocation of time and energy by parental adults and their offspring in winter and the impact of parental investment on their activity budgets have not been adequately described. Extensive marking of Canada Geese in the Mississippi Flyway with neck bands (Sullivan et al. 1989) provided

the opportunity to compare activity budgets of wintering Canada Geese of known age, sex, and family affiliation. This study describes the differences in diurnal activities between adults and their offspring and between adults in pairs within four periods of the non-breeding season.

Study area and methods.—Neck-banded Canada Geese were observed from October through March, 1983–1987, near Swan Lake National Wildlife Refuge, Missouri, a traditional migration and wintering area. Observations were conducted where marked pairs and families were present. Observations were random relative to time of day and reflected the distribution of geese among habitats, which changed seasonally (Austin 1988). Marked individuals of pairs and families were observed for ≥15 minutes to determine differences in activities. Activities of two or more marked individuals in a pair or family were recorded simultaneously every 15 seconds using a 15–60× spotting scope and metronome (Wiens et al. 1970, Altmann 1974). Activities were classified into the following categories (McKinney 1965, 1969): (1) sleep (bill is tucked under wing); (2) loaf (head and neck are reclined on the back); (3) preen; (4) comfort (stretch, shake, or scratch); (5) feed (including all feeding modes such as digging, dabbling, and tipping up); (6) locomotion (swim and walk); (7) high alert (where the neck is stretched upward to full length); and (8) low alert (where the neck is upright but relaxed). Age and sex of individual birds were determined from neck band codes and banding records. Family or pair status was determined by the behavior of marked individuals toward other geese (Raveling 1970) and close association with other marked geese.

Observations were divided among four periods each year, based on conditions recorded locally: (1) early fall (October, during early migration, mild temperatures, and prior to hunting season); (2) late fall (November to freeze-up [which occurred when mean temperatures were <0°C for five or more days], and including the hunting season); (3) winter (freeze-up period); and (4) spring (final thaw, starting when mean temperatures were >7°C for four or more days). For each observation session, the percentage of time spent in each activity was determined for each individual. Differences in time spent in each activity between an adult male and adult female in a pair or between an adult and a juvenile in a family group were determined for each observation session. Within each seasonal period, these differences were tested using Wilcoxon signed-rank tests (Conover 1980), pooling observations from all years and habitat types. These tests were based on differences between two individuals during simultaneous observation sessions rather than based on means between two groups. Because each set of birds was observed simultaneously, variability due to habitat type and environmental factors such as disturbances and weather was eliminated. The influence of family size on activities was not evaluated because of difficulties in accurately identifying total family size in many cases. Habitat type and family size and interaction between these factors may influence activities (Gregoire 1985, Lamprecht 1986, Black and Owen 1989b); however, pooling of observations from different habitats and of all family observations may minimize these potential effects on activities.

Results.—Juveniles and adult males within families differed fairly consistently in their allocation of time to feeding and vigilance (alert behavior) (Table 1). I did not test differences in winter because of the small number of simultaneous observations; however, differences were similar to those in other periods. Juveniles allocated significantly more time to feeding than did adult males in fall and spring. Adult males spent more time at high alert than their offspring in all periods and at low alert in spring. Total time spent alert (low and high alert combined) was significantly higher in adult males in late fall and spring. Adult males and juveniles in families were similar in the time spent in other activities ($P > 0.10$). Similar differences are apparent in the comparisons between adult females and juveniles (Table 1), although only feeding activity in late fall could be statistically tested. In late fall and winter,

TABLE 1

AVERAGE DIFFERENCES ($\bar{x} \pm$ SE) IN THE PERCENTAGE OF TIME SPENT IN VARIOUS ACTIVITIES BY WINTERING CANADA GEESE IN FAMILIES AND PAIRS IN THE SWAN LAKE AREA, 1983–1987

		Families									Pairs				
		Adult males vs juveniles					Adult females vs juveniles				Adult males vs adult females				
Season	Activity	(N)	(h)	$\bar{x}$	SE	P^a	(N)	(h)	$\bar{x}$	SE	P	(N)	(h)	$\bar{x}$	SE	P
Early fall	Sleep	(6)	(5.7)	−6.0	4.7		(0)	(0)				(24)	(30.1)	1.8	5.9	
	Loaf			5.5	5.6									−9.7	5.8	
	Preen			3.5	3.4									5.7	1.6	***
	Locomotion			0.1	0									−0.2	1.1	
	Comfort			−0.2	0.2									0.3	0.2	
	Feed			−0.6	5.4									−1.4	2.3	
	High alert			9.6	4.0	**								1.6	1.6	
	Low alert			2.6	7.4									0	1.8	
	Total alert			12.2	7.6									1.6	1.8	
Late fall	Sleep	(22)	(18.5)	3.3	3.9		(6)	(5.2)	−1.4	2.5		(22)	(20.9)	−2.0	3.2	
	Loaf			−0.9	1.3				2.7	2.2				−5.3	2.4	***
	Preen			−3.4	1.9				0.2	0.6				−1.3	1.8	
	Locomotion			−1.5	1.3				−1.4	0.9				−0.5	0.8	**
	Comfort			−0.4	0.3				0.3	0.2				0.1	0.3	
	Feed			−14.1	4.5	**			−7.7	5.8	**			−0.8	3.4	
	High alert			14.6	2.9	***			10.2	5.1				2.2	1.3	
	Low alert			1.0	4.3				−2.1	2.8				3.9	2.3	
	Total alert			15.6	6.0	***			8.1	6.0				6.1	2.8	

TABLE 1
CONTINUED

		Families									Pairs				
				Adult males vs juveniles					Adult females vs juveniles					Adult males vs adult females	
Season	Activity	(N)	(h)	$\bar{x}$	SE	P[a]	(N)	(h)	$\bar{x}$	SE	P	(N)	(h)	$\bar{x}$	SE	P
Winter	Sleep	(4)	(3.0)	−12.2	5.9		(3)	(3.5)	3.1	0.7		(23)	(24.1)	5.4	4.6	*
	Loaf			6.8	4.0				−0.7	1.2				−5.6	4.4	
	Preen			1.3	1.5				0.6	1.2				1.6	1.3	
	Locomotion			0.3	0.7				0	0				0	0.9	
	Comfort			0	0.4				0.5	0.7				−0.2	0.2	
	Feed			−7.3	7.3				−16.3	8.6				−6.5	2.9	***
	High alert			7.2	6.0				16.0	9.3				4.8	1.5	***
	Low alert			2.4	2.2				0.4	1.9				4.6	2.0	**
	Total alert			9.6	4.5				16.4	7.6				9.4	2.1	***
Spring	Sleep	(9)	(9.0)	−2.3	7.0		(0)	(0)				(17)	(14.2)	−3.5	2.1	**
	Loaf			0.9	2.0									3.6	2.9	
	Preen			1.3	1.4									−1.6	1.8	
	Locomotion			−1.6	1.2									0.5	0.5	
	Comfort			0	0.8									1.1	1.0	
	Feed			−21.3	8.5	**								−4.8	2.6	
	High alert			8.6	3.2	**								2.0	1.4	
	Low alert			10.0	6.8	*								1.4	1.9	
	Total alert			18.6	5.8	**								3.4	2.1	

[a] * $P \leq 0.10$, ** $P < 0.05$, *** $P < 0.01$.

adult females spent less time feeding than juveniles and appeared to spend more time at high alert and in total time alert.

Differences in some activities occurred between paired adult males and females in each period (Table 1). Females spent significantly more time than their mates moving and loafing in late fall and sleeping in spring. Males devoted significantly more time than females to preening in early fall and sleeping in winter, but spent less time feeding in winter. Vigilance varied little between members of a pair except in winter, when males spent significantly more time at high alert and low alert. Differences in total time alert were also significant.

Discussion.—The consistent differences in time spent foraging and vigilant behavior between adult males and their offspring suggest a trade-off between time allocated to the two activities and behavioral costs for continued parental care in the non-breeding season. In wintering Barnacle Geese (*B. leucopsis*) (Black and Owen 1989a) and Lesser Snow Geese (*Anser caerulescens*) (Gregoire 1985), feeding time of parents appeared to be restricted because they devoted more time than non-parental pairs to vigilance and aggression. High vigilance and low foraging time of adults with young also were reported for Snow Geese on the breeding ground (Giroux et al. 1986). The actual cost to the parent (less time available for foraging or maintenance activities), however, may not be significant enough to affect the parent's body condition or survival. Vigilant parents may compensate for less foraging time by increasing their efficiency or intensity of feeding (e.g., food finding or peck rate). Also, Black and Owen (1989a) suggested that continued association of parents with their offspring in spring may increase the parents' chance of breeding in the future due to a "contributor effect," where goslings in the family contribute to vigilance and family defense. This would allow greater foraging time for parents and help minimize the cost of parental care.

The behavioral costs to the parent of increased vigilance may be balanced by benefits to their offspring and future fitness (i.e., better survival of its offspring through the non-breeding season). Vigilance of adult geese acts to maintain family cohesiveness, such as in flight initiation, and in the defense of food patches or family members. Because adult males with families are highest in the social hierarchy of the flock (Raveling 1969, Prevett and MacInnes 1980), vigilance of adult males may reduce the need for juveniles' vigilance and also enhance the foraging opportunities of their offspring through agonistic behavior in defense of food resources (Raveling 1970, Lazarus and Inglis 1978, Scott 1980, Gregoire 1985). In wintering Barnacle Geese, goslings in families grazed for longer periods and were less frequently victims of intraspecific aggression than unattached goslings (Black and Owen 1989a). In Greater Snow Geese (*Chen caerulescens atlantica*) on spring staging areas, lone juveniles spent more time searching and walking and less time foraging than juveniles with families (Turcotte and Bedard 1989). The increased foraging opportunities for juveniles with families may thus result in better levels of nutrition and energy reserves, as indicated for wintering Barnacle Geese (Black and Owen 1989a), and, in turn, in better survival or health during stresses encountered during migration and winter. In ducks, lipid reserves have been related to ability to survive inclement weather (Bennett and Bolen 1978, Whyte and Bolen 1984) and the hunting season (Haramis et al. 1986, Hepp et al. 1986).

Although behavioral trade-offs are less apparent between paired adults, the increased vigilance of males in some periods also may be related to future fitness consequences. As described above for their offspring, vigilance and protection by dominant adult males may enhance survival and foraging opportunities for their mates. Male Canada Geese spent more time vigilant and less time feeding than their mates in winter when environmental conditions were most severe. Lack of differences of vigilance and feeding time in the other periods of this study may be related to the low power of the tests, more moderate environmental conditions relative to winter, and, in late fall, to the higher level of disturbances due to the hunting season.

In spring, enhanced foraging opportunities may be particularly important for adult females because of their reliance on lipid reserves for reproduction (Raveling and Lumsden 1977, Aldrich and Raveling 1983). In both parental and non-parental pairs of wintering Barnacle Geese, males spent less time feeding than their mates, and parental males also spent more time vigilant (Black and Owen 1989a). However, migrant Canada Geese do not begin spring deposition of lipid reserves in preparation for breeding while in Missouri (Austin 1988). Differences in spring foraging and vigilance between mates may be more marked on northern staging areas.

Simultaneous observations of wintering Canada Geese in families and pairs suggest a trade-off between vigilance and feeding. Whether the general patterns reported here differ among habitats, family size, time of day, or later into spring is unknown. Although the data are insufficient for specific hypothesis testing, the results provide preliminary information for further investigations. The interactions within and among families of geese are complex and warrant more detailed examination to understand better family social systems, allocation of time and energy, and parental investments. More thorough studies of the activities and parental investment of nonbreeding geese should evaluate multiple factors, including habitat type, family size, dominance or agonistic behaviors, season, body condition, survival, and future fitness for breeding activity.

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"Foot-quivering" as a foraging maneuver among migrating *Catharus* thrushes.—We have observed a foraging technique ("foot-quivering") among *Catharus* thrushes that, heretofore, had been described only as an aggressive display used during intraspecific encounters. Foot-stirring or paddling behavior has been observed among foraging waders, gulls, and shorebirds