PROTEIN RESERVES DURING STAGING IN GREATER SNOW GEESE

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The quantity of protein reserves available to female ducks and geese at the outset of the breeding season is a determinant of reproductive success in several species (Korschgen 1977, Ankney and MacInnes 1978). Catabolism of muscle proteins by nesting females has been described for Lesser Snow Geese (*Chen c. caerulescens*; Ankney and MacInnes 1978), Canada Geese (*Branta canadensis*; Hanson 1962, Raveling 1979), Common Eiders (*Somateria mollissima*; Korschgen 1977) and Mallards (*Anas platyrhynchos*; Krapu 1981). These proteins may play a role during yolk formation or, to a lesser extent, act as an ultimate energy source (Ankney and MacInnes 1978).

Anatids of several species can store proteins during the pre-nesting phase on the breeding ground. Arctic-nesting geese, however, must store proteins before arriving at their nesting grounds (McLandress and Raveling 1981). The Greater Snow Goose (*Chen caerulescens atlanticus*) nests in the high arctic region and makes a single staging halt in spring in the St. Lawrence river estuary. During six weeks in April and May, the entire population occupies bulrush (*Scirpus americanus*) marshes in the upper part of the estuary. Over the past two decades, concurrent with a great increase in numbers, the geese have also come to occupy cordgrass (*Spartina* sp.) marshes of the lower estuary (Anon. 1981). During this period, they accumulate large fat reserves, and the pattern of fattening differs between birds using the two types of marsh (Gauthier et al. 1984). Since the St. Lawrence estuary is the only major staging ground known for this population, we predicted that protein storage should occur at the same time. We also examined whether protein storage differs between birds using these two habitats, as we established for fat reserves (Gauthier et al. 1984).

STUDY AREA AND METHODS

Two representative sites in Quebec were selected and studied in 1979 and 1980. The first, located at Cap-St.-Ignace and used by a flock of approximately 10,000 birds, was typical of the fresh-water *Scirpus* marshes (SCI) traditionally used by geese. The other, located at Isle Verte, 150 km downriver, was used by a flock of approximately 14,000 geese and was typical of the salt-water *Spartina* marshes (SPA) recently invaded by the birds. At both locations, hayfields adjacent to the tidal marshes were also used by feeding geese (see Gauthier et al. 1984 for details).

We collected a total of 373 geese (only birds two years old or older are considered here) at about weekly intervals from early April until the third week of May. Geese collected within 10 days after the arrival of the first birds seen were called "arriving," whereas those collected during the four days preceding mass departure were called "departing" birds. Protein levels of the two groups were then compared.

In 1979, the right half of the breast muscles, the right leg muscles (including all those originating on the femur,

tibiotarsus or pelvis) and the gizzard were excised. The remaining carcass, excluding the skin, abdominal fat, liver, sternum, pelvis, gonads, and oviduct, was also analyzed. As we found no significant trends in several tissues during the first year (see Results), only the gizzard and the leg muscles were removed in 1980.

Tissues were freeze-dried to constant weight and fat was extracted using the Rafatec method (see Gauthier et al. 1984 for details). In 1980, fat was estimated from water content for leg muscles, because we found a strong correlation between the fat and water content in these muscles in 1979 ($r = -0.92$, $P \ll 0.001$, $n = 222$). The fat-free dry weight (FFDW) was taken as an indicator of protein reserves. Minerals and soluble carbohydrates were assumed to make up a negligible fraction of the mass in all tissues (Drobney 1982), except the carcass.

RESULTS

For both arriving and departing birds, and for both sexes, the fat-free dry weight (FFDW) of breast and leg muscles, and of the carcass did not differ between SCI and SPA birds in most comparisons (t-test, $P > 0.05$). However, the difference was marginally significant ($P = 0.03$) for breast muscles in arriving males in 1979. Data were therefore pooled over habitats for further tests with these tissues. The FFDW of these tissues was not significantly different between arriving and departing birds in either year of the study for both sexes (Table 1).

The FFDW of the gizzard did not differ between habitats in 1979 and therefore data from both habitats were pooled. However, in 1980, the gizzards of arriving males and females were heavier at SPA ($P < 0.01$, Table 1) than at SCI, but this did not hold for departing birds. The FFDW of the gizzard was significantly greater ($P < 0.01$) for arriving birds than for departing ones in 1979 but not in 1980 (except for females at SPA, Table 1). Regression analysis also revealed that in 1979, the FFDW of the gizzard was inversely related to date for both sexes (males, $r = -0.56$, $P < 0.001$, $n = 92$; females, $r = -0.52$, $P < 0.001$, $n = 99$). In 1980, the regression analysis indicated a more complex situation. The correlation was inverse but weak in SPA males ($r = -0.30$, $P < 0.05$, $n = 44$), and SPA females ($r = -0.30$, $P < 0.05$, $n = 34$), but positive in SCI males ($r = 0.30$, $P < 0.05$, $n = 49$), and non-existent in SCI females ($r = 0.07$, $P > 0.05$, $n = 48$).

DISCUSSION

Our results failed to reveal differences in protein accumulation of birds using the two habitats; in fact, we found no increase in protein reserves during the spring staging on the St. Lawrence river. These results could be biased in two ways. First, if geese traveled between our two study areas and/or if departures of geese were not synchronized, protein accumulation could have been masked in our results. However, monitoring of the flocks in spring showed that they were indeed stable, and that birds left the estuary synchronously (J. Bédard, unpubl. data).

Unlike other organs, the carcass included bone tissues and therefore contained a significant amount of mineral. If this fraction was not constant during the spring, it could bias the estimate of protein reserves. However, Gauthier (unpubl. data) found that calcium accumulation in spring is negligible in this species, and that the weight of the sternum, pelvis, and leg bones remains constant. We conclude that the mineral fraction included in the carcass does not introduce a significant bias in protein-level assessment.

Protein accumulation in spring has been described for the Lesser Snow Goose (V. Thomas, pers. comm.) and for the Canada Goose (McLandress and Raveling 1981). In Greater Snow Geese, proteins could still be accumulated on the wintering ground, either before or after the staging halt. Unfortunately, no data on body composition of these geese on the wintering grounds are available. Wypkema

TABLE 1. Fat-free dry weight (FFDW in g) of the right breast and leg muscles, gizzard, and carcass (see text) in Greater Snow Geese at the beginning (Arriving), and the end (Departing) of the staging period in the St. Lawrence river estuary. Data from the two habitats (*Scirpus* marshes, SCI; *Spartina* marshes, SPA) were pooled when there was no significant difference. Differences between means were tested by Student *t*-test, and homogeneity of the variances was respected. Mean ± SE (*n*).

	Males			Females		
	Arriving		Departing	Arriving		Departing
1979						
Breast	65.4 ± 1.4 (25)	NS	65.8 ± 1.5 (25)	60.8 ± 1.7 (28)	NS	64.6 ± 1.5 (12)
Leg	28.9 ± 0.6 (25)	NS	29.0 ± 0.7 (25)	26.1 ± 0.5 (28)	NS	27.1 ± 0.7 (12)
Gizzard	46.3 ± 1.0 (24)	**	38.1 ± 0.8 (25)	44.4 ± 0.9 (28)	**	38.5 ± 0.9 (12)
Carcass	351.0 ± 6.1 (25)	NS	349.3 ± 6.2 (25)	314.5 ± 6.2 (28)	NS	308.4 ± 6.3 (12)
1980						
Leg	26.9 ± 0.6 (25)	NS	28.4 ± 1.0 (11)	25.0 ± 0.6 (18)	NS	25.1 ± 0.6 (14)
Gizzard						
SCI	36.2 ± 1.4 (15)	NS	37.5 ± 1.2 (6)	35.6 ± 1.4 (7)	NS	37.8 ± 1.2 (8)
	**		NS	**		NS
SPA	45.1 ± 1.6 (10)	NS	41.5 ± 2.8 (5)	43.4 ± 1.4 (15)	*	37.9 ± 0.6 (6)

* $P < 0.05$; ** $P < 0.01$; NS, not significant.

and Ankney (1979) reported protein storage in Lesser Snow Geese during their last spring halt along the James Bay coast. From the time when Greater Snow Geese leave the St. Lawrence estuary (third week of May) until they settle on the breeding grounds (second week of June; Lemieux 1959), there is a two- to three-week interval during which their whereabouts are unknown. Potential staging grounds during this period would be at least 5°, and perhaps as much as 20° farther north of James Bay (Anon. 1981). Whether geese could find the nitrogen-rich food plants required as a source of protein in an arctic staging area at this time of the year is doubtful. Indeed, a comparison of our departing birds with the Lesser Snow Geese arriving on the breeding ground (Ankney and MacInnes 1978) suggests that Greater Snow Geese do not accumulate significant protein reserves after leaving the estuary. Our results are within 5% of the protein reserve index (PRI) of Ankney and MacInnes (PRI = dry weight of breast muscles + leg muscles + gizzard; the Greater Snow Goose is about 15% larger than the Lesser but the dry weight of muscles includes about 15% of fat in spring; Gauthier, unpubl. data). Year-round sampling would be required to clarify this point.

The decline in FFDW of the gizzard in 1979 and the variations in 1980 are difficult to explain. Because of the digestive function of the gizzard, its size has been shown to be affected by hyperphagia and fasting (Ankney 1977), and by food quality (Moss 1974, Paulus 1982). This suggests that the gizzard may not always be a good indicator of protein reserves.

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PLUMAGE COLOR CHANGES IN A NIHOA MILLERBIRD (*ACROCEPHALUS FAMILIARIS*)

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On 15 August 1981 at 06:30, while censusing birds on the east slope of Miller Valley on Nihoa Island, Hawaiian Islands, I saw a predominantly white Nihoa Millerbird (*Acrocephalus familiaris*) at a distance of about 150 m. Upon relocating the bird at close (about 4 m) range a few minutes later, I saw that it had been banded with a plastic color band and a U.S. Fish and Wildlife Service aluminum band. A check of the band combination in my records showed that I had banded the bird on 10 June 1980 within 50 m of where I saw it the next year. My records also showed that the bird was an adult (based on complete skull ossification), of normal color (dull brown above, whitish below), and of unknown sex. Its weight and wing length were within the usual range of adult measurements (Conant, unpubl. data). That the bird was singing when I rediscovered it in August 1981 indicates that it was a male, based on my observations of banded birds at 33 active nests. (None of the birds behaviorally identified as females ever sang.) The present individual's plumage was entirely white except for several brown feathers or small patches of feathers on the back. Its iris was dark, probably the dark brown characteristic of this species. I again saw this individual, with an unbanded female, in approximately the same spot on 20 April 1983 for about one minute. On this occasion the bird's plumage was again predominantly brown, but patches of white remained on its flanks, back, and outer primaries. The iris was dark, and the legs and mandibles were grayish to dark brown. According to Harrison (1963) this bird would be considered "leucistic," a condition in which melanin pigments are produced, appearing in the iris and soft parts, but not in the feathers.

At least three cases of **loss** of plumage color in wild (non-domesticated) birds have been documented. Two of these cases involve American Robins (*Turdus migratorius*), one a banded bird that showed patches of white two years after it had been seen with normal plumage (Frazier 1952). The second robin was a normally-colored captive bird that acquired some white plumage (Koch 1877). Root (1944) reported recapturing a Song Sparrow (*Melospiza melodia*) with extensive patches of white only months after it was banded and in normal plumage. I have found no published reports of loss and subsequent recovery of plumage color in a wild bird, such as I observed in a Nihoa Millerbird.

Although the Sylviinae is not a group in which frequent incidences of albinism have been reported (Sage 1963, Gross 1965), some island populations of *Acrocephalus* (e.g., *A. caffer, A. vaughani*) are actually noted for this (Nicoll 1904; Ogilvie-Grant 1913a, b; C. J. O. Harrison, pers. comm.). A recent examination of specimens of *A. atypha* in the American Museum of Natural History by P. L. Bruner (pers. comm.) revealed the presence of several leucistic or albinistic individuals.

The occurrence of partial albinism in wild island populations where inbreeding is naturally high lends credence to Sage's (1962) suggestion that this phenomenon is hereditary. However, the loss and subsequent recovery of plumage color by the Nihoa Millerbird reported here indicates that some environmental factor, e.g., nutrition or a pathological condition, could be a cause of change in plumage color. The Nihoa Millerbird is not noted for frequent occurrence of albinistic or leucistic individuals, and this was the only such individual I saw during about seven months of intensive observation, including banding, of this small population. The case lends support to the idea that plumage color can be changed by environmental rather than genetic causes. Other evidence supporting the hypothesis that the environment or stress can cause change in plumage color has been reviewed by Sage (1962).

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