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Fat Deposition in Spitzbergen Ptarmigan *(Lagopus mutus hyperboreus)*

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ABSTRACT. Fat depots and muscle lipids were measured in ptarmigan shot at Longyearbyen in fall and in spring. In the fall the ptarmigan weighed 740 g of which 100 g was dissectable fat and 11.5% of the pectoralis dry weight was lipid. In the spring the fat depots were almost absent and muscle lipid was halved. Neither Alaskan nor Scandinavian rock or willow ptarmigan show comparable fat depots, but the muscle lipid levels compare favourably with values obtained for Spitzbergen ptarmigan. Even larger fat depots were found in the Spitzbergen reindeer and fall fat deposition is most likely an important metabolic adaptation in high-arctic herbivores.

INTRODUCTION

The only native herbivores wintering in Spitzbergen (the largest island of Svalbard) are Spitzbergen reindeer (*Rangifer tarandus platyrhynchus*) and Spitzbergen rock ptarmigan (*Lagopus mutus hyperboreus*). These animals are subjected to a prolonged scarcity of food in winter which may be completely inaccessible for periods of days or weeks due to ice covering the ground.

The Spitzbergen reindeer have adapted to these extreme conditions by depositing impressive subcutaneous and interintestinal fat depots in the fall (Øritsland; 1970, Krog *et al.*, 1976). These depots, calculated to cover the basal metabolism for up to 2 months, may be completely exhausted in May if the foraging situation has been poor during the winter (Lund-Larsen, pers. com.). The only information on fat deposition in the Spitzbergen rock ptarmigan is given by Johnsen (1941) who states that they are fatter in the fall than in the spring. Studies on the Scandinavian willow ptarmigan and rock ptarmigan show that these birds never deposit fat of any significance and that they always have a rather low concentration of lipids in the muscles (West and Meng, 1968; Myrberget and Skar, 1976). We have measured the body composition of the Spitzbergen rock ptarmigan in the autumn and in the spring. The result gives information on the extent of fat depots and contributes to the understanding of the biology of herbivores living under extremely demanding winter conditions.

Ptarmigan were shot near Longyearbyen on Spitzbergen (78°N, 16°E) in September and in April. The birds were kept frozen in plastic bags until dissected and may have suffered dessication during storage. All birds were dissected in June. The breast muscles (M. pectoralis and M. supracoracoideus) and visible adipose tissue was dissected carefully out as

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described for the willow grouse (Grammeltvedt, 1978). Most adipose tissue of the Spitzbergen ptarmigan is in clearly defined fat pads, but there is also some fat visibly infiltrated in the skin. It is difficult to evaluate the amount of the latter fat, but it probably constitutes a few grams only, even in a very fat bird. This fat is absent in birds with small fat pads. Dry weights of muscles were found by freeze-drying or ovendrying. Lipid contents of muscles were determined as the material extracted into ether during 18 hours in a Soxhlet apparatus (Grammeltvedt, 1978).

The total body weight is the weight at the time of dissection. The non-adipose body weight is total body weight minus the weight of crop contents and dissected adipose tissue.

Table 1 shows the results. Since the available material was small the data are given as means without consideration of age or sex of the birds. However, the age and sex compositions of the two groups were similar.

The weight of the autumn shot birds averaged 740 g which is within the range given by Johnsen (1941), whereas the spring birds weighed 150 g less. About 100 g of this decrease is due to depletion of fat depots, 32 g to reduced skin and plumage weight, 9 g to reduced crop content and the rest to reduction in the weight of muscles and other tissues. The dry weight of the breast muscles was reduced by 2% from autumn to spring. The lipid content of the breast muscles of the spring birds was about 4% of the fresh weight. This compares favourably with values on lipid content in wild Norwegian willow

TABLE 1. Body weights (g) and body compositions of autumn and spring shot Spitzbergen ptarmigan. Mean ± Standard deviation (number of birds).

	Autumn	Spring
Total body weight	741 ± 89 (7)	591 ± 23 (8)[a]
Dissected adipose tissue	99 ± 32 (7)	5 ± 7 (8)[a]
Crop content	22	13
Non-adipose body weight	620 ± 66 (7)	573 ± 22 (8)[b]
Weight of skin with feathers	130 ± 25	98 ± 14 (6)[b]
Dissected adipose tissue, % of non-adipose body weight	15.9 ± 4.0 (7)	0.8 ± 1.3 (8)[a]
Dry weight of breast muscles	34.1 ± 5.1 (6)	32.1 ± 2.7 (5)
Dry weight of breast muscles, % of non-adipose body weight	5.6 ± 0.3 (6)	5.7 ± 0.3 (5)
Lipid contents of the breast muscles, % of dry weight	11.5; 12.2 (2)	5.9; 8.3 (2)

a. Significantly different ($P < 0.002$) from value of ptarmigan shot in autumn (by Mann-Whitney U test).

b. Significantly different ($P < 0.04$) from value of ptarmigan shot in autumn (by Mann-Whitney U test).

ptarmigan (Myrberget and Skar, 1976). In spring birds the lipid content was about 2% of the fresh weight. The water content of breast muscles was higher in the spring than in the fall (71.1 ± 1% vs. 65.7 ± 1.7%) which is probably due to dessication during storage.

Grammeltvedt (1978) followed the composition of domestic Norwegian willow ptarmigan during 5 days of fasting. These birds rarely have more than 20 g of adipose tissue (which is 4-5 times more than found in wild birds). These stores are used during the first 2 days of fasting. From then on a striking reduction in dry muscle weight was recorded. The slight reduction in pectoralis weight in Spitzbergen rock ptarmigan from fall to spring indicates that they had not been exposed to severe starvation immediately prior to when they were shot.

The 100 g of adipose tissue typical of a Spitzbergen ptarmigan in the autumn, will give some 700-800 kcal of metabolic energy. If the Spitzbergen ptarmigan have approximately the same resting metabolism as the Alaskan rock ptarmigan (Moss, 1973) or the Alaskan willow ptarmigan (West, 1968), this store would suffice for little more than 10 days of complete starvation provided a low level of activity. The Sptizbergen ptarmigan is, in fact, remarkably docile (Løvenskiold, 1964). During most of the winter the Spitzbergen ptarmigan obtain some food from ridges where the snow has blown away (Johnsen, 1941). This may provide the carbohydrate necessary to metabolize the fat.

It is interesting to note that both of the two herbivores of arctic Spitzbergen have larger fat depots than the corresponding races or species of subarctic Scandinavia and Alaska. These depots may be of crucial importance for the survival of these animals. Future studies of fat depots in carnivores will reveal if fall deposition of fat is a general adoptation in animals inhibiting barren areas during the winter.

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