Seasonal changes in crop content of the Svalbard Ptarmigan *Lagopus mutus hyperboreus*

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Crop contents of Svalbard Ptarmigan have been examined. For chicks younger than 25 days the crops contained almost exclusively bulbils of *Polygonum viviparum*. High incidence of this food item was also found in crops from adult birds during late summer and autumn (July–October). Midwinter (November–February) crops contained a mixture of plant species dominated by herbs like *Saxifraga oppositifolia* and *S. cespitosa*, but with a significant contribution from *Salix polaris*. The proportion of *S. polaris* increased throughout the winter and became highly dominant in spring (May–June). During all seasons the birds ingested plant parts of high nutritional value. The change in crop content from *P. viviparum* to *S. polaris* via different herbs was associated with a decrease in the content of crude protein from 20–25% in July–August to about 16% in March–April, and a corresponding increase in crude fibre from about 10% to about 15%. The content of inorganic constituents (P, Mg, Ca, K, Na) varied insignificantly with season and was fairly high.

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Animals of the Svalbard archipelago are of special biological interest because of the extreme environmental conditions to which they are adapted. The northern location (77°N to 81°N) implies four months of midnight sun during summer and two months of continuous darkness during winter. The islands are to a great extent covered by ice, which is penetrated by numerous sharp-pointed mountains known as nunataks. Vegetation and animal life is therefore concentrated upon the coastal plains and mountain sides.

The Svalbard Ptarmigan (*Lagopus mutus hyperboreus*) is the only non-migratory, herbivorous bird in Svalbard. The food of this bird has been the subject of several articles (Ekstam 1897; Høeg 1929; Løvenskiold 1964; Byrkjedal 1975) dealing with summer and early autumn only, with no mention of the nutritional value of the food eaten.

The vegetation of Svalbard comprises a total of 164 species of vascular plants, few of which reach 15 cm above ground (Rønning 1979). Few of them are abundant enought to be of importance as food for herbivores. The vegetation of the Brøggerhalvøya peninsula at northwestern Spitsbergen, a representative Svalbard Ptarmigan area, has been mapped by Brattbakk (1981), the dominating types being *Saxifraga oppositifolia–Cetraria delisei* heath (45% cover) and *Kobresio–Dryadion* heath (10% cover).

In the present study we have examined the food eaten by the Svalbard Ptarmigan by botanical and chemical analysis of crop contents from birds shot throughout the year in Svalbard.

Material and methods

Crop contents from a total of 167 (91 cocks, 76 hens) fully grown Svalbard Ptarmigan and 14 chicks less than 25 days old were examined. The birds were shot throughout the year at Ny-Ålesund (79°N, 12°E) and Longyearbyen (78°N, 16°E), in the period from September 1979 to November 1981.

The dead birds were kept frozen at −20°C in plastic bags until processing. Botanical analyses were performed on samples of fixed volume (3 ml) from each crop. The samples were separated into plant species and plant parts. After separation the samples were dried at 80°C and grouped according to month of the year and sex of the bird. Species samples from each group were

pooled after drying and weighed to the nearest milligram on a Mettler PC 180.

Chemical analyses of the crop contents were performed at the Holt Agricultural Research Station, Tromsø. After samples for botanical analysis were taken, the residual crop contents were pooled according to month and sex. Water content was determined by drying to constant weight at 80°C. Nitrogen was determined by the Kjeldahl method, using copper oxide as catalyst. Crude protein was obtained by multiplying by 6.25. Crude fibre was determined according to the Weende method, using glass wool filtration. Crude fat was obtained by extraction with diethyl ether in a soxhlet apparatus. Determination of ash was made by heating the samples overnight at 450–500°C. Inorganic phosphorus was determined spectrophotometrically according to Gericke & Kurmies (1952). Ca, Mg, Na, and K were measured by atomic absorption spectrophotometry (Perkin-Elmer model 300).

In order to achieve the amounts of material needed for the botanical and chemical analyses it was necessary to pool the contents of several crops. Unfortunately, the possibility to perform a meaningful statistical treatment of the results was thereby strongly restricted.

Results

Botanical composition

A high proportion of the crop contents could be determined to species, in some instances to genera or to a group of species. A total number of 83 different plant species were identified, including 36 vascular species, 34 mosses, 4 hepatics, 8 lichens and one parasitizing fungus. The most important species are shown in Table 1.

During mid-winter (November–February) the crop content of the Svalbard Ptarmigan was very varied (Fig. 1, Table 1). It contained mainly herbs, *Saxifraga oppositifolia* and *S. cespitosa* being predominant. Buds and twigs of *Salix polaris* formed a low proportion of the crop content in both sexes. *Polygonum viviparum* was almost non-existent in the crop content during this period, probably due to low availability.

In March–April *Salix polaris* made up more than 50% of the crop content of both sexes; its proportion increased further during spring, and in May–June this plant formed 90% of the food of the cocks. The crop content of the hens was apparently more varied and *Saxifraga oppositifolia* was subdominant. The weight increase in hens prior to egg-laying in June (Steen & Unander 1985) is mainly based on *S. polaris* as food. From the end of June green leaves of *S. polaris* were most important for both sexes, especially for hens during the egg-laying and incubation periods.

Dryas octopetala was an important forage species from November to April, while it was almost neglected from May to October. The Svalbard Ptarmigan showed a high degree of selectivity by eating only the small greenish leaflets of *Dryas* surviving the winter. The ingestion of *Dryas* may be explained by the fact that it grows on ridges and is thus available during the winter months. Nine crop samples from March to May contained the large rhizomes of *Polygonum viviparum*, the only typical geophyte in Svalbard.

In July the crop content changed significantly. The incidence of *Salix polaris* decreased and summer organs of herbs constituted the main content. Bulbils of *Polygonum viviparum* were the most abundant food item, but leaves of *S. polaris* were still important. For 14 chicks younger than 25 days, 94% of the crop contents was bulbils of *P. viviparum* and 6% a mixture of leaves and fruits of *Saxifraga oppositifolia* and leaves and bulbils of *Saxifraga cernua*. No insects were found in the chick crops. Bulbils of *P. viviparum* and leaves of *S. polaris* and different herbs were the main food of hens in August when the autumnal fattening started (Mortensen et al. 1983). The crops of cocks contained comparatively fewer bulbils of *P. viviparum* and their crop content was apparently more varied, containing leaves of *S. oppositifolia*, *Poa* spp., *Stellaria* spp., and *S. polaris*.

During summer and autumn a high proportion of plant reproductive organs was found in the crop contents. This was caused mainly by the large amount of vegetative propagation bulbils of *Polygonum viviparum* and lesser amounts of *Saxifraga cernua*. The crops also contained flowers, e.g. *S. cespitosa* and *S. oppositifolia*, and fruits with seed, e.g. the silicles of *Draba* spp. and the capsules of *Cerastium arcticum* and *Papaver dahlianum*. The only organs that were found of *Cassiope tetragona*, *Pedicularis dasyantha* and *Equisetum arvense* were capsules and strobili, respectively.

During late autumn and winter the crops contained a significant amount of pseudo-viviparous

Table 1. Proportion (% of dry weight) of different plant species in the crops of Svalbard Ptarmigan.

	November/ February		March		April		May/ June		July/ August	July	August	September		October	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♀	♂	♀	♂	♀
Dryas octopetala	12.2	—	22.5	7.8	21.5	9.5	0.7	0.9	—	1.7	1.5	0.7	0.1	0.4	0.2
Salix polaris	15.6	27.2	53.9	53.8	50.6	52.5	89.5	66.5	32.8	38.8	17.5	6.7	10.0	31.1	18.1
Saxifraga oppositifolia	21.8	25.6	7.2	21.2	18.8	19.4	2.7	6.0	—	4.9	0.3	14.1	1.1	7.0	6.7
Saxifraga cespitosa	5.5	20.0	1.1	2.9	0.9	2.6	1.0	1.4	3.2	0.9	0.9	2.4	2.8	11.0	0.8
Polygonum viviparum	1.2	—	0.9	4.5	2.0	1.2	0.9	1.1	20.8	50.5	55.9	46.2	29.8	13.1	54.9
Stellaria crassipes	2.9	6.9	1.7	2.5	0.4	1.4	0.1	0.2	—	—	0.2	4.3	3.3	4.6	4.4
Poa spp.	13.5	7.0	—	—	—	—	—	—	—	—	—	12.6	4.8	16.9	—
Papaver dahlianum	—	—	—	0.3	0.3	8.1	0.7	—	6.7	0.7	8.8	0.2	3.1	—	0.2
Cerastium arcticum	1.4	6.8	7.0	4.3	1.6	1.6	0.9	—	—	—	0.7	1.8	3.8	4.8	3.3
Saxifraga cernua	0.6	0.5	—	—	—	—	—	—	—	0.3	—	2.5	3.8	—	2.6
Alopecurus alpinus	10.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Luzula arcuata confusa	10.4	—	0.2	—	—	—	—	—	0.4	—	0.2	0.5	—	—	—
Draba spp.	—	1.6	1.7	0.3	—	1.6	0.4	5.4	0.7	—	0.3	2.5	4.5	1.9	0.5
Cochlearia officinalis	—	—	0.5	0.9	—	0.1	0.5	1.4	—	—	—	—	2.3	1.0	—
Equisetum spp.	—	0.2	—	—	—	—	—	0.8	17.6	—	3.3	1.7	0.4	5.4	0.1
Ranunculus sulphureus	—	—	—	0.2	—	—	—	1.7	6.7	—	0.6	—	3.8	—	—
Saxifraga nivalis/tenuis	—	1.3	—	—	—	—	—	8.2	0.3	—	—	—	6.3	0.9	—
Graminoids, bryophytes, lichens	4.7	2.9	3.8	1.3	3.8	2.0	2.5	6.6	10.8	1.5	9.8	3.8	16.7	1.9	8.3

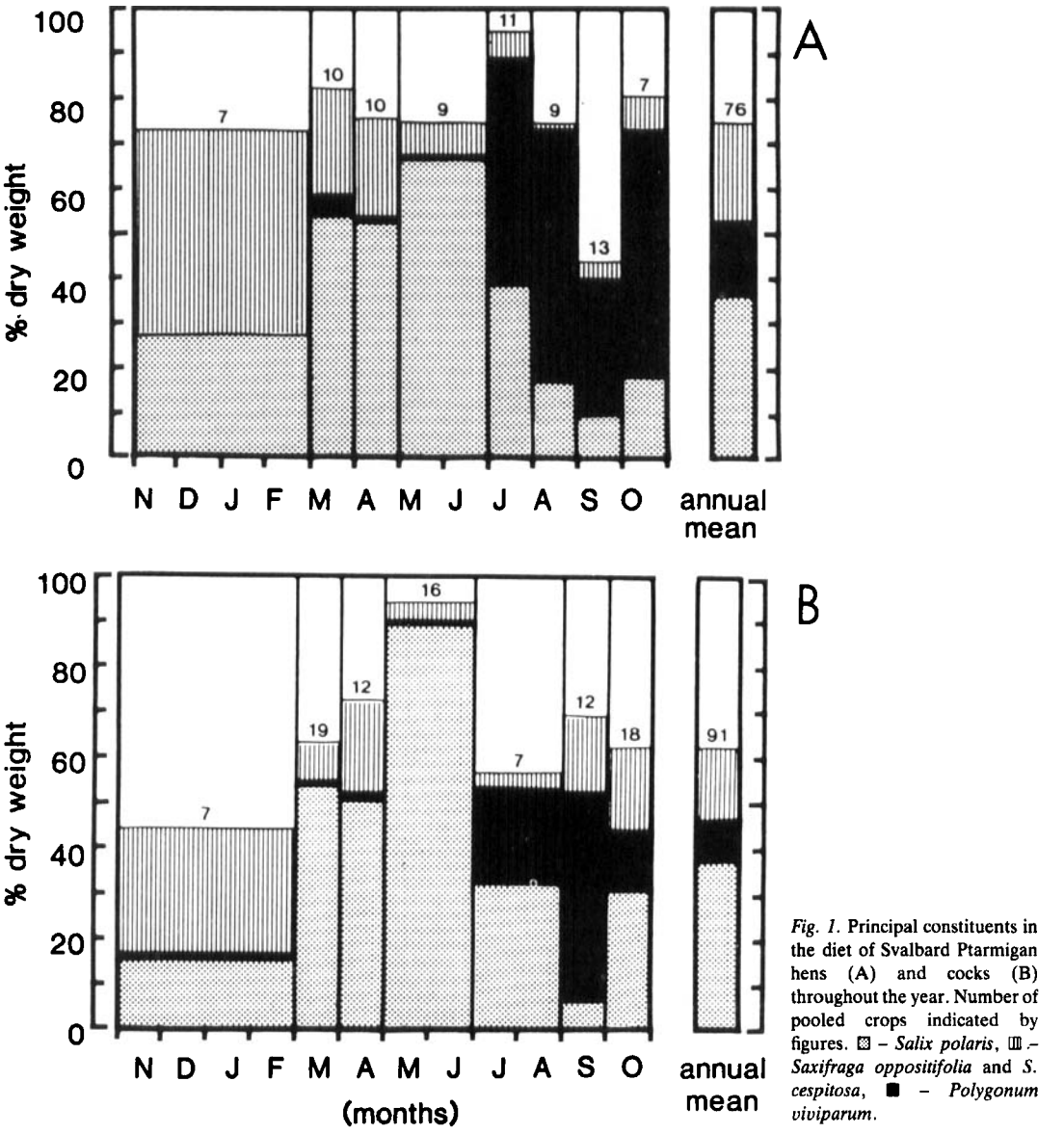

Fig. 1. Principal constituents in the diet of Svalbard Ptarmigan hens (A) and cocks (B) throughout the year. Number of pooled crops indicated by figures. ▨ – *Salix polaris*, ▥ – *Saxifraga oppositifolia* and *S. cespitosa*, ■ – *Polygonum viviparum*.

bulbils of grasses like *Poa alpina*, *P. arctica*, *P. pratensis* s.l., and *Deschampsia alpina*. The presence of *Poa* spp. and *Cochlearia officinalis* coll. in the late autumn and winter samples could indicate a search for food in bird cliff vegetation during these periods. From July to September *Salix polaris* was mainly represented by green leaves, but during winter and spring there was typically a mixture of winter buds and young twigs. *Saxifraga oppositifolia* and *Stellaria crassipes*, which were eaten from September to April/May, but neglected during the summer months, were represented by their typical winter leaf buds.

Chemical composition

Results from the chemical analysis are presented in Table 2. Protein content in cock crops varied between 15.3% in November–February and 25.3% in July–August. Protein content had the same tendency for both sexes, being lowest in the winter and highest in summer.

The crude fibre content varied between 9.6% (in July–August) and 15.6% (in March–April). Highest and lowest values were found in the crop contents of cocks, but hen values showed a similar pattern.

Table 2. Chemical composition (% of dry weight) and water content (% of fresh weight) of pooled crop contents from Svalbard Ptarmigan. Number of crop contents in each pool indicated by *n*.

Period	Sex	*n*	Crude protein	Crude fibre	Ether extract	Ash	P	Mg	Ca	K	Na	Water content
July –	♀	20	20.4	10.8	2.4	6.5	0.35	0.21	0.52	0.87	0.14	75.0
Aug.	♂	7	25.3	9.6	•	7.3	0.38	0.24	0.72	1.25	0.25	75.7
Sept. –	♀	20	20.6	10.2	4.3	6.5	0.41	0.23	0.63	1.23	0.12	70.1
Oct.	♂	30	18.6	12.3	3.9	5.9	0.35	0.16	0.46	1.12	0.13	67.9
Nov. –	♀	7	18.8	13.4	4.3	6.4	0.41	0.24	1.10	1.15	0.12	67.5
Feb.	♂	7	15.3	14.2	3.5	6.0	0.31	0.17	0.67	0.75	0.19	65.2
March –	♀	20	15.4	13.7	4.5	7.8	0.31	0.25	0.88	0.77	0.15	61.6
April	♂	31	17.0	15.6	4.0	6.8	0.33	0.24	0.75	0.65	0.16	62.5
May –	♀	9	21.8	•	3.0	4.2	0.41	0.23	0.60	0.75	0.15	66.1
June	♂	16	22.5	14.9	2.4	7.6	0.39	0.24	0.51	0.63	0.18	66.3

• not measured.

The proportions of crude fibre and of crude protein tended to vary inversely. By excluding samples from cocks in May–June, which were high both in protein and fibre, this relationship proved to be significant at the 1% level ($r = 0.850$).

The ether extract (crude fat and resin) changed from 2.5–3.0% in the summer to 3.5–4.5% in the winter. The values for hens were generally higher than those for cocks, though the differences were small.

The ash content varied between 5.6% and 7.8% throughout the year, except for the May–June value for the hens, which was 4.2%. No seasonal pattern was evident. Water content was highest during the summer months (July–August) and exceeded 75% for both sexes. From September to October a steady decrease in water was observed, reaching the lowest value (62%) in March–April.

Phosphorus varied from 0.31% to 0.41% and magnesium from 0.16% to 0.25%. Both were unrelated to season. The highest values for calcium were found in the period November–April. Potassium values were highest in July–October, and low in May–June. No clear seasonal variation was found for sodium.

Discussion

The content of the crop of the Svalbard Ptarmigan is generally varied, but at certain times of the year certain plant species predominate. During late summer and autumn (July–October) the contribution of *Polygonum viviparum* exceeds 50% in hens and chicks; in late winter and spring *Salix polaris* is even more predominant, making up close to 90% of the crop content of cocks in May–June.

High incidence of *P. viviparum* in the food during late summer and autumn has previously been reported for the Svalbard Ptarmigan (Ekstam 1897; Høeg 1929; Løvenskiold 1964; Byrkjedal 1975), and for Rock Ptarmigan in Greenland (Gelting 1937), Alaska (Weeden 1969; Gasaway 1976) and Iceland (Gardarsson & Moss 1970). The present study confirms earlier studies (Gardarsson & Moss 1970; Løvenskiold 1964; Byrkjedal 1975) that bulbils of *P. viviparum* are the most important food of Rock Ptarmigan chicks in their first few weeks of life. In comparison, young chicks of Willow Ptarmigan *Lagopus lagopus* eat large amounts of insects (Spidsø 1980).

Salix polaris is the most common food item in the crop content of the Svalbard Ptarmigan. The contribution from this plant increases steadily from autumn to spring. During the pre-laying season (May–June) *S. polaris* makes up 65–90% of the crop content. Although *Salix* spp. are of major importance in the winter diet of the Rock Ptarmigan in Greenland (Gelting 1937), Alaska (Weeden 1969; Gasaway 1976), and Iceland (Gardarsson & Moss 1970), the contribution of *Salix* at these locations never reached similar levels. Part of the reason for this is probably that *Betula* spp. was also available to Rock Ptarmigan in Alaska and Iceland. Only little *Betula nana* is found in Svalbard (Rønning 1979).

In addition to *Polygonum viviparum* and *Salix polaris*, *Saxifraga oppositifolia*, *S. cespitosa*, *Dryas octopetala* and various *Poa* spp. contribute

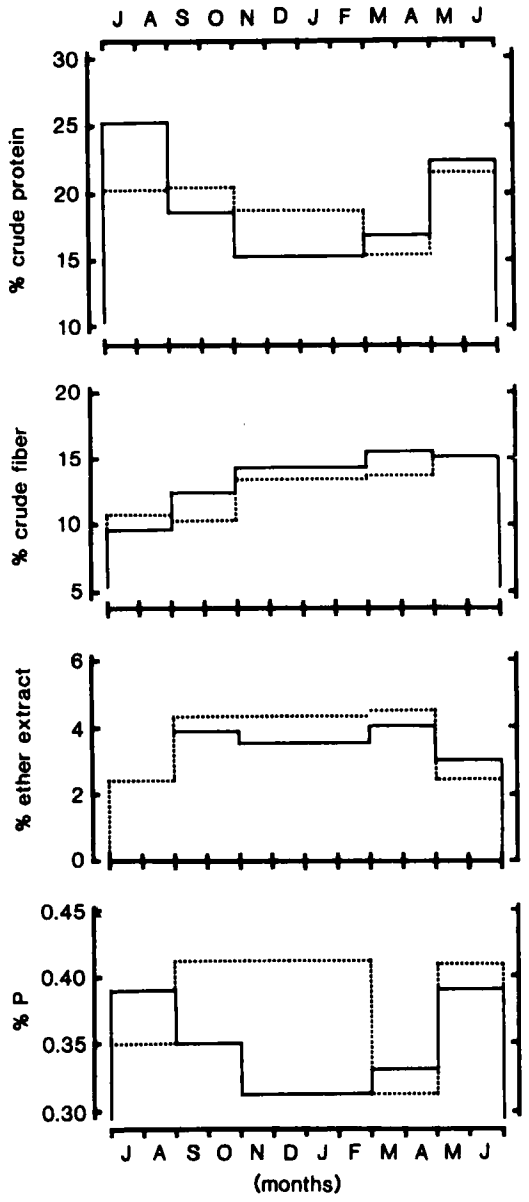

Fig. 2. Chemical composition (% of dry weight) of crop contents from Svalbard Ptarmigan hens (. . . .) and cocks (———).

significantly to the crop content of the Svalbard Ptarmigan. These are also the most important food items of the Greenland Rock Ptarmigan (Gelting 1937). In this case, however, *S. polaris* is replaced by *S. arctica.*

Ptarmigans generally prefer food of high nutritional value, i.e. easily digested food with a high content of proximal nutritional compounds, of which nitrogen and phosphorus seem to be the most important (Pulliainen 1970; Gardarsson & Moss 1970; Pulliainen & Salo 1973; Savory 1983). In vitro experiments have revealed that digestibility is negatively correlated with the content of crude fibre (Moss et al. 1974).

The crop content of the Svalbard Ptarmigan had an especially high proportion of crude protein from July to October, probably due to the high incidence of *Polygonum viviparum* at this time of the year. According to Moss & Hanssen (1980), growing leaves and bulbils of *P. viviparum* have a protein content of 29% and 20%, respectively. During the same period the content of crude fibre was low, indicating high digestibility. Moss et al. (1974) in their digestibility trials obtained the highest score (74%) for bulbils of *P. viviparum.* The Svalbard Ptarmigan chicks grow rapidly, reaching a body weight of 400 grams in 40 days (Steen & Unander 1985). This rapid growth is based on a diet of almost 100% bulbils of *P. viviparum*, which thus proves to be an excellent substitute for the insects in the diet of the Willow Ptarmigan chicks (Spidsø 1980).

Salix polaris is probably of lower nutritional value than *Polygonum viviparum* and most of the other herbs found in the crop of the Svalbard Ptarmigan due to its high content of crude fibre. The increase in the proportion of *S. polaris* in the crop content from February to summer may therefore be a matter of availability. The increased energy requirement from February to spring (Mortensen & Blix 1985) may force the birds to eat the most available food items, even though these items are of inferior quality. In the Red Grouse *Lagopus lagopus scoticus* a negative correlation between food intake and its ability to choose the nutritional best food has been found (Savory 1983).

Staaland et al. (1983) have determined the chemical composition of different plant species from Svalbard. Although their results cannot be directly compared with those of the present study, certain tendencies still emerge: the protein content is generally higher and the fibre content lower in the crop contents than in hand-picked plants of the same species. The reason for this difference is probably that the Svalbard Ptarmigan, like other ptarmigans, is able to select the plants of highest nutritional quality (Savory 1983) and also to ingest only the best parts.

This study has revealed that the Svalbard Ptarmigan can achieve a diet of prime quality throughout the year. Great seasonal changes in the diet

result from the seasonal changes in availability and phenology of the ingested plants. An inadequate supply of nutrients is more likely to be caused by restricted availability than by poor quality of the food eaten.

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