I realized how efficiently ptarmigan can walk on soft snow during an attempt to capture some Willow Ptarmigan near Lake Athabasca in March. The birds, walking quite leisurely and leaving tracks only about 15 mm deep, easily kept ahead of my companion and me. Wearing only boots, I sank in the snow to mid-thigh, while he, wearing my snowshoes (small for his size), fared little better.

To find the degree to which foot feathering reduces sinking in snow, I placed on snow an intact and a plucked foot of each of the three species of ptarmigan. Some of the feet were first softened by immersion in water so that the toes could be flexed perpendicular to the tarsometatarsus and then dried in this position. A (weighed) "wall" of modelling clay between the dorsum of the middle toe and the front of the tarsometatarsus supported a (weighed) piece of cardboard placed horizontally and slotted to admit the tarsometatarsus. Weights were placed on the cardboard and the depth that the foot sank in the snow was measured (Table 2). As the tests were spread over a period of time, the consistency of the snow probably varied on different occasions; only comparisons between a feathered and an unfeathered foot under the same load are valid. The comparisons of feathered and unfeathered feet do not allow for the (probably small) contribution to the snowshoe effect of the longer winter claws, for claw lengths were identical in the feathered and plucked feet.

The data show that sinking in snow is reduced to about one-half by foot feathering with loads up to about half the bird's body weight i.e., the load carried when standing on both feet. The values for Willow Ptarmigan suggest that the effect may be even greater in snow of a certain density when, as in mid-stride, one foot carries the bird's full weight.

Foot feathering clearly increases the bearing surface of the foot by about four times and reduces sinking of the foot in snow by about half. The demonstrated snowshoe function of the foot feathering surely is adaptive, for it must inevitably reduce the energy required for all leg movements on snow.

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SNOW COVER AND THE USE OF TREES BY SPRUCE GROUSE IN AUTUMN

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Spruce Grouse (*Canachites canadensis*) in autumn shift from a summer diet of foods taken mostly from the forest floor to a winter diet of conifer browse. Zwickel et al. (Condor 76:212–214, 1974) reviewed the data on this changeover and concluded that it occurs long before snow cover makes herbaceous food unavailable. These authors suggested four reasons for the early change in diet: (1) the shift must be gradual; (2) alternative foods decline in quality or quantity; (3) there is a change in preference; or (4) some behavioral change occurs, unrelated to food, which results in birds spending more time in trees than on the ground.

Relevant to this last possibility, I investigated whether snow in autumn affects the tendency of Spruce Grouse (*C. c. franklinii*) to spend more time in trees. Previous work on dietary change used only crop analyses and did not document snow conditions. This report augments data of earlier workers by documenting snow conditions and site selection (tree or ground) over the period that dietary change occurs.

METHODS

Data presented are proportions of Spruce Grouse found in trees from 1 August until the start of winter, 1970–72. I use the percentage of birds found in trees as an index of time spent in trees. The work was conducted in Lodgepole Pine (*Pinus contorta*) forest, about 1,750 m altitude, 27 km W of Turner Valley, Alberta. Pointing dogs were used to locate most grouse; I saw no evidence that they did not find birds in proportion to where the birds were, i.e. in the trees or on the ground. Data are omitted if the original site of the bird was in question. All sex and age categories of grouse sighted are combined. The amount of snow cover was recorded at each site a bird was found. Differences between numbers of birds in trees and on the ground were tested for statistical significance with 2 × 2 contingency tables (*G* test where appropriate). Significant differences are at least at the 0.05 level.

RESULTS AND DISCUSSION

The earliest dates of complete and lasting snow cover were 10 November, and 17 and 1 December, 1970–72 respectively. But Spruce Grouse were making increased use of trees as early as September (Fig. 1). With two exceptions (August to September, and October to November 1970), changes in birds in trees between successive months were significantly different. Temporary snow cover occurred periodically each autumn. In 1970, 23 cm of snow fell on nine separate days and covered the ground for ten days; in 1971, 88 cm of snow fell on 20 separate days and covered the ground for 47 days; in 1972, 74 cm of snow fell on 16 separate days and covered the ground for 42 days.

Data were analyzed to determine if the increased frequencies of birds in trees in early autumn, over low frequencies in late summer, were related to the beginning of snowfall. Proportions of birds in trees in August versus those in trees in September before the first snowfall (11, 20 and 7 September 1970–72 respectively) were:

	1970	1971	1972
August	6%	5%	5%
September	3%	3%	6%
χ^2	1.64	0.20	0.68
	$P > 0.05$	$P > 0.05$	$P > 0.05$

Hence, the significant increases of birds in trees from August to September in 1971 and 1972 occurred only after the first snowfall. The difference between August and September (whole months) for birds in trees was smallest in 1970, when the fewest days of snow cover in September occurred (9%; 25–26% in 1971 and 1972).

I then examined whether birds were in trees more frequently on days when snow covered more of the ground. The extent of snow was categorized daily as absent, less than 50%, or more than 50%. Within months, birds were usually in trees more frequently on days with greater snow cover than on days with lesser snow cover (Table 1). Tests were conducted on the differences of birds in trees according to snow cover (within months); in 15 out of 19 cases, proportionally more birds were in trees on days when a greater extent of snow was present and differences were significant in 13 cases.

Finally, the proportion of birds in trees on snow-free days increased significantly between successive months (Table 1) in only two (September to October 1970 and 1971) of five possible instances.

In summary, Spruce Grouse were seen more frequently in trees as the autumn progressed, and long before snow cover became permanent. The frequency of birds in trees did not begin to increase until after the first snowfall. Grouse were found in trees more often on days of major snow cover. The proportion of birds in trees on snow-free days generally did not increase through autumn, although snow-free days became less common as autumn progressed. This latter point suggests that after being in trees on a day with much snow cover, grouse did not tend to remain in trees on a succeeding day with less snow present.

These results confirm the speculation by Zwickel et al. (1974) that Spruce Grouse spend increasingly more time in trees in autumn; although my data merely are correlative, they suggest snow as a causal agent. The same authors also suggested that grouse may need to change their diet gradually. Similarly, Pendergast and Boag (Condor 73:437–443, 1971) speculated whether heavy mortality, particularly of young, might occur at the start of winter if grouse were suddenly forced onto a conifer diet because of heavy snows, without previous conditioning of the gastrointestinal tract to the new diet. This probably does not occur, at least in regions with autumn snow. Data from Alberta suggest that periods of temporary snow accustom the grouse to aboreal life.

My initial interpretation of my data was that snow causes birds to take to trees more frequently, enabling them to begin heavy feeding on conifer browse, thus changing the size of the gastrointestinal tract (Pendergast and Boag, Auk 90:307–317, 1973). With a

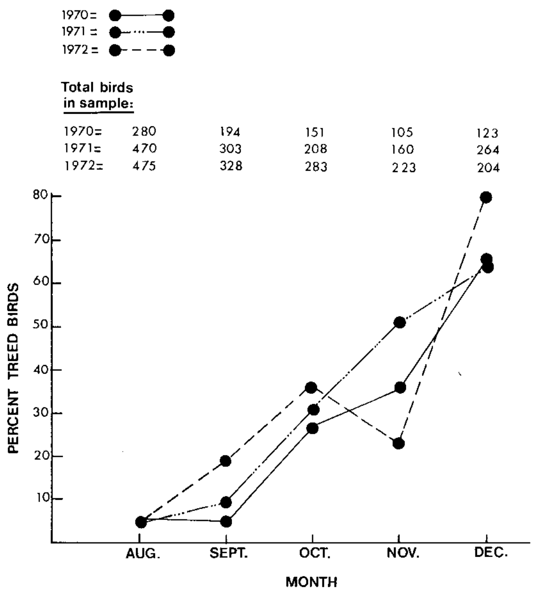

FIGURE 1. Proportions of Spruce Grouse found in trees in southwestern Alberta, August through December 1970–72.

TABLE 1. Percentages of Spruce Grouse found in trees in autumn according to snow cover, 1970–72.*

Period	Extent of Snow Cover: No snow (a)	< 50% cover (b)	> 50% cover (c)	x^2**
1970				
September	5(185)	0(7)	50(2)	a:b = 0.64
October	20(107)	35(37)	86(7)	a:b = 2.86
				b:c = 6.58
				a:c = 12.58
November 1–9	10(58)	–	–	–
1971				
September	4(230)	25(73)	–	a:b = 24.89
October	11(73)	27(70)	54(65)	a:b = 5.1
				b:c = 8.93
				a:c = 27.52
November	–	9(45)	68(115)	b:c = 50.18
December 1–16	–	40(5)	47(144)	b:c = 0.32
1972				
September	11(259)	0(6)	56(63)	a:b = 1.36
				b:c = 9.18
				a:c = 59.86
October	13(111)	10(49)	67(123)	a:b = 0.03
				b:c = 42.46
				a:c = 68.25
November	15(27)	14(114)	37(82)	a:b = 0.0
				b:c = 11.13
				a:c = 4.96

* Total birds seen in parentheses; dashed lines signify the snow cover did not exist.
** $P < 0.05 = > 3.84$; insufficient samples precluded some tests.

delay in snowfall, the chain of events might be delayed, as well as in areas without autumn snow. If this sequence does occur, ineffective dietary changeover might cause mortality in regions that are snow-free in autumn.

To evaluate part of this hypothesis I collected 32 Spruce Grouse (*C. c. canace*) along the Northwest Miramichi River (47° lat. 65° long.), New Brunswick, between 16 October and 8 November 1975. Snow did not fall prior to or during the collection period. Crops of all grouse collected contained only or mostly conifer needles. Although Spruce Grouse spend more time in trees when autumnal snow is present (Alberta data), the New Brunswick data show that snow cover is not necessary for birds to spend at least enough time in trees to feed on needles. Also, an early dietary changeover in areas with snow-free autumn weather should reduce the possibility of mortality associated with a sudden onset of winter weather. Hence, whether dietary changes precede or result from gut changes (Moss, J. Wildl. Manage. 36:99–104, 1972; Pendergast and Boag 1973) probably becomes less important in relation to the effects of dietary change on survival in autumn and winter.

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COLOR PREFERENCE AND SHORT-TERM LEARNING BY STELLER'S JAYS

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The purposes of this study were to establish color preference in the selection of food by Steller's Jays (*Cyanocitta stelleri*) and to determine how long a short-term negative stimulus associated with the most favorite color would alter the natural color preference scheme. Natural color preference by the Steller's Jay probably reflects the colors of its natural foods and therefore may be difficult to change on a long-term basis. If, however, a sufficiently large, yet constant, population of birds could be enticed to feed on an unnatural bait, color preference (independent of food source) and short-term learning behavior could be studied.

Our observations were made in Camp Laurels, Tilden Regional Park, Alameda Co., California. The study area was within a grove of trees near a dry river bed. Steller's Jays in Tilden Park are quite tame and have acquired the habit of foraging on the picnic grounds; consequently, it is a simple matter to lure them to a particular spot for observation. Since the area is relatively open, birds from neighboring territories can see when bait is available and come to it quickly.

Unshelled roasted peanuts were selected as bait for the jays. Batches of peanuts were colored red, yellow, blue and green with food coloring. We placed batches of differently colored peanuts in one or more piles in the middle of a path near the river bed and then retired to a distance of 15–20 ft. The birds appeared to be familiar with peanuts, as they would select the nuts and natural peanuts over any of the colored peanuts.

The study was conducted during a nine-day period in July. Observations were made twice daily, at noon and between 1800 and 1900.

A jay entering the study area typically would alight on a branch in a tree overlooking the pile of peanuts, call, and then fly down to select a peanut. When two or more birds flew to the food, one generally supplanted the others and selected one or two peanuts while the subordinate birds watched from a distance of 2–3 ft.

Most birds would select a peanut and shake it as if to judge whether the kernels were inside. If a rattle could not be heard or felt, they would take one or two more peanuts before flying off. Occasionally, a bird would eat one of the peanuts within the study area by grasping the ends of the peanut with its feet and pecking at the shell to remove the nuts inside. Frequently, while one bird attempted to store two peanuts in its mouth, another bird would quickly pick the nearest peanut from the pile and fly away. We did not include these selections in the data because they were not determined by color.

Generally 20 birds fed in the study area at noon and 12–15 in the evening. Perhaps because of the greater number of birds feeding at noon, competition among birds appeared to be greater at this time. We generally found four to six jays competing near the peanuts at mid-day, but rarely more than three in the evening.

Figure 1 shows the order in which peanuts were selected at noon from four adjacent piles of red, yellow, blue and green peanuts, each containing 25

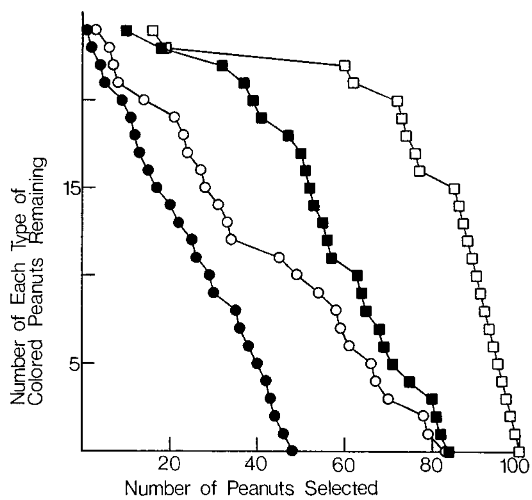

FIGURE 1. Order of selection of differently colored peanuts by Steller's Jays. Four adjacent but separate piles of red (black dots), yellow (white dots), blue (black squares) and green (white squares) peanuts, each pile initially containing 25 peanuts, were set out at noon.