BODY CONDITION OF GRAY PARTRIDGE

(*Perdix perdix* L.) DURING FALL

AND WINTER IN SASKATCHEWAN

A thesis submitted in partial fulfillment
of the requirements for the degree of Master
of Science in the Department of Biology.

by

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Declaration

The research presented in this thesis was conducted by the author and has not been previously submitted for credit toward any degree or diploma.

The work of others, where included in this thesis, has been appropriately cited.

April 1983

ABSTRACT

During August 1979 to March 1980, 118 Gray Partridge were collected from a 207 km^2 study area near Tugaske, Saskatchewan. Temperature and snowpack information were monitored throughout the study period. Partridge were necropsied, searched for internal and external parasites, and fat, protein and moisture determinations conducted for each bird.

Mean monthly temperatures during the study period approximated the 30 year mean for the area. The winter of 1979 - 80 was characterized by reduced snow depths and a longer snow-free period than normally occurs in this area of Saskatchewan.

Male and female partridge exhibited a similar seasonal pattern of body weight fluctuation during the study period. There were no significant differences ($P > .05$) in mean monthly body weights of adult and subadult male partridge during August to March. Female partridge weights increased significantly ($P < .05$) from September to January, then declined through to March. Body weight of male and female partridge attained January maxima of 416 g and 410 g, respectively and are among the highest recorded in North America. The application of several condition indices failed to provide more accurate estimates of metabolic reserves than carcass weight alone.

Lipid reserves appeared to be of significant metabolic importance to Gray Partridge in Saskatchewan. Among male Gray Partridge,peak fat reserves (29% dry body weight) occurred in January and among females,in December (30% dry body weight). There was no significant difference ($P > .05$) in mean monthly weight of body fat of male partridge. Body fat increased significantly ($P < .05$) among females between September and December. Thereafter, fat reserves in both male and female partridge declined but not significantly, to the end of March.

Subcutaneous fat deposits constituted the largest fat reserve in partridge, comprising 53% and 48% of total body fat in males and females, respectively. Carcass protein levels in both sexes were relatively constant during the period of study.

Weight of the abdominal fat depot represented a practical, easily obtained and relatively accurate predictor of total body fat reserves, while carcass weight was the best predictor of protein reserve in Gray Partridge.

Endoparasite and ectoparasite loads were not overly large among partridge examined and appeared of no significance as a mortality factor.

The implications of these findings to partridge management are discussed.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF TABLES (CONT'D)

LIST OF FIGURES

LIST OF FIGURES (CONT'D)

LIST OF APPENDICES

LIST OF APPENDICES (CONT'D)

1. INTRODUCTION

The reproductive ecology and mechanisms of population regulation of Gray Partridge (Perdix perdix L.) in their native European range have been investigated by several researchers (Middleton 1935, Ford et al. 1938, Lack 1947, Blank and Ash 1956, Jenkins 1961a, 1961b, Pulliainen 1965, Southwood and Cross 1968, Potts 1970). In North America, where the species was introduced in the late 1800's, research focusing on reproductive ecology has been conducted by Yeatter (1934), McCabe and Hawkins (1946), Porter (1955), Westerskov (1966), Gates (1973), Hunt (1974) and Weigand (1980). Relatively few studies however have concentrated on winter ecology and the physiological aspects of winter survival of partridge.

Major contributions to our knowledge of partridge winter ecology and population dynamics have been made by Finnish researchers. Siivonen (1956) determined it was possible to forecast in April the size or trend of the partridge populations in the upcoming fall by comparing fluctuations in fall population levels with temperature and the amount of snow in the preceding winter. Suomus (1958) observed a 41% decline in partridge populations during November to March in Finland. During severe winters, a general decrease in mean covey size was evident. The food and feeding habits of partridge during the fall and winter of 1964 - 1965 in Finland was reported by Pulliainen (1965). Based on the collection of 143 partridge, no difference could be found in the weight of juvenile and adult birds in October. Snow depth, hardness, temperature and food resources were the most important ecological factors affecting partridge in winter.

In North America, Westerskov (1965, 1966) concluded the major factor responsible for the successful introduction and winter survival of partridge was a shift to a high protein (grain and weed seed) diet. In their native European range, green leaf material was the major dietary component and was incapable of supplying the energy necessary for survival under Canadian winter conditions. Weigand (1980) detailed the seasonal population composition, dynamics, movements, habitat preferences, food habits and effects of land management practices on Gray Partridge in Montana.

Szwykowska (1969) determined the fat, protein, moisture and caloric value of adult partridges in Poland but did not discuss the significance of these findings to winter survival. A similar study has not been published for this species in North America.

The consequences of suboptimum body condition (defined primarily by body weight) have been demonstrated in the Ring-Necked Pheasant (Phasianus colchicus). Gates and Woehler (1968) reported below normal body weights in late winter resulted in delayed attainment of maximum spring weights, delayed onset of egg production, lower body weights throughout egg laying and higher adult hen mortality. Breitenbach et al. (1963) reported similar results with penned pheasants that were on limited food intake. Barrett and Bailey (1972) concluded from studies on female pheasants that low energy diets caused reduced body weights, poorer physical condition and a delayed onset of egg laying. The results of earlier studies (Kabat et al. 1956, Hanson 1962, Anderson 1972) emphasized the significance of optimum body weight and good physical condition in resisting stress-related mortality. Kabat et al. (1956) suggested the weight of female pheasants was a useful index of body condition and was particularly indicative of the ability to withstand environmental stress. The greatest resistance to such stress was therefore at the period of peak body weight. Seasonal variations in pheasant body weight were due principally to changes in body fat (Greely 1953, Anderson 1972). Increases in body weight (ie. fat and protein deposition) during winter represented increases in metabolic reserves in preparation for the energetic demands associated with reproduction. Similar conclusions have been reported for waterfowl (Hanson 1962, Ryder 1970, Ankney 1974, Korschgen 1977).

The physical condition of female pheasants in early spring was partially controlled by the severity of weather the previous winter (Edwards et al. 1964). Siivonen (1956) reported snow depth to be the most influential of the variables studied in determining subsequent fall populations of partridge in Finland. Partridge and pheasants in The Soviet Union and Europe starved during winters of above average snowfall because deep snows covered food supplies (Formozov 1973). The significance of snow depth was increased by the hardness of the crust. Ambient temperatures were considered of secondary importance to partridge survival. Winters characterized by average snow depths of greater than 15 cm preceded low fall partridge populations in Finland. A deterioration in body condition during the winter ultimately led to a reduction in clutch size which in turn contributed to the population decline (Siivonen 1956).

In North America, Gray Partridge were heaviest in December and January (Keith 1962, Weigand 1980, Kobriger 1980). Carcass fat content of Bobwhite Quail (Colinus virginianus) gradually increased from a minimum in September to a January maximum, followed by a gradual decline to March (Robel 1972). Assuming weight is indicative of condition, these weights probably represent maximum body condition. The dynamics of fat deposition and depletion have not been documented for partridge under North American climatic conditions.

Survival studies of penned Gray Partridge indicated the species is markedly affected by food shortages. Deprived of food, partridge died of starvation when they lost 33 % - 43 % of initial body weight (Gerstell 1942, Hine and Flakas 1957, Keith 1962, Pulliainen 1965, Kobriger 1980). Death occurred in an average of 10 days (Hine and Flakas 1957) but also occurred in as few as 6 days (Pulliainen 1965). Given the short survival time of partridge, a winter food shortage may result in acute mortality or a depletion of body energy reserves ultimately scheduled for reproductive activities.

Male partridge lived 39% longer than females (Latham 1947); however, no explanation was given for this disparity. Similar studies with pheasants (Anderson 1972) and Bobwhite Quail (Robel 1965, Roseberry and Klimstra 1971) indicated either no apparent sexual differences in survival or a slight female advantage due to greater body weights and/or fat reserves. Partridge reacted to lowered environmental temperatures in winter by increasing their metabolic rate and/or through behavioral modifications such as feather fluffing, decreased activity and snow roosting (Delane and Hayward 1975).

Studies have shown the intensity of parasitic infections may also affect body condition. Abnormally high intensities of endoparasites have been found to have a direct detrimental effect on body condition or predispose individuals to other mortality factors (Welty 1982). Ectoparasitic infestations generally exhibited little or no effect on healthy avian hosts (Edminster 1954, Ash 1960, Bergstrand and Klimstra 1964).

My study sought to resolve the following questions:

What seasonal changes occur in the body weight, fat and protein levels of adult and subadult Gray Partridge in Saskatchewan that may influence reproductive performance?

Are the changes in body weight, fat or protein related to the sex or age of individuals and are they manifest in differential mortality?

What influence does weather have on seasonal changes in body weight, fat and protein?

Do Gray Partridge in Saskatchewan harbour parasites during the fall and winter and if so, to what extent do they influence body condition?

The final objective of this study was to develop an index that would enable determination of the body condition of Gray Partridge during the fall and winter that may be useful in predicting reproductive performance.

2. MATERIALS AND METHODS

2.1 DEFINITIONS

BODY WEIGHT: Weight (g) of partridge at time of collection (ie. field weight) minus weight of the contents of the esophagus, crop, proventriculus, gizzard and intestines (Wishart 1979).

CARCASS WEIGHT: Weight (g) of partridge after grinding and homogenation excluding wings, tarsus, foot, feathers, and contents of esophagus, crop, proventriculus, gizzard and intestines.

DRY FAT-FREE WEIGHT: Dry carcass weight minus dry fat weight as determined by ether extraction (Association of Official Analytical Chemists 1975).

VISCERAL FAT DEPOT: Fat surrounding the ventriculus, heart and in the intestinal mesentery (Bailey 1979).

ABDOMINAL FAT DEPOT: Fat deposited in the abdominal cavity ventral to and separate from the intestines and in the area surrounded by the pubic bones (Bailey 1979).

SUBCUTANEOUS FAT DEPOT: Fat present on internal skin surface and that adhering to the external muscle surfaces. Does not include fat which was grossly inseparable from the internal skin surface.

TOTAL BODY RESERVES: Dry weight (g) of ether-extracted lipid plus dry weight (g) of protein (Wishart 1979).

BODY CONDITION: Body condition is referred to here as consideration of body weight and total fat and protein reserves.

BODY LENGTH: Length (mm) from tip of upper mandible to longest retrix with bird straightened firmly but not stretched (Bailey 1979).

WING LENGTH: Length (mm) of the closed wing from the bend to the tip of the longest primary (ie. wing chord) (Canadian Wildlife Service and United States Fish and Wildlife Service 1980).

EXPOSED CULMEN: Length (mm) from the beak tip to the point where the beak is covered by feathers (Canadian Wildlife Service and United States Fish and Wildlife Service 1980).

BILL DEPTH: Maximum depth (mm) from the highest point on the upper mandible to the bottom of the lower mandible (Canadian Wildlife Service and United States Fish and Wildlife Service 1980).

TARSUS LENGTH: Length (mm) from the notch on the back of the intertarsal joint to the lower edge of the last scute before the toes begin (Canadian Wildlife Service and United States Fish and Wildlife Service 1980).

KEEL LENGTH: Measurement (cm) along the ventral ridge of the carina taken with a flexible ruler (Bailey 1979).

PREVALENCE: Number of hosts infected divided by number of hosts examined; expressed as a percentage (Margolis et al. 1981).

MEAN INTENSITY: Total number of parasites in a sample of hosts divided by number of infected hosts in the sample equals mean number of parasites per infected host in a sample (Margolis et al. 1981).

2.2 STUDY AREA DESCRIPTION

2.2.1 LOCATION, TOPOGRAPHY AND SOILS

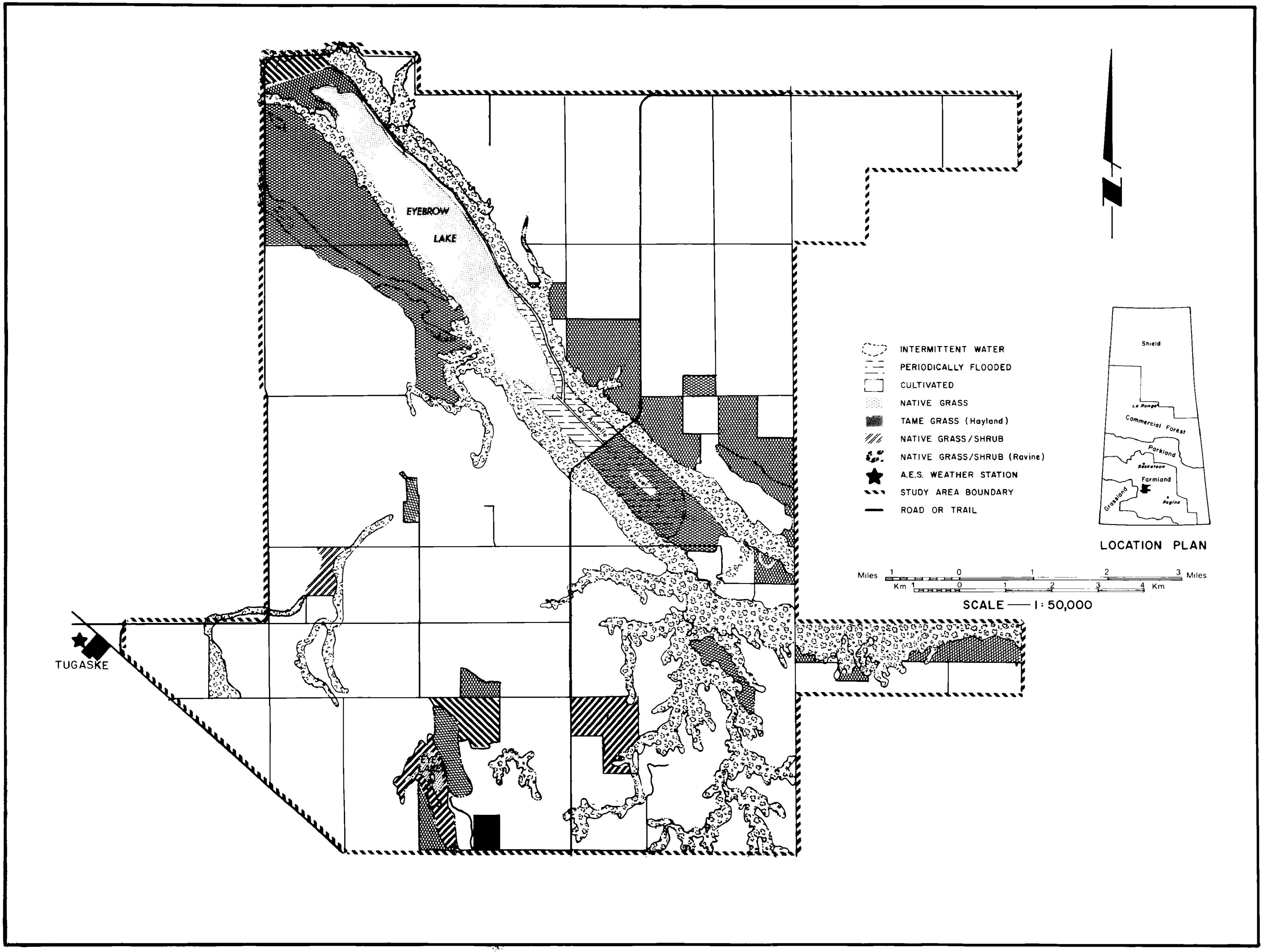
The 207 km^2 study area was located in south-central Saskatchewan near the village of Tugaske (Fig. 1). The Qu'Appelle River Valley, a former glacial meltwater channel, bisects the study area from northwest to southeast. Topography is flat to gently undulating (elevation 579 m above sea level) except for the steep slopes of the Qu'Appelle Valley and its tributary drainages. The Eyebrow Hills, a small area of high relief moraine (maximum elevation 655 m above sea level), are situated in the extreme southwest corner of the study area. Soils in the area are primarily fine sandy loams located within the Dark Brown soil zone of Saskatchewan (Moss 1965).

2.2.2 VEGETATION AND LAND USE

Cereal crops, mainly spring wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*), occur on approximately 75% of the study area although only about one-half of this land is seeded annually (ie. the remainder is summerfallow) (Fig. 2). Following harvest, the grain stubble is usually left standing until the following spring as a soil and water conservation measure. Upland native grass and shrub cover occurs on 16% of the area with an additional 6% in the valley complexes (Fig. 1).

The study area lies within the Mixed Prairie zone of

Figure 1. Location, land use and habitat types of the study area.



EYEBROW
LAKE
Qu'Appelle
River
TUGASKE
INTERMITTENT WATER
PERIODICALLY FLOODED
CULTIVATED
NATIVE GRASS
TAME GRASS (Hayland)
NATIVE GRASS/SHRUB
NATIVE GRASS/SHRUB (Ravine)
A.E.S. WEATHER STATION
STUDY AREA BOUNDARY
ROAD OR TRAIL
Shield
La Ronge
Commercial Forest
Parkland
Saskatoon
Farmland
Regina
Grassland
LOCATION PLAN
Miles 1 0 1 2 3 Miles
Km 1 0 1 2 3 4 Km
SCALE — 1: 50,000

Figure 2. Oblique aerial photograph of a portion of the study area showing the juxtaposition of cultivated land and native habitat. Eyebrow Lake is pictured in the upper left-hand corner. Refer to Figure 1 for approximate scale.

Saskatchewan (Coupland 1950). Native upland plant communities are dominated by spear grass (*Stipa comata*), wheat grasses (*Agropyron* spp.) and blue grama (*Bouteloua gracilis*), with June grass (*Koeleria cristata*) and hoary sagebrush (*Artemisia cana*) also common. Crested wheat grass (*Agropyron cristatum*) is the most common species on disturbed sites. Manitoba maple (*Acer negundo*) and aspen poplar (*Populus tremuloides*) are the dominant tree species. Shrubs commonly found in the area are western snowberry (*Symphoricarpos occidentalis*) and rose (*Rosa* spp.).

Valley plant communities are dominated by spear grass, green needle grass (*Stipa viridula*) and blue grama with varying amounts of porcupine grass (*Stipa spartea*) and June grass. Western snowberry, rose, saskatoon (*Amelanchier alnifolia*) and chokecherry (*Prunus virginiana*) are scattered throughout the ravines and water courses with some aspen poplar present in shaded and/or moist areas (Coupland and Rowe 1969, Lieffers 1977). Caragana (*Caragana arborescens*) hedgerow habitat is confined to farmyards and four rows totalling 0.7 km near the centre of the study area. Botanical nomenclature follows that of Looman and Best (1979).

There are 70 farmsteads on the study area, 43 (61%) of which are abandoned. Sixteen are occupied year-round, 4 only seasonally (spring and fall), and 7 are in various stages of disturbance (ie. buildings removed, large portion of farmland cultivated). These farmsteads characteristically contain crested wheat grass, brome grass (*Bromus inermis*), Manitoba maple and aspen poplar shelter-belts, carragana hedges, and various shrubs.

2.2.3 CLIMATE

The climate of this portion of Saskatchewan is continental semi-arid with long, cold winters and short, warm summers. Mean January and July temperatures are -16.9^{o}C and 18.6^{o}C respectively, although extremes of -46.7^{o}C and 42^{o}C have been recorded at Tugaske (Atmospheric Environment Service 1975). Annual precipitation averages 394 mm. Snow is normally present on the ground from early November until mid-April, with mean February snow depths approximately 370 mm (Atmospheric Environment Service 1975).

2.3 WEATHER OBSERVATIONS

A Stevenson screen housing a 7-day thermograph (Lambrecht K. G. Gottingen) was positioned in the centre of the study area in August 1979 to provide continuous temperature data. An Atmospheric Environment Service (AES) climatological station at Tugaske (Fig. 1) provided current and historical temperature and precipitation data for the area.

Snow stations were established in three representative habitats occupied by Gray Partridge on the study area: native grassland, grain stubble and summerfallow. Both a valley and an upland sample of the latter two were included. Snow depth, density, hardness, crust formation and snow type, as well as ambient and subnivean temperature were measured bi-monthly at each station (Appendix A) using a snow kit designed and built at Lakehead University (Fig. 3). Snow depth was recorded as the mean of ten measurements obtained along a 10 m transect. Snow hardness (measured on the surface of the snow) and density (measured in the center of the snowpack) were averaged from three point measurements along the same transect. Subnivean temperatures were measured at ground level.

2.4 COLLECTION OF PARTRIDGE

Between 22 August 1979 and 26 March 1980, 118 Gray Partridge were collected on the study area (Appendix B). A 12 guage shotgun or a .22 caliber rifle equipped with a 4X scope was used to collect 114 birds, 2 were live-trapped and 2 were obtained as roadkills. Partridge were weighed (1.0 g) at the time of collection with a 500 g capacity Pesola scale then frozen at -20^{0}C for subsequent carcass analysis.

2.5 SEX AND AGE DETERMINATION OF PARTRIDGE

The sex of partridge was determined using scapular and covert color pattern (Yeatter 1934) and facial plumage characteristics (Weigand 1977). Sex was verified by gonadal examination. Juvenile partridge were identified according to McCabe and Hawkins (1946). Non-adult birds older than 17 weeks were regarded as subadults through to the next molt (Weigand 1980). Adults were identified on the basis of proximal primary condition (McCabe and Hawkins 1946), tarsi color (Witherby et al. 1944) and absence of a Bursa of Fabricus (Gower 1939).

Figure 3. Snow kit used to measure snow pack characteristics.

2.6 NECROPSY PROCEDURES

Partridge were thawed at room temperature for 12 - 15 h. before necropsy. All necropsy information was recorded on standard forms (Appendix C).

Length of exposed culmen and right tarsus were measured with vernier calipers graduated to 0.1 mm. A meter stick was used to measure length of body, wing, intestines and cecae to 1.0 mm whereas a flexible plastic ruler was used to measure keel length and depth to 0.1 mm.

Body constituents were excised and weighed (0.01 g) on a Torbal beam balance. The gullet (esophagus, crop and proventriculus), gizzard and intestines (including cecae) were removed, individually weighed and/or measured, their contents extracted and the organs reweighed. Subjective estimates of intestinal fullness (empty, 1/3, 2/3 or full) were made before emptying. The gall bladder was excised before the liver was weighed. The wings were severed from the body at the radiohumeral joint and weighed. The foot was removed at the tibiotarsal joint. Leg muscles included all those with their origin or insertion on the femur or tibiotarsus; breast muscles included the pectoralis, supracoracoideus and coracobrachialis. Leg and breast muscles, lungs and kidneys were excised unilaterally and weighed. These values were then doubled for the analysis.

Subjective evaluations of fat deposits were made of 9 areas on the skin and carcass employing a relative scale of 0 (no fat) to 4 (maximum observed fat). Scoring was based on previous examination of extremely fat birds. These fat deposits were located on the breast and lower neck, back, axillary region, flanks, legs, heart, intestines and cecae, gizzard, and abdominal-cloacal area.

2.7 CHEMICAL ANALYSES

Fat, protein and moisture determinations were conducted for each bird by the University of Saskatchewan Feed Testing Laboratory employing standard methods (The Association of Official Analytical Chemists 1975). In preparation for these analyses, the feathers were removed with an electric clipper, the carcass (less feet, wings and feathers) ground in an electric meat grinder, homogenized in a food processor and weighed (K. Mitchell, pers. comm.) (Fig. 4). Fifteen to 20 g samples were placed in individual glass jars and refrozen until chemical analyses could be completed. A 1 g subsample was used for each of the fat, protein and moisture determinations.

2.8 PARASITOLOGICAL EXAMINATION

Partridge were placed in plastic bags immediately after collection to retain any ectoparasites which may have detached from the plumage as the body cooled. At the time of necropsy, the plumage was fluffed by hand to loosen any ectoparasites still attached. Ectoparasites were preserved in 10% glycerin-alcohol and representative specimens were identified by Dr. G. Surgeoner, University of Guelph and

Figure 4. Single carcass following grinding and homogenation.

Dr. J. E. H. Martin, Department of Agriculture, Biosystematics Research Unit.

The body muscles, liver, gizzard lining, heart, lungs, trachea, air sacs and gastro-intestinal tract were examined for helminths. The gastro-intestinal tract was slit along its length, scraped and the contents (minus gullet and gizzard contents) washed through a No. 20 sieve and examined for endoparasites. The gullet and gizzard were searched for parasites during a food habits study. The results of this parasitic survey are reported herein. Helminths were preserved in 10% formalin and identified by Dr. M. Lankester, Lakehead University.

2.9 STATISTICAL METHODS

Data were punched onto IBM cards. Statistical analyses followed Sokal and Rohlf (1969) and Zar (1974) and were performed using the Statistical Analysis System (SAS) (Helwig and Council 1979). Significance was assumed at $P<0.05$ unless otherwise stated. Duncan's Multiple Range Test was employed to determine if means were significantly different.

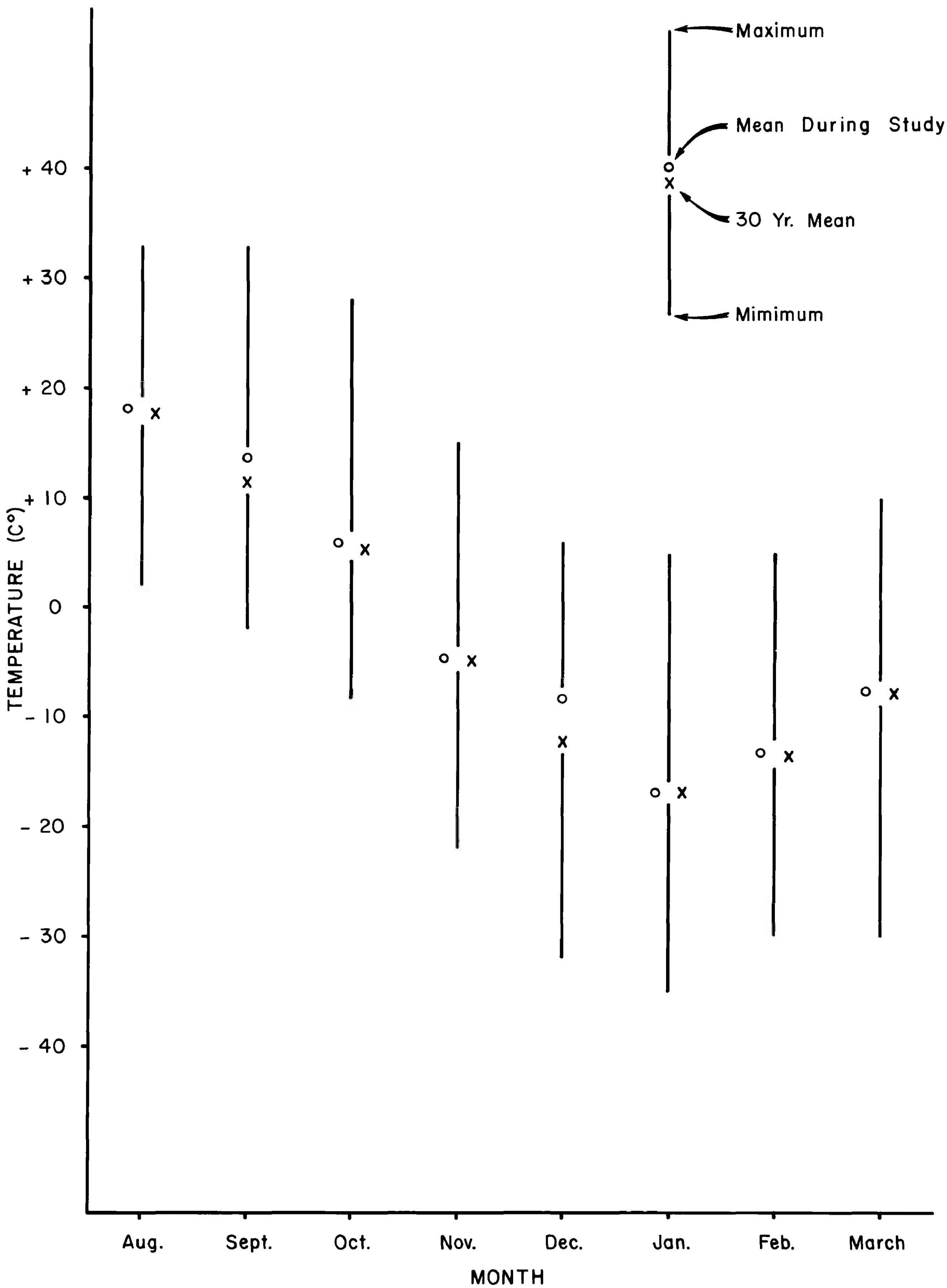
3. RESULTS AND DISCUSSION

3.1 WEATHER OBSERVATIONS

3.1.1 TEMPERATURE

Mean monthly temperatures on the study area were similar to the 30 year mean for the Tugaske climatological station (Fig. 5).

Figure 5. Mean daily temperature (^{o}C) on the study area August 1979 to March 1980.



Maximum
Mean During Study
30 Yr. Mean
Mimimum
+ 40
+ 30
+ 20
+ 10
0
- 10
- 20
- 30
- 40
TEMPERATURE (C°)
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
March
MONTH

Unseasonably warm temperatures did occur during December when the mean was $4^{o}C$ warmer than the normal.

In other studies, partridge were able to survive extreme cold provided they had access to an adequate food supply (Siivonen 1956, Westerskov 1964, 1966, Pulliainen 1965, Hunt 1972). Temperatures were not severe during the study and partridge mortality was only 9.4 % during December to February (Appendix D). It was unlikely temperature had any detrimental effect on partridge during the study period.

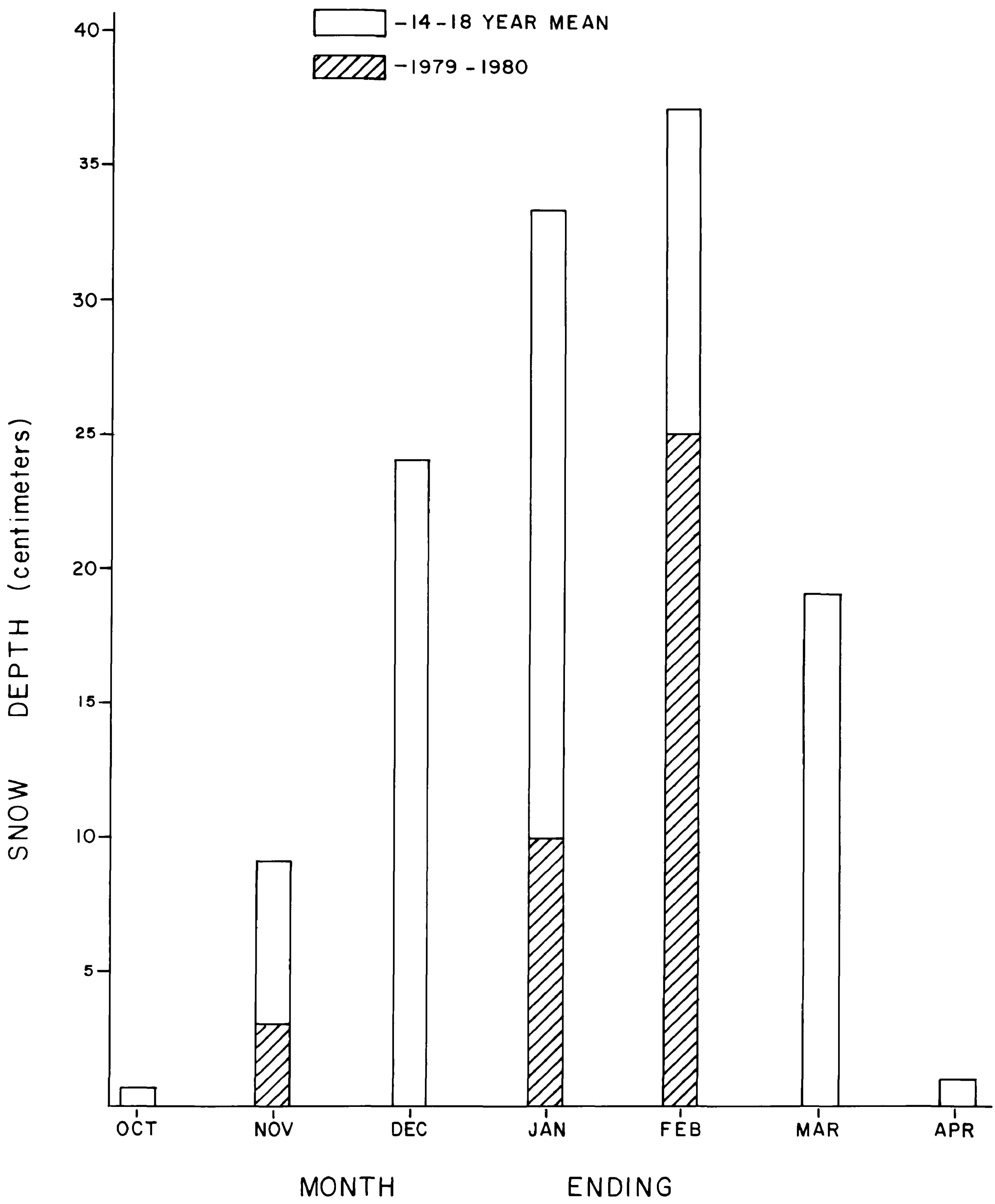
3.1.2 DEPTH AND DURATION OF SNOW COVER

The winter of 1979 - 80 was characterized by reduced snow depths and a longer snow-free period than normally occurs in this area (Fig. 6). Snow cover was not permanent until mid-January, after which 8 to 20 cm of snow persisted in most habitats (Fig. 7). By the third week of March, only patches of snow remained.

The shallowest and most intermittent snow cover occurred on summerfallow fields, where maximum depths were less than 6 cm (Fig. 7). Frequently, these areas were blown clear of snow (Fig. 8). Upland summerfallowed sites generally contained more snow than valley sites, although the reverse occurred in early March. Partridge were rarely observed in summerfallowed habitat during the winter, likely because of an absence of food and cover.

Grain stubble retained more snow than summerfallowed areas (Fig. 7), with stubble height determining the depth

Figure 6. Mean month end snow depth (cm) as recorded by the Atmospheric Environment Service at Tugaske, Saskatchewan.



-14-18 YEAR MEAN
-1979-1980
40
35
30
25
20
15
10
5
SNOW DEPTH (centimeters)
OCT
NOV
DEC
JAN
FEB
MAR
APR
MONTH ENDING

Figure 7. Snow depth (cm) in 3 habitats on the study area November 1979 to April 1980.

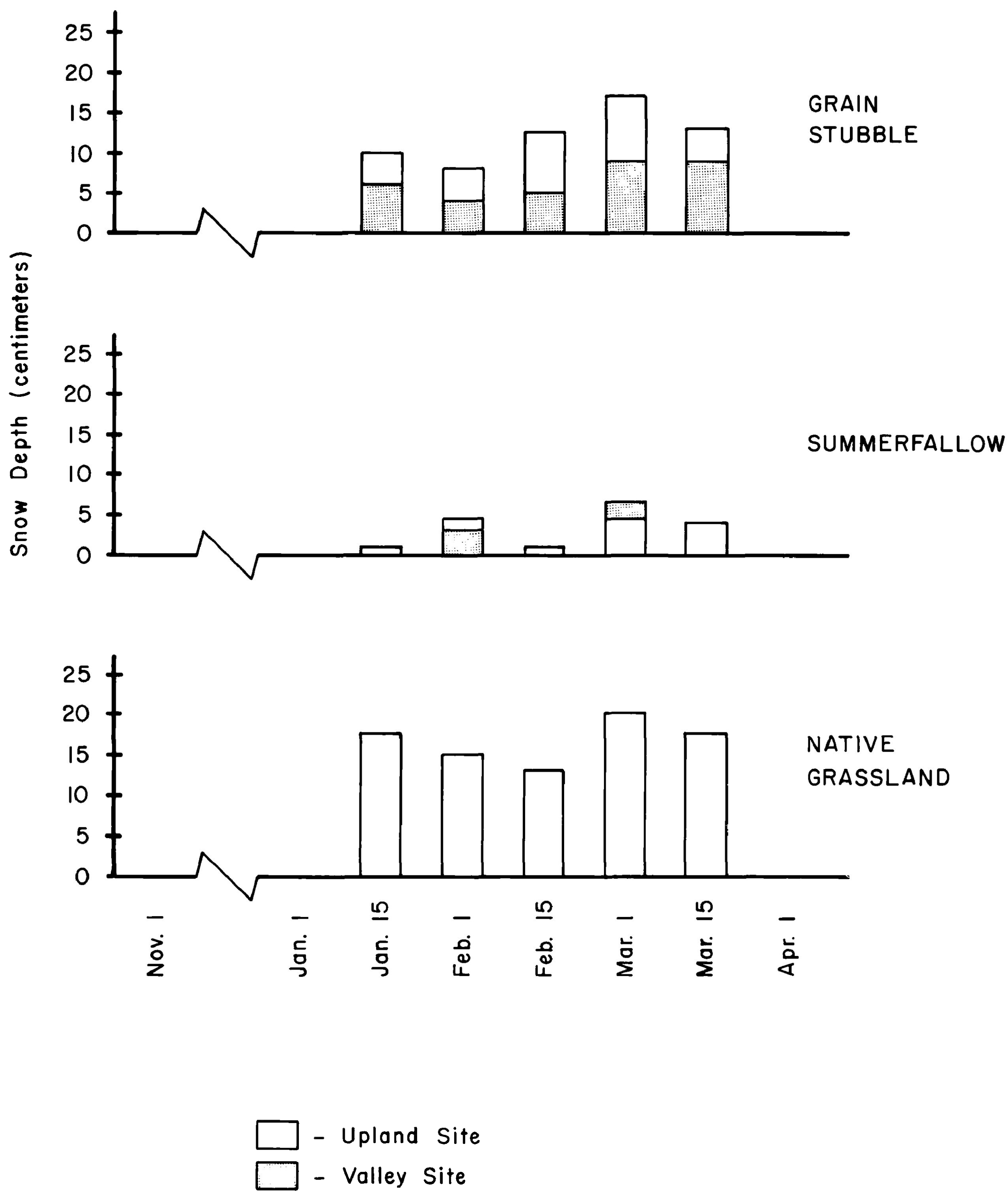

Snow Depth (centimeters)
0
5
10
15
20
25
GRAIN
STUBBLE
SUMMERFALLOW
NATIVE
GRASSLAND
Nov. 1
Jan. 1
Jan. 15
Feb. 1
Feb. 15
Mar. 1
Mar. 15
Apr. 1
- Upland Site
- Valley Site

Figure 8. Snow conditions on the study area November 1979 to February 1980.


NOVEMBER 19 1979


DECEMBER 12 1979


JANUARY 10 1980


FEBRUARY 12 1980

of snow retained. Snow depth in stubble, the primary feeding site of partridge, varied between 5 and 17 cm. Snow cover in valley stubble was uniform and about one-half the depth on upland sites. Partridge were observed most frequently in grain stubble, although the birds were probably more visible here than in grassland or shrub cover. Grain stubble was an important habitat for Gray Partridge as it provided a readily available food supply (waste grain) and an unrestricted view of approaching predators.

The greatest snow depths occurred on native grassland sites (Fig. 7). Vegetation served to trap blowing snow, and except for mid-February, snow depths were between 15 and 20 cm. Partridge utilized grass as escape cover and day and night roost sites during the winter.

Partridge feed exclusively on the ground, hence snow depth strongly influences the availability of their winter food. In Utah, prolonged deep snow resulted in 85% winter mortality (Porter 1955). In southern Manitoba and Saskatchewan, 70% of the total winter mortality was attributed to one storm in which 16.5 cm of snow fell (Knapton 1980). Siivonen (1956) regarded snow depth as the decisive factor in the developmental trend of partridge populations in Finland. Winter temperatures were only of secondary significance. A growth in population followed winters in which the maximum snow depth was less than 15 cm whereas snow depths greater than 15 cm led to a decline in the population. Potts (1980) reanalyzed Siivonen's (1956) data and found snow depth accounted for 53% of the total population variance, 79% of which was attributable to snow depth in mid-April. Field observations by Hammond (1941) disclosed that partridge were capable of digging through 6 inches (15 cm) of snow on stubble fields without difficulty. The snow depths observed during this study were not considered a barrier to foraging partridge.

3.1.3 SNOW DENSITY

Snow density varied monthly among the 5 habitats sampled. Average densities however were similar, fluctuating between .23 and .25 g/ml (Table 1).

Stubble and fallow habitats were characterized by average snow densities of .24 and .23 g/ml respectively, and were considered equal. Although there were slight monthly differences, the influence of site location (ie. valley or upland) on density was not apparent in either stubble or fallow habitat. Snow density in grass was slightly higher than in other habitats on most dates sampled; however, the average density (.25 g/ml) was similar.

With the exception of 14 February, snow density ranged between .20 and .25 g/ml during the winter and averaged .24 g/ml. Density increased from .20 g/ml on 30 January to .25 g/ml in mid-March.

Table 1

Mean (± SD) snow density (g/ml) in 5 habitat types on the study area 30 January - 13 March 1980

	HABITAT TYPE					
	UPLAND STUBBLE	UPLAND FALLOW	VALLEY STUBBLE	VALLEY FALLOW	GRASS	VALLEY
30 January	.20±.04	.21±.01	.18±.03	.19±.02	.24±.02	.20±.02
14 February	.30±.04		.27±.02		.27±.05	.28±.02
27 February	.24±.02	.25±.03	.25±.03	.27±.04	.20±.01	.24±.03
13 March	.22±.00		.26±.03		.27±.05	.25±.03
Average	.24±.04	.23±.03	.24±.04	.23±.06	.25±.03	

Snow density is highly variable and may change as a result of heat exchange due to convection, condensation, radiation and conduction, pressure of the overlying snow, wind, temperature and water variations within the snow pack, and percolation of melt water (McKay 1974). Time, weather and vegetative cover have considerable influence on the density of snow. Snow density at Regina increased from .23 to .35 g/ml from February to March (McKay and Thompson 1967). The density of settled snow is 0.2 to 0.3 g/ml but can increase to 0.7 g/ml in firm snow (snow consolidated partly into ice). Hence, snow densities recorded during the study in sampled habitats coincide with the range of values documented for settled snow in this region of the province during January to April (Gray 1974). Based on similar density measurements in each habitat, partridge appeared to be equally affected by snow density, regardless of habitat type.

3.1.4 SNOW HARDNESS

Hardness of the snowpack varied dramatically on a temporal and spatial basis (Table 2). Maximum values of 483.0 and 466.7 g/cm^2 were recorded in upland locations on 14 February and 13 March, respectively. Strong winds were believed responsible for the formation of a crust which, in some upland fallow sites, could support a man's weight.

Snow hardness was similar in valley stubble and fallow habitats. The hardest snow was present in upland sites. Snow hardness in grass was 76.1 g/cm^2, intermediate between stubble and fallow habitats.

Table 2

Mean (± SD) snow hardness (g/cm^2) in 5 habitat types on the study area 30 January - 13 March 1981.

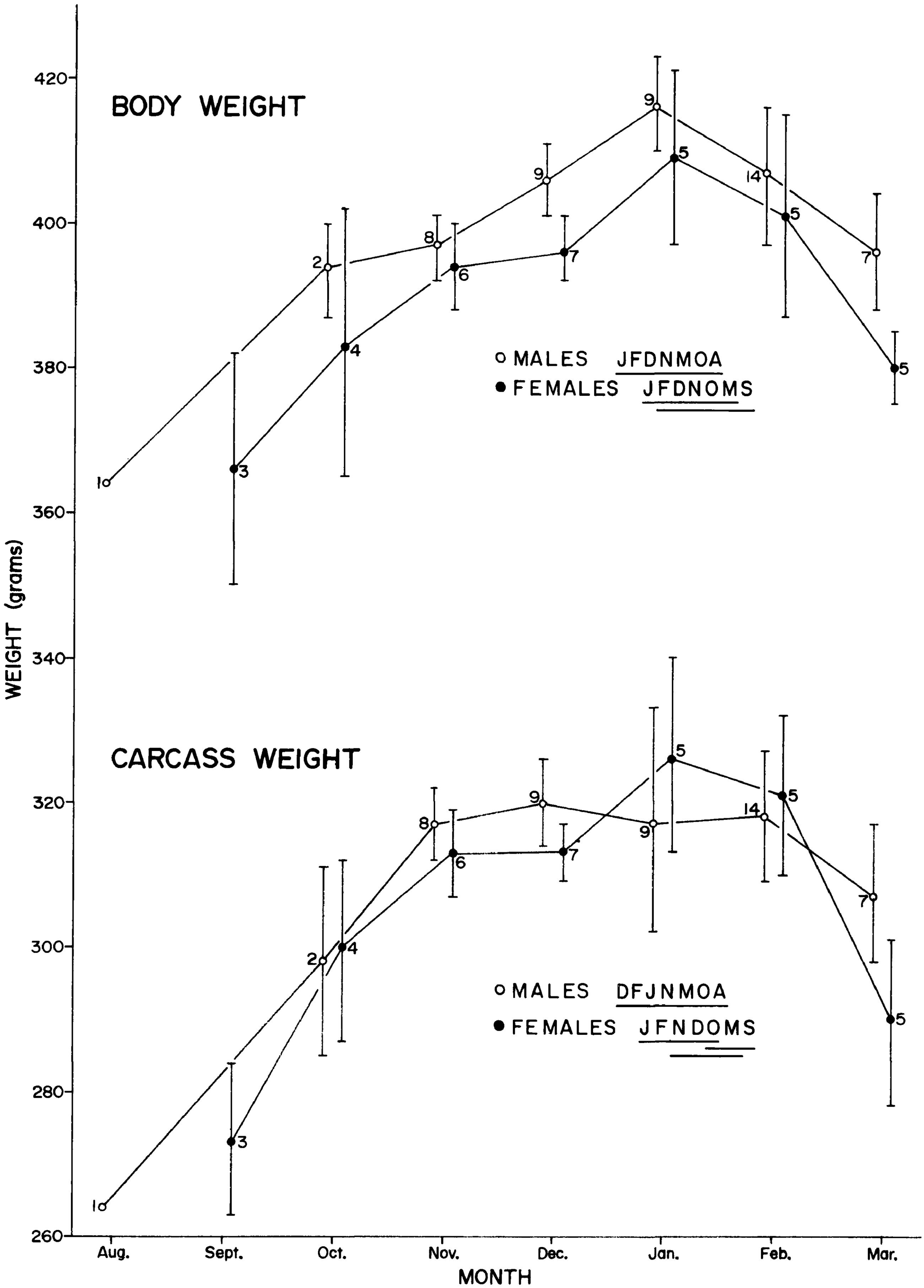
	HABITAT TYPE					
DATE	UPLAND STUBBLE	UPLAND FALLOW	VALLEY STUBBLE	VALLEY FALLOW	GRASS	AVERAGE
30 January	5.0±1.7	21.7±16.1	1.8±1.3	20.8±25.3	31.7±7.6	16.2±12.5
14 February	483.0±115.5	Trace	63.3±75.2	Trace	183±104.1	243.1±216.2
27 February	7.2±.29	40.0±27.8	26.7±5.8	33.3±10.4	3.8+104.1	22.2±16.0
13 March	23.3±18.9	466.7±293.0	21.3±25.1	Trace	86±2.8	149.3±213.7
Average	129.6±235.7	176.1±251.8	28.3±25.7	27.1±8.8	76.1±79.0	

Hardness of the snow crust, in addition to snow depth and ambient temperature, is an important ecological factor affecting partridge populations (Siivonen 1956, Pulliainen 1965). Alternating periods of freezing and thawing temperature, combined with deep snow, serves to prevent partridge from reaching their food (Westerskov 1964). In 1937, widespread mortality of partridge occurred on the Northern Plains due to the formation of an ice crust on the snow surface (Hawkins 1937, Yocum 1943). Despite the presence of a hard crust in some localities on the study area, crust formation was not considered sufficiently widespread to restrict partridge access to food resources. This conclusion was supported by casual field observations which indicated partridge experienced little or no difficulty in securing roost sites or food.

3.2 SEASONAL CHANGES IN BODY WEIGHT AND CARCASS WEIGHT

There were no significant ($P > .05$) differences in mean monthly body weight of adult and subadult male partridge during the course of this study (Fig. 9). Although male partridge were slightly heavier than females during August to March, both sexes exhibited a similar pattern of body weight fluctuation. Males increased in body weight from August to January, then decreased to 396 g in March. Female partridge weights increased significantly ($P < .05$) from September to January, then declined through to March (Fig. 9). Maximum recorded weight (including gut contents)

Figure 9. Mean (± SE) monthly body and carcass weight (g) of adult and subadult Gray Partridge August 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.



BODY WEIGHT
CARCASS WEIGHT
WEIGHT (grams)
420
400
380
360
340
320
300
280
260
MALES JFDNMOA
FEMALES JFDNOMS
MALES DFJNMOA
FEMALES JFNDOMS
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

of female partridge was 454 g, slightly less than that of males (482 g) (Table 3). Partridge body weights reported in this study were among the highest recorded in North America. In North Dakota, Kobriger (1980) recorded peak winter weights of 485 g in December, similar to the 482 g maximum observed in this study. The significance of these findings was confounded by the fact that Gray Partridge body weights varied greatly in response to differences in age, sex, season, geographic location and method of measurement.

On the basis of body weight, male partridge appeared to have a slight survival advantage over females. Roseberry and Klimstra (1971) drew a similar conclusion for Bobwhite Quail. Latham (1947) also found male partridge lived 39% longer than females during survival studies. Assuming partridge succumb once they have lost approximately 40% of body weight (Gerstell 1942, Kendeigh 1945, Keith 1962, Kobriger 1980), male and female partridge in January in Saskatchewan have critical weight minimums of 246 g and 250 g, respectively.

Mean carcass weight fluctuated in a pattern similar to that of body weight in females but among males peaked in December rather than January (Fig. 9). Mean carcass weight of males varied less than 3 g from November to February. Female carcass weights fluctuated 13.4 during the same period.

The pattern of body weight change observed in this study paralleled that documented for Gray Partridge in North Dakota.

Table 3

Body weight (g) of Gray Partridge in North America.

Location	Sex/Age[1]	Weight Mean	Weight Maximum	Reference
North America	AM	396	454	Johnsgard 1973
	AF	379	432	Johnsgard 1973
Wisconsin	Unknown	385	493 (Dec.)	McCabe & Hawkins 1946
Montana	A/SM		493 (Dec.)	Weigand 1980:22
	A/SF		508 (Apr.)	Weigand 1980:22
Michigan	AM	381.8		Yeatter 1934:38
	AF	374.6		Yeatter 1934:38
Washington	AM	386		Yocom 1942:12
	AF	367		Yocom 1942:12
North Dakota	AM	418	483 (Jan.)	Kobriger 1980
	All	429	485 (Dec.)	Kobriger 1980
Alberta	F	385		Westerskov 1965
	M	425[2]		Keith 1962
	F	418[2]		Keith 1962
Saskatchewan	A/SM	403.8	482 (Feb.)	This study
	A/SF	392.0	415 (Feb.)	This study

[1] A = Adult, S = Subadult, M = Male, F = Female.

[2] Approximated from Keith 1962:336 (Fig. 1).

Weight of adult partridge in North Dakota rapidly increased from August to December at which time a maximum weight of 429 g was attained (Kobriger 1980). Body weights declined from January to March. There were no significant differences in weight of adult male and female partridge during August to March inclusive. Female weights increased rapidly during April, reaching 482 g in May, while weight of males continued to decline. Minimum weight of male and female partridge approximated 365 g in August and September, respectively. Similar weight fluctuations in Gray Partridge were recorded by Keith (1962) in Alberta and by Weigand (1980) in Montana. Keith (1962) reported no significant difference in mean monthly weight between the sexes from October to March. Peak weights of 420 g were recorded in December and January. The pattern of weight change and the mean monthly weight of partridge reported in this study were comparable to those reported from adjoining portions of the species range. The weight decline observed in December-January through March appears typical of partridge populations in northern latitudes and may be characteristic of the species. This conclusion is supported by the fact that a weight decline occurred despite mild weather conditions and a readily available food source.

3.3 CONDITION INDICES

Several structural indices were applied to body and carcass weights to develop a condition index useful for the adjustment of body size differences (Table 4). As pointed out

Table 4

Regression of total body reserves (Y) (fat and protein) on several condition indices (X). The numerator represents adult and subadult male values and the denominator adult and subadult female values.

Independent Variable (X)	N	Coefficient of Determination r^2	Coefficient of Variation	Equation
Body Weight	50/35	.49/.64	10.95/10.44	$\hat{Y} = -75.05 + .43X$ $\hat{Y} = -120.00 + .56X$
÷ Wing + Length	49/35	.01/.07	15.35/16.85	
÷ Excul x Keel	47/34	.27/.37	13.41/14.02	
÷ Keel	49/35	.29/.35	12.99/14.04	
÷ Excul	48/34	.36/.31	12.42/14.72	
÷ Length	49/35	.38/.40	12.16/13.57	
÷ Tarsus	50/34	.48/.48	10.98/12.59	$\hat{Y} = -77.07 + 18.37X$ $\hat{Y} = -107.38 + 21.24X$
Carcass Weight	50/35	.66/.76	8.93/8.57	$\hat{Y} = -28.38 + .40X$ $\hat{Y} = -83.84 + .60X$
÷ Wing + Length	49/35	.01/.07	15.35/16.85	
÷ Excul + Keel	47/34	.47/.50	11.35/12.57	
÷ Keel	49/35	.52/.61	10.74/10.91	
÷ Excul	48/34	.52/.49	10.76/12.68	
÷ Length	49/35	.58/.60	9.96/11.04	
÷ Tarsus	50/34	.63/.64	9.24/10.42	$\hat{Y} = -25.00 + 16.58X$ $\hat{Y} = -85.17 + 24.17X$

by Bailey (1979), it is important to test whether the incorporation of structural parameters as condition indices reduce sample variation. Among Gray Partridge, carcass weight divided by tarsus length was the best condition index tested but yet could only account for 63% and 64% of the variation in total body reserves of males and females, respectively (Table 4). Carcass weight alone provided estimates with less variance and similar coefficients of determination (males r^2 = 0.66, females r^2 = 0.76). A lack of variation in each of several parameters (Table 5) would explain the failure of condition indices to reduce this variability.

Body weight alone was as reliable as a condition index ($\sqrt{\text{body weight}}^{\,3}$ ÷ wing length) in evaluating the physical condition of pheasants (Anderson 1972). Bailey (1979) also found body weight a superior index to total body fat in Redhead ducks (Aythya americana). Body weight divided by body length plus wing length was a good predictor of condition in American Wigeon (Anas americana) (Wishart 1979) but better estimates were obtained using plucked, eviscerated carcass weights. Correlation of body weight and lipid content could not be demonstrated in Ruffed Grouse (Bonasa umbellus) (Thomas et al. 1975) or Rock Ptarmigan (Lagopus mutus rupestris) (Thomas and Popko 1981). None of the measurements obtained from live partridge produced good correlations with total body reserves. Therefore, to obtain accurate information

Table 5

Selected body measurements of adult and subadult Gray Partridge collected August 1979 - March 1980

	N	X ± SD	Range
Male			
Body Length	49	298.0 ± 10.9	269 - 324
Wing Length	50	165.4 ± 4.3	151 - 174
Tarsus Length	50	42.3 ± 1.2	39.4 - 44.6
Exposed Culmen	48	14.6 ± 0.7	12.9 - 16.3
Keel Length	49	7.1 ± 0.3	6.5 - 7.9
Female			
Body Length	35	293.4 ± 9.6	271 - 319
Wing Length	35	161.1 ± 4.2	152 - 169
Tarsus Length	34	40.3 ± 1.4	36.9 - 44.1
Exposed Culmen	34	14.4 ± 0.7	13.0 - 15.6
Keel Length	35	6.8 ± 0.2	6.3 - 7.2

on fat and protein levels in Gray Partridge, birds must be sacrificed and necropsies performed.

3.4 BODY WEIGHT BIAS

To detect the possibility of a collection bias, variability in body weight, carcass weight and dry, fat-free weight of Gray Partridge were examined. There was considerable variation in body and carcass weight as evidenced by the relatively large standard deviations associated with these two variables (Table 6). In turn this suggested a wide range of weights sampled and therefore little tendency to collect larger or smaller birds. In addition there was no significant difference ($P > 0.05$) in the dry, fat-free weight of female partridge throughout the collection period (Fig. 10), further evidence that the sample was representative with respect to body size. Dry, fat-free weight of male partridge was also relatively constant although mean December weights were significantly different ($P < 0.05$) from those of August and March (Fig. 11). These differences however, may have been the result of small sample size during those months.

3.5 SEASONAL CHANGES IN FAT RESERVE

3.5.1 TOTAL BODY FAT

There was no significant difference ($P > .05$) in mean monthly total body fat of male Gray Partridge (Fig. 12). Total body fat reached a maximum in January (Fig. 12). Total body fat increased significantly ($P < .05$) among female

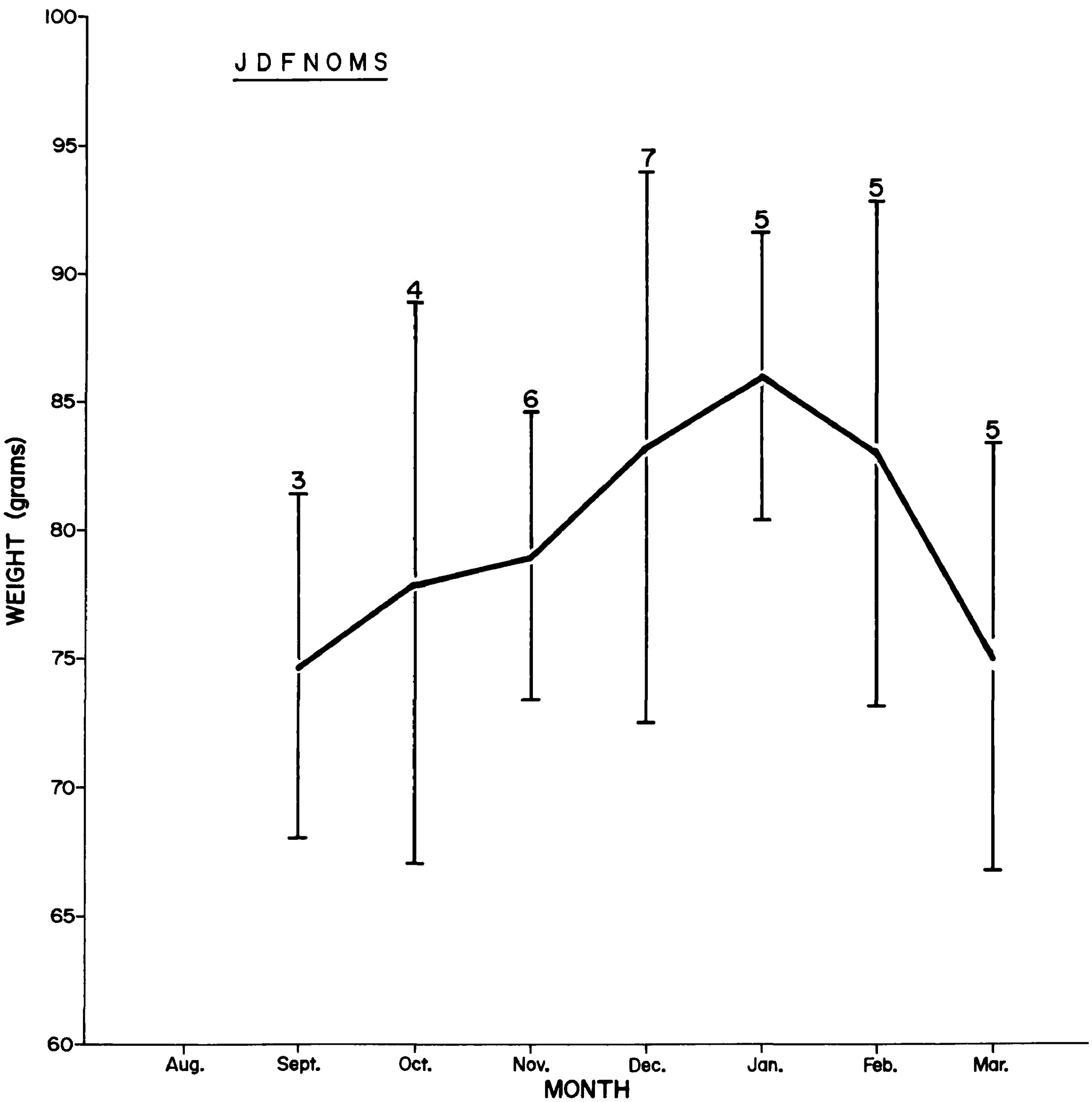
Table 6

Weight of adult and subadult Gray Partridge

August 1979 - March 1980

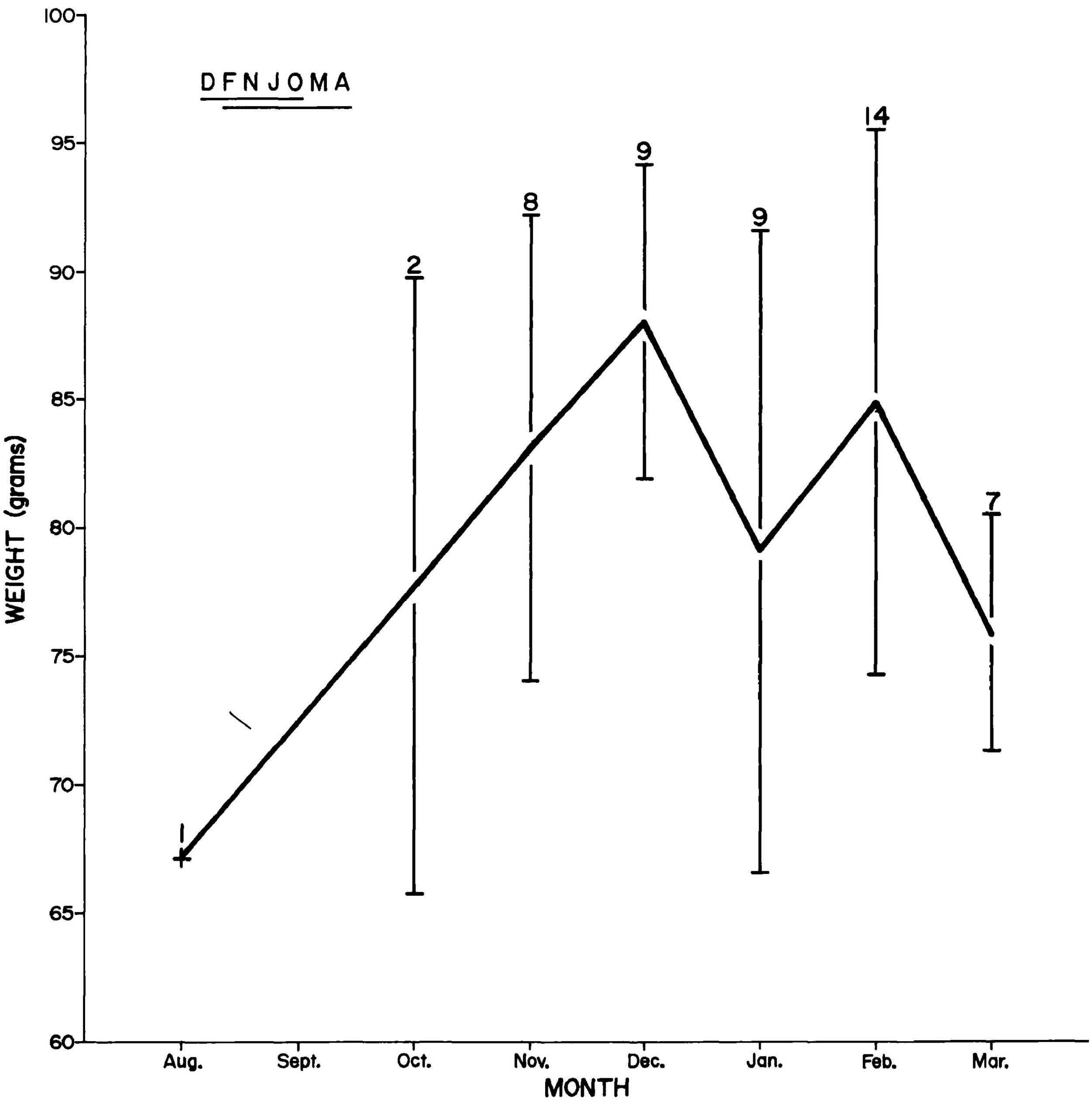
	No. of Birds	Mean	S.D.
Body Weight			
Male	50	403.8	24.2
Female	35	392.0	24.5
Carcass Weight			
Male	50	314.7	30.0
Female	35	307.7	25.0

Figure 10. Dry, fat-free weight ($\bar{X} \pm SD$) of adult and subadult female Gray Partridge August 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.



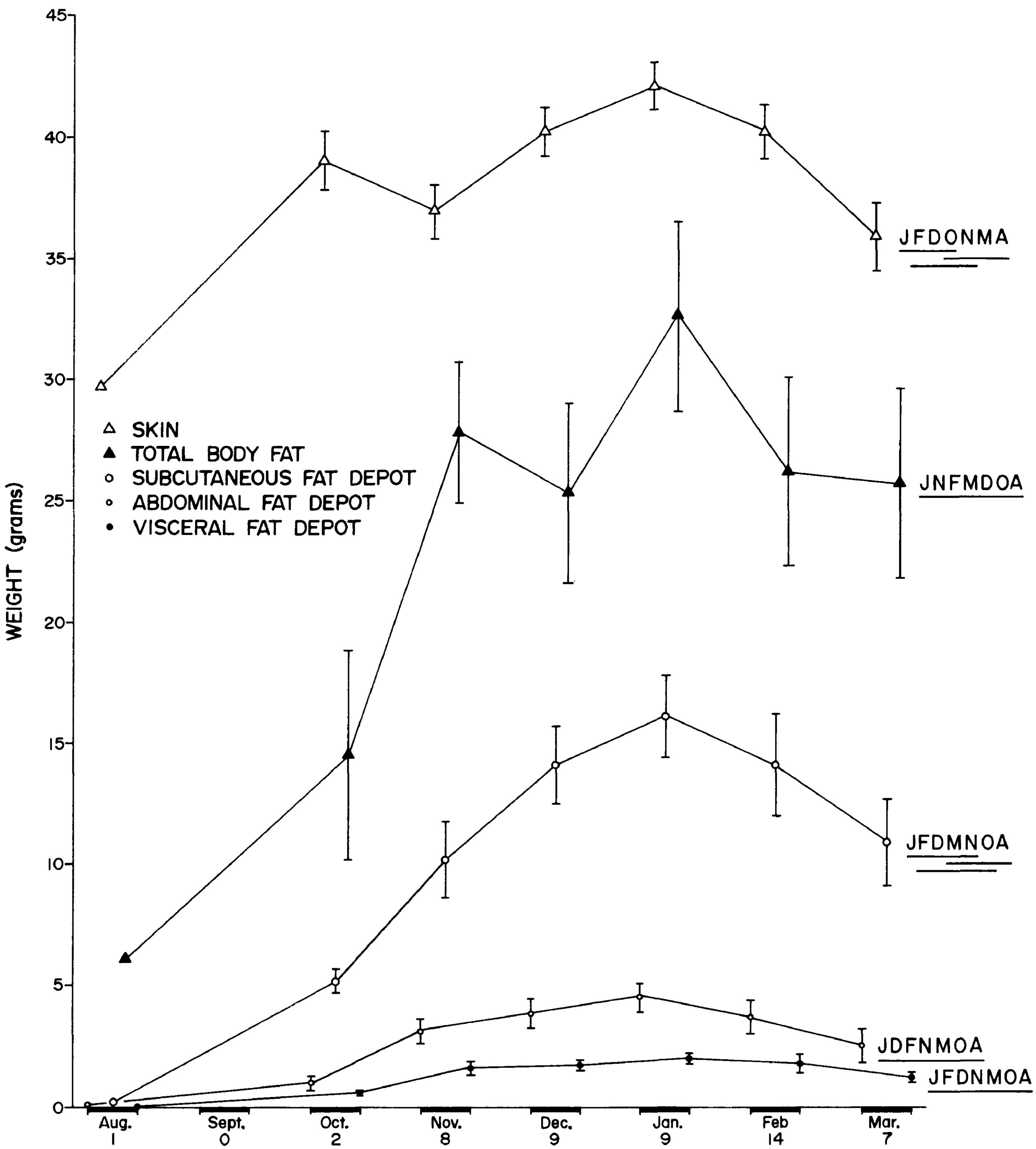
JDFNOMS
WEIGHT (grams)
100
95
90
85
80
75
70
65
60
3
4
6
7
5
5
5
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

Figure 11. Dry, fat-free weight ($\bar{X} \pm SD$) of adult and subadult male Gray Partridge August 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.



DFNJOMA
100
95
90
85
80
75
70
65
60
WEIGHT (grams)
2
8
9
9
14
7
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

Figure 12. Mean (± SE) monthly weight of skin, total body fat, subcutaneous, abdominal and visceral fat depots of adult and subadult male Gray Partridge August 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.

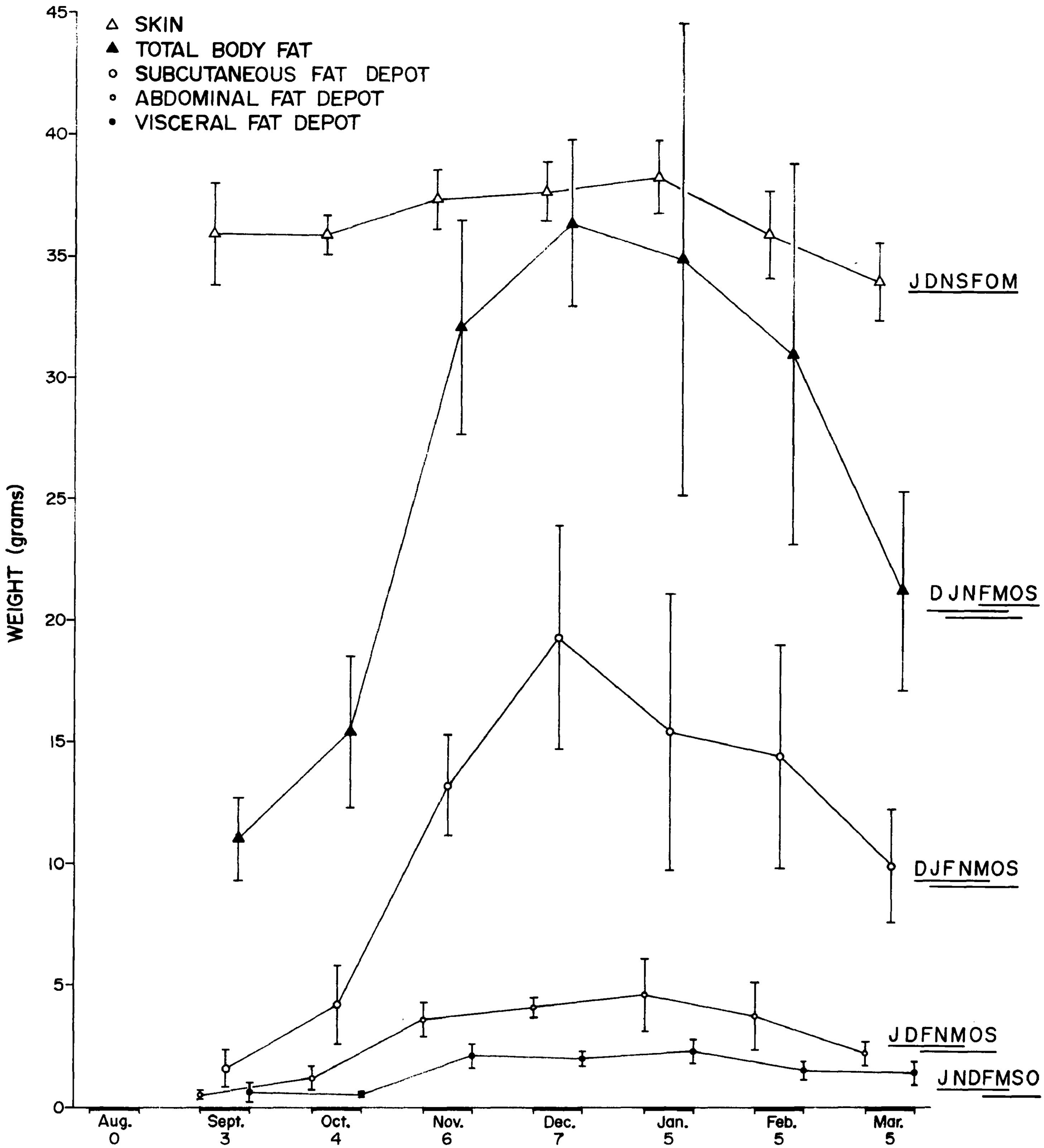


45
40
35
30
25
20
15
10
5
0
WEIGHT (grams)
SKIN
TOTAL BODY FAT
SUBCUTANEOUS FAT DEPOT
ABDOMINAL FAT DEPOT
VISCERAL FAT DEPOT
JFDONMA
JNFMDOA
JFDMNOA
JDFNMOA
JFDNMOA
Aug.
1
Sept.
0
Oct.
2
Nov.
8
Dec.
9
Jan.
9
Feb
14
Mar.
7

partridge between September and December (Fig. 13). Body weight of female partridge peaked in January. However, maximum fat accumulations occurred one month earlier (Fig. 13). Male fat reserves declined sharply, but not significantly in February and remained at this level throughout March (Fig. 12); in females the decline was continuous and more gradual (Fig. 13). The general decline in female fat reserves likely continued through July due to the energetic demands of egg production, incubation, molting and brood rearing as documented by Szwykowska (1969).

Partridge in the study area accumulated fat reserves during the fall presumably in preparation for the environmental stresses associated with winter. Based on similarities in body weight, juvenile and adult partridge entered the winter with equivalent energy reserves. A study of partridge in Poland (Szwykowska 1969) indicated similar seasonal changes in fat reserves. Szwykowska recorded peak fat accumulations in Gray Partridge in November (29.7% dry weight) (Appendix E). January fat reserves constituted 26.7% dry weight. Percentage fat declined steadily to 12.8% in July, with a slight increase observed in May (due to the presence of fat-rich yolk in oviducts). Low fat reserves in June were attributed to the energetic requirements of molting. The 1 - 2 month differential in peak fat accumulation between Poland and Saskatchewan was likely the result of differences

Figure 13. Mean (± SE) monthly weight of skin, total body fat, subcutaneous, abdominal and visceral fat depots of adult and subadult female Gray Partridge September 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.

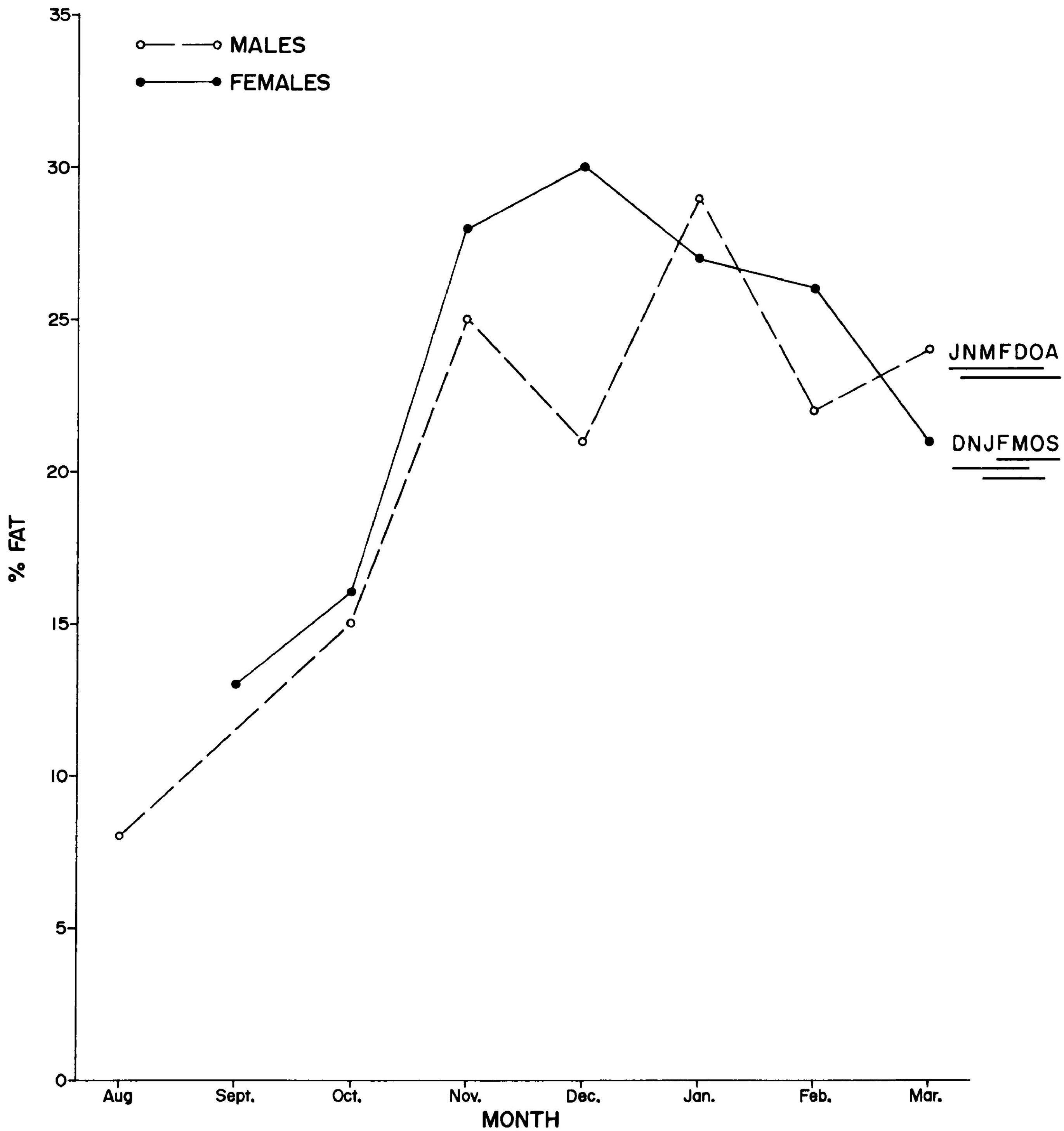


SKIN
TOTAL BODY FAT
SUBCUTANEOUS FAT DEPOT
ABDOMINAL FAT DEPOT
VISCERAL FAT DEPOT
WEIGHT (grams)
0
5
10
15
20
25
30
35
40
45
JDNSFOM
DJNFMOS
DJFNMOS
JDFNMOS
JNDFMSO
Aug. 0
Sept. 3
Oct. 4
Nov. 6
Dec. 7
Jan. 5
Feb. 5
Mar. 5

in temperature, snowfall and food availability on the two study areas. January 1968 was very mild and the fields on the Polish study area were not covered with snow, hence the partridge had unrestricted access to food (Szwykowska 1969). The fat dynamics of Bobwhite Quail in Kansas (Robel 1972) appeared similar to those documented for Gray Partridge in this study. Ether-extractable fat content was lowest (7.29 ± 0.35% dry weight) in September, gradually increased during October, November and December, and reached a peak (20.13 ± 1.69%) in January after which levels gradually declined to March. Quail residing close to artificial food plantings had nearly twice the fat reserves of those collected far from food plots. Consequently, birds close to food plots had a probability of survival 79% greater than birds not having access to a food plot (Robel 1972).

Fat constituted 29% and 30% (dry matter) of male and female peak body weight, respectively (Fig. 14). There did not appear to be any sexual bias in survivability among Gray Partridge based on the size of fat reserves. This contradicts Latham's (1947) findings of male superiority in withstanding fasting and climatic extremes, although his was a laboratory study incorporating only 3 pairs of partridge. Robel (1965) reported no differential mortality between male and female Bobwhite Quail under winter conditions. The percentage of body fat (dry weight basis) in male and female pheasants in December averaged 15.4 ± 4.1% and 29.9 ± 9.1%

Figure 14. Mean monthly fat content (% dry matter) of adult and subadult Gray Partridge collected August 1979 to March 1980. Months sharing a line beneath them were not significantly different.



MALES
FEMALES
JNMFDOA
DNJFMOS
% FAT
35
30
25
20
15
10
5
0
Aug
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

respectively under controlled experimental conditions (Barrett and Bailey 1972). Highly significant differences in fat content were apparent at different times of the year and females had at least twice the body fat of males. Reduced body weights, delayed onset of egg laying, increased hatchability of eggs and poor physical condition were manifest in pheasants fed low energy diets. Female pheasants on high and medium metabolizable energy diets characteristically had body fat levels of 36.1 ± 6.0% and 34.3 ± 6.8% respectively, and as such approximated maximum accumulations recorded for female Gray Partridge in the present study.

Ruffed Grouse in Ontario had a relatively low lipid content (5.91 - 9.17% dry weight) (Thomas et al. 1975). Lipids did not constitute major energy reserves of Ruffed Grouse during the winter and birds must feed regularly to maintain homeothermy. Similar findings have been reported for Willow Ptarmigan (Lagopus lagopus)(West and Meng 1968). Rock Ptarmigan in northern Ontario also had small fat reserves ie. approximately 4% of wet body weight (Thomas and Popko 1981). Based on the weight of three fat depots, Schmidt (1980) reported a November maximum in fat storage in adult male Sharp-tailed Grouse (Pediocetes phasianellus) in Saskatchewan. At this time, fat amounted to approximately 3% of wet body weight. Based on the relatively high proportion of body fat and the continual accumulation of energy stores prior to winter , fat reserves appear to be of significant metabolic importance to Gray Partridge in Saskatchewan. Adoption of a high-energy fall and winter diet (Melinchuk 1981) facilitates the preparation and maintenance of body fat (and protein reserves.

3.5.2 FAT DEPOTS

Subcutaneous fat deposits constituted the largest fat store in Gray Partridge, averaging 12.8 ± 0.9 g and 12.4 ± 1.7 g in males and females, respectively. Extensive deposits of fat were located in the interclavicular, axillary, flank and leg region (Fig. 15). In both sexes, weight of subcutaneous fat depots and body weight peaked simultaneously. Subcutaneous fat deposits in males approximated 16 g (53% of total body fat) in January (Fig. 12). In females, the subcutaneous fat depot attained a maximum weight of 19 g (48% of total body fat) in December (Fig. 13). The accumulation of subcutaneous fat was continuous and rapid in both sexes. The subsequent gradual decline in weight was also similar in males and females with March weights approximating 10 - 11 g. Subcutaneous fat insulates against heat loss and provides a source of reserve energy (Westerskov 1965). Subcutaneous fat was also the largest source of stored energy in redheads (Bailey 1979). In Canada Geese (<u>Branta canadensis</u>) subcutaneous fat is the first to be metabolized, followed by visceral and abdominal fat reserves (Hanson 1962). Assuming this relationship holds true for partridge, the presence of subcutaneous fat reserves

Figure 15. Axillary, leg and flank fat depots present on a juvenile female collected 6 February 1980.


Feb 6/80 JF
467g.
(11)
#42
1 of 3.
Remarks:

suggest that Gray Partridge were not subject to significant nutritional stress during the period of study.

The abdominal fat deposit was the second largest fat reserve in Gray Partridge. Changes in abdominal fat were less pronounced than those of subcutaneous fat but did exhibit monthly fluctuations (Fig. 12, 13). Maximum abdominal fat reserves of slightly more than 4 g occurred in January in both sexes. Abdominal fat stores comprised 20% - 25% of the large subcutaneous fat depot. Increases in weight of this fat depot between August and January were gradual as was the post-January decline. Approximately 2 g of fat were present in the abdominal depot of males and females in March.

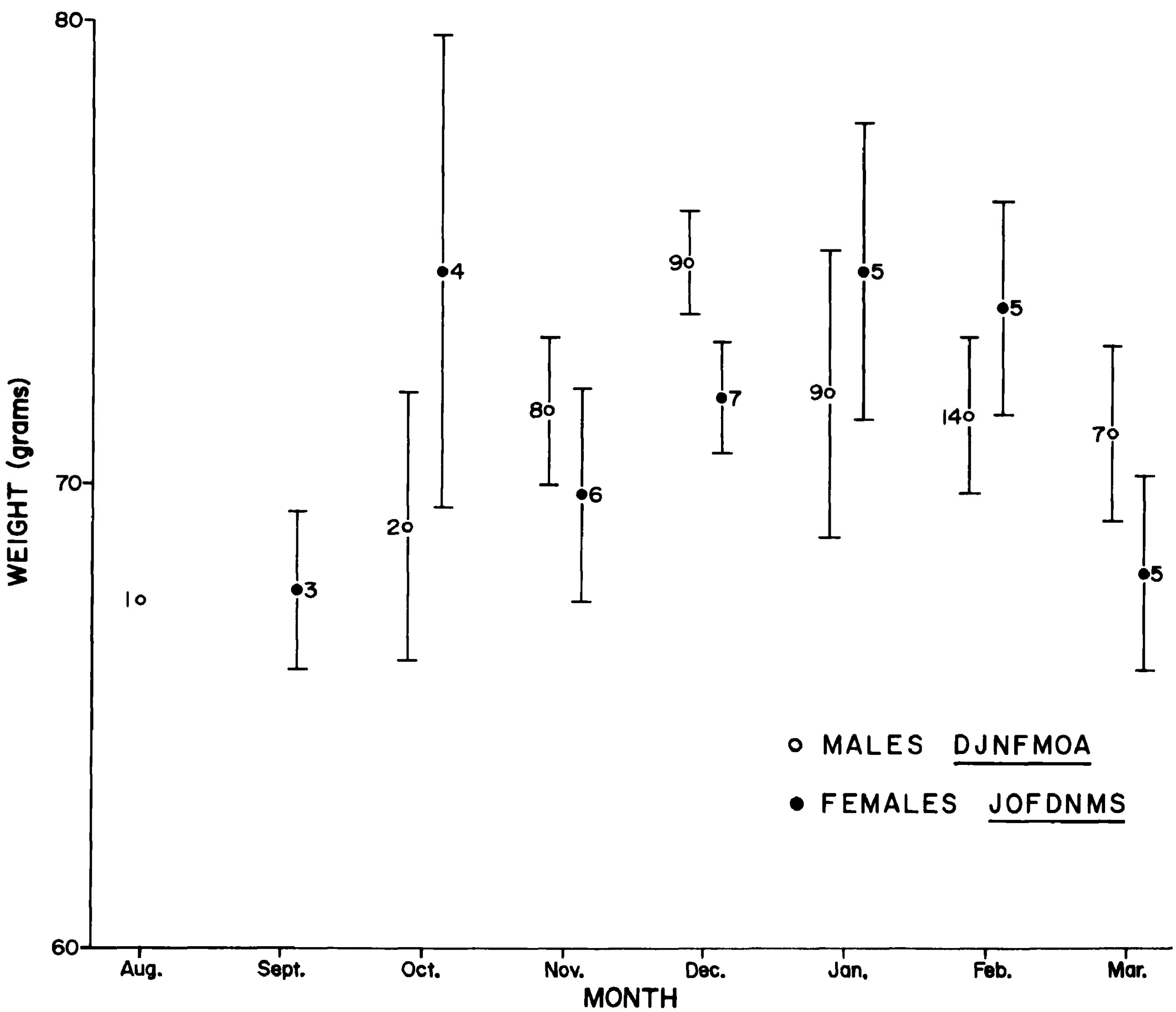
The visceral fat depot was the smallest and least variable of the depots examined. In males, visceral fat increased to a maximum of 2 g in January, then declined to approximately 1 g in March (Fig. 12). Maximum visceral fat accumulations in females were attained in November and remained at this level during December and January (Fig. 13). The amount of visceral fat in males and females was similar in March. In Spruce Grouse (<u>Canachites canadensis</u>) the amount of depot fat (located primarily in the mesenteries) was small and relatively constant (except in females prior to laying) and was not considered a significant factor in observed weight changes (Pendergast and Boag 1973).

3.6 SEASONAL CHANGES IN PROTEIN RESERVE

Carcass protein levels were relatively constant during the period of study in both male and female partridge (Fig. 16). Mean dry matter protein varied by only 7.3 g and 6.9 g in males and females, respectively. Percentage protein in male partridge ranged from 76.02% in October to 64.96% in January, with the exception of August (Table 7). Female protein levels fluctuated between 60.61% in December and 80.49% in October. Such weights must be expressed on a dry weight basis to compensate for variations in carcass moisture content.

Data presented by Szwykowska (1969) were expressed on a wet weight basis and have been recalculated as percent dry matter for comparison (Appendix E). These data indicate monthly protein levels varied little throughout the year, ranging between 57.87% in January and 70.19% in June. Observed protein changes were attributed to molt patterns. Although high protein levels in late summer-early fall may be associated with completion of the post-nuptial molt, it is unlikely that variations between October and May resulted from feather wear. Feathers were not incorporated in the present study, hence cannot be associated with observed variations in protein reserve. Thomas and Popko (1981) reported carcass protein levels of 62.94% - 65.78% in wintering Rock Ptarmigan in northern Ontario.

Figure 16. Protein content (g. dry matter) of adult and sub-adult partridge August 1979 to March 1980. Indicated are mean (± SE) weight and sample size. Months sharing a line beneath them were not significantly different.



80
70
60
WEIGHT (grams)
MONTH
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
1
3
2
4
8
6
9
7
9
5
14
5
7
5
MALES DJNFMOA
FEMALES JOFDNMS

Table 7

Protein (% dry matter) content of adult and subadult Gray Partridge August 1979 - March 1980

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Male								
$\bar{X}$	91.94		76.02	65.18	66.26	64.96	65.12	70.42
SE			7.4	2.89	1.44	1.91	1.97	2.27
N	1	0	2	8	9	9	14	7
Female								
$\bar{X}$		79.39	80.49	63.23	60.61	62.97	66.32	71.67
SE		3.46	2.71	2.83	2.25	3.79	5.13	4.05
N	0	3	4	6	7	5	5	5

It is generally agreed that fat and protein reserves cannot be preferentially utilized within the body (Hanson 1962, Cahill 1978) although they may be utilized disproportionately (Barrett and Bailey 1972). Protein reserves may be depleted during periods of environmental stress or egg formation. However, this would occur only in combination with lipid oxidation. Jones and Ward (1976) suggested protein reserve was the factor limiting egg production in Red-billed Queleas (*Quelea quelea*). There were no significant differences in the monthly protein content of partridges during the study (Fig. 16) suggesting such stress situations probably did not exist. Hence, protein reserves probably were not reduced to a detrimental level. Female protein reserves declined slightly but not significantly between January and March (Fig. 16). This decline coupled with depletion of body fat, may have been in response to the energetic demands of egg development as demonstrated in Lesser Snow Geese (*Anser caerulescens caerulenscens*) (Ankney and MacInnes 1978). Whether these responses also occur in Phasianidae is unclear. The ability of female Bobwhite Quail to increase levels of circulating lipids and lipoproteins while maintaining fat reserves (McRae and Dimmick 1982) further confounded interpretation of these results.

3.7 PREDICTION OF BODY RESERVES

Chemical carcass analysis is an expensive and time consuming process requiring elaborate laboratory facilities. An easily obtained, accurate and objective index of carcass fat and protein reserves is of great advantage (Smith 1970). The derivation of such indices eliminates the need for detailed chemical analyses and allows the prediction of various body energy reserves based on a minimum of measurements.

3.7.1 BODY FAT RESERVE

The best correlate of total body fat in Gray Partridge was the multiple-regressed weight of fat from the abdominal, subcutaneous and visceral fat depots. The combined fat weight explained 89% and 62% of the variation in total body fat of females and males, respectively (Table 8). Bailey (1979) found over 93% of the variation in total body fat of Redheads could be accounted for by the measurement of fat in these 3 depots. Weight of abdominal fat and skin fat was the best predictor (r^2 = .92) of total body fat in American Wigeon (Wishart 1979). In the present study abdominal plus subcutaneous fat weight yielded results similar to those obtained using all 3 depots, indicating the minor contribution of visceral fat in understanding total body fat fluctuations in partridge. The best single predictor of total body fat was the subcutaneous fat depot (r^2 = .57 for males, r^2 = .79 for females) (Table 8); however to obtain the weight of this fat depot involved considerable time to skin the bird and

Table 8

Regression of total body fat (Y) on independent variables (X). The numerator represents adult and subadult male values and the denominator adult and subadult female values.

Independent Variables (X)	N	r^2	F Value	P>F*	d.f.**	Equation
AFD + VFD + CFD[1]	50/35	.62/.89	24.69/83.54			
VFD + CFD	50/35	.59/.87	34.33/106.93			
AFD + CFD	50./35	.60/.87	34.87/105.27			
AFD + VFD	50/35	.61/.87	37.01/57.18			
CFD	50/35	.57/.79	63.38/125.14			
AFD	50/35	.57/.76	63.93/105.59			$\hat{Y} = 11.68 + 4.34X$ $Y = 10.23 + 5.65X$
VFD	50/35	.52/.55	52.05/40.62			
% Moisture	50/35	.36/.77	26.81/110.56			
SFI[2]	49/34	.38/.59	28.96/45.75		48/33	
Carcass Weight	50/35	.35/.51	25.59/34.78			
Body Weight	50/35	.31/.39	21.35/21.37			
Skin Weight	50/34	.16/.40	9.20/21.06	.0039/	—/33	

* .0001 unless otherwise indicated.

** numerator = 49; denominator = 34 unless otherwise indicated.

1. AFD (Abdominal Fat Depot) VFD (Visceral Fat Depot), CFD (Subcutaneous Fat Depot)
2. Subjective Fat Index.

separate the fat from the internal skin surface. A similarly accurate estimate was the weight of the abdominal fat depot (r^2 = .57 for males, r^2 = .76 for females). The abdominal fat depot represented a practical, easily-obtained and relatively accurate predictor of total body fat reserves. This fat depot was also the most useful correlate (r^2 = 0.83) of total body fat in Wigeon (Wishart 1979). Bailey (1979) found whole skin weight and abdominal fat depot weight to be readily-obtained, good predictors of total body fat in Redheads. A high correlation (r^2 = +0.95) between omental fat (similar to abdominal fat + visceral fat in this study) and total body fat was also reported in Redbilled Teal (Anas erythrorhyncha) (Woodall 1978). Baldassarre et al. (1980) found subcutaneous fat (r^2 = 0.92) and omental fat (r^2 = 0.80) the best independent variables for predicting total fat in mallards (Anas platyrhynchos).

The abdominal fat depot can be quickly excised from the body of collected or hunter-killed Gray Partridge via an incision on the ventral surface of the abdominal wall. The layer of fat lying ventral to the intestines but separate from them can be extracted and the viscera then removed from the body cavity. The fat deposits situated on each side of the cloaca can then be removed and placed along with the other fat deposit in a plastic bag and frozen or put on ice. After thawing, weights can be recorded to the nearest .01 g.

Extraction of this fat depot is relatively rapid and does not affect the culinary value of the bird (Woodall 1978). Collection of such material from hunters is relatively easy because samples can be obtained in the field without excising the edible portion of the carcass.

Total fat content has also been estimated using carcass moisture content (Child and Marshall 1970, Campbell and Leatherland 1980). Percentage moisture was not a reliable index to total body fat in Gray Partridge nor is it a rapidly obtained measure. Water content of female partridge carcasses was closely correlated with total body fat ($r = .88$) but accounted for only 36% of the variation in the fat content of males (Table 8). Bailey (1979) and Wishart (1979) also dismissed this variable as an estimate of fat reserves because of the time required to obtain it compared with actual fat determinations. Among Gray Partridge the subjective fat index (SFI) was a reasonably good predictor of total body fat ($r^2 = .59$) for females but a poor one for use on males, hence did not constitute a practical means of fat assessment in this species.

Male and female coefficients of determination were considerably different in most regressions tested. Females generally yielded higher values. Considering the chemical analyses were run simultaneously, it is possible that the fat content of all female fat depots was less variable and hence produced better correlations.

3.7.2 PROTEIN RESERVE

Carcass weight was the best predictor of protein re-reserve in Gray Partridge (r^2 = .72 males, r^2 = .57 females). Carcass weight was also the best predictor of total body reserves (fat plus protein reserve) in partridge, accounting for 66% of the variation in male body reserves and 76% of observed female variation (Table 4). Wishart (1979) found carcass weight divided by body length + wing length the best predictor of protein reserve in Wigeon, but could account for only 60% of the observed variation. Although breast muscle constituted the largest source of protein in partridge, correlation of this muscle mass with total protein reserve was poor for males (r^2 = .35) and only fair for females (r^2 = .58) (Table 9). Leg muscle weight accounted for approximately one-third of the variation in protein reserve. The combined wet weight of breast muscle, leg muscle and gizzard and the multiple regression of these 3 muscle masses yielded lower coefficients of determination than carcass weight alone. No correlation existed between gizzard weight and protein reserve. Fat-free weight was also not an acceptably accurate index to protein reserve, accounting for less than one-half the observed variation in protein reserve. The poor correlations obtained for many of the variables tested for both partridge and Wigeon may have been the result of variation in water content of muscle mass and may be improved by using

Table 9

Regression of protein reserve, g dry matter (Y) on protein variables (X). The numerator represents adult and subadult male values, the denominator adult and subadult female values.

Independent Variable (X)	N	r^2	F value	P>F*	d.f.**	Equation
Body Weight	50 35	.42 .60	32.02 49.98			
Carcass Weight	50 35	.72 .57	123.67 44.11			$\hat{Y} = 19.37 + .17x$ $\hat{Y} = 16.79 + .18x$
Fat-free Weight	50 35	.32 .44	23.09 26.01			
Breast Muscle Weight (BMW)	50 35	.35 .33	25.65 45.86			
Leg Muscle Weight (LMW)	50 35	.31 .33	22.06 16.22	.0003		
Gizzard Weight (GW)	48 34	.00 .02	.00 .51	.9895 .4805	47 33	
BMW + LMW + GW	48 34	.43 .63	11.05 17.36		47 33	
BLG[1]	48 34	.41 .63	32.23 53.38		47 33	

* .0001 unless otherwise indicated.

** numerator = 49, denominator = 34 unless otherwise indicated.

[1]BLG = combined wet weight of breast, leg and gizzard muscles.

lipid-free, dry muscle weights as suggested by Wishart (1979).

3.8 PARASITOLOGICAL EXAMINATION

I examined 35 juvenile, 55 subadult and 32 adult partridge for parasites and found one Acanthocephalidae, three genera of Mallophaga, one Hippoboscidae, one species of tick and an unidentified mite. Because of inadequate taxonomic keys and a lack of type species for the Mallophaga of western Canada (J.E.H. Martin pers. comm.) species identification was made for only one genus.

3.8.1 ECTOPARASITES

Goniocotes sp., *Cuclotogaster* sp., and *Amyrsidea perdicis* (Denny), were present on Gray Partridge (Table 10). *Cuclotogaster* spp. was the most prevalent genus of Mallophaga, occurring on 13.0% of partridge. Only five partridge were infected with *Goniocotes*. Presence of two or more genera of Mallophaga on the same bird was uncommon, ranging from 0.8% to 7.3%. The mean intensity of Mallophaga was low (<5) although all lice present may not have been located.

Cuclotogaster heterogrammicus, *Goniocotes microthorax*, *G. simillimus* and *Amyrsidea perdicis* have been reported previously from Gray Partridge (Emerson 1951, Malcolmson 1960). *Amyrsidea* sp. has been found on Willow Ptarmigan,

Table 10

Prevalence and association of 3 genera of Mallophaga on Gray Partridge collected August 1979 - March 1980 (N = 123)

GENUS	NO. INFECTED	PREVALENCE (%)
Cuclotogaster sp.	16	13.0
Cuclotogaster sp. and Goniocotes sp.	9	7.3
Cuclotogaster sp. and A. perdicis	3	2.4
Cuclotogaster sp., Goniocotes sp. & A. perdicis	1	0.8
Goniocotes sp.	5	4.1
Goniocotes sp. and A. perdicis	2	1.6
A. perdicis	11	8.9

Ring-necked Pheasants (Malcolmson 1960), Rock Ptarmigan and Sharp-tailed Grouse (*Pedioecetes phasianellus campestris*) in North America (Emerson 1951, Malcolmson 1960) but were not encountered in this investigation, although the latter species is known to occur on Gray Partridge in Saskatchewan (Emerson 1951).

Adult and/or larval rabbit ticks (*Haemaphysalis leporispalustris*) were present on three (2.4%) Gray Partridge; a single adult was found on each of two partridge and nine larval ticks were present on one other bird. *H. leporispalustris* was also the most common tick on Bobwhite Quail, occurring on 22.7% of 339 quail examined throughout the year (Bergstrand and Klimstra 1964). This tick has also been implicated in the transmission of tularemia to Sharp-tailed Grouse and Ruffed Grouse (Green and Shillinger 1932). Although the presence of this tick on partridge suggests the potential for disease transmission, there is no report to date that tularemia exists in Gray Partridge in Saskatchewan.

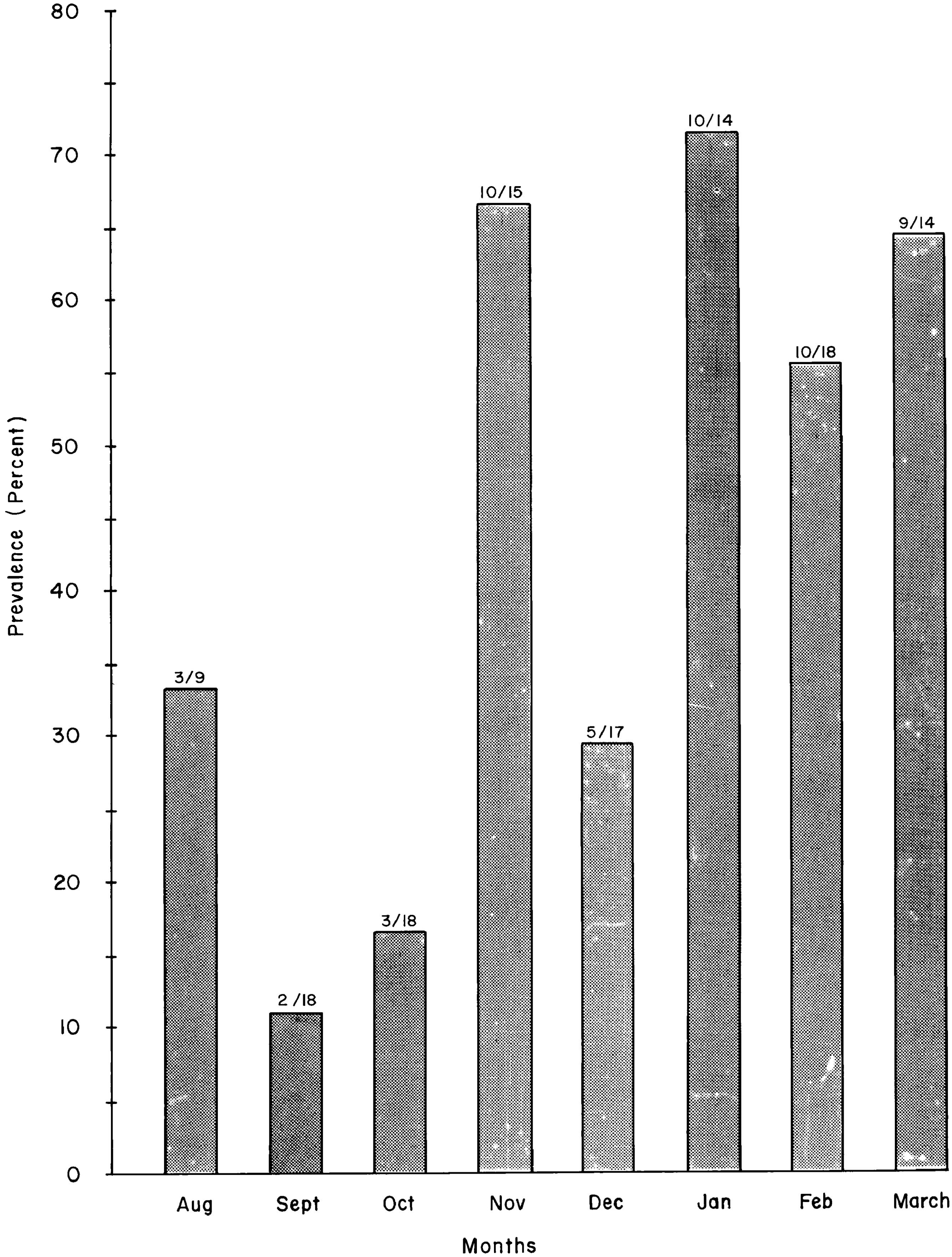
The avian Hippoboscid, *Ornithioca vicina* (Walker), was found on an adult male partridge collected in August and one mite (Acarina) was present on an adult female in September. *O. vicina* is a common ectoparasite, having been reported from over 120 species of birds in North America (Surgeoner, pers. comm.). The singlar occurence of this species and an unidentified mite suggest only a rare or accidental presence on Gray Partridge in Saskatchewan.

The overall prevalence of ectoparasites was 41.5% but varied with age of the birds and with season (Fig. 17, Table 11). Ectoparasites were most prevalent on adult birds (50.0%) and lowest on juveniles (20.0%). The prevalence of Mallophaga on adult and subadult partridge of both sexes was not significantly different (females: $G = 1.06$ $P > 0.05$, males: $G = 0.16$ $P > 0.05$); hence these two age classes were combined for statistical analysis. Mallophaga occurred on juvenile partridge at one-third to one-half the rate observed in adults (Table 11), and was probably a function of exposure time. Mallophaga were significantly ($G = 5.14$ $P < 0.05$) more prevalent on adult/subadult than on juvenile male partridge. A similar relationship also existed among females ($G = 17.72$ $P < 0.05$).

Juvenile birds usually are not as heavily infested with ectoparasites as adults, a conclusion drawn by Ash (1960) after examining 125 specimens of several species from April to September. However, among Bobwhite Quail, 98.4% of juveniles and 90.4% of adults were infected with Mallophaga (Bergstrand and Klimstra 1964).

Sex-related differences in the prevalence of Mallophaga were not apparent in either adult and subadult ($G = 1.60$ $P > 0.05$) or juvenile ($G = 0.48$ $P > 0.05$) partridge

Figure 17. Monthly prevalence of Mallophaga on Gray Partridge (no. infected/total).



80
70
60
50
40
30
20
10
0
Prevalence (Percent)
3/9
2/18
3/18
10/15
5/17
10/14
10/18
9/14
Aug
Sept
Oct
Nov
Dec
Jan
Feb
March
Months

Table 11

Prevalence and intensity of Mallophaga

on Gray Partridge collected August 1979 - March 1980

AGE	SEX	NUMBER EXAMINED	NUMBER INFECTED	PREVALENCE	MEAN INTENSITY
Adults	Males	17	9	52.9	2.67 ± 2.55
	Females	15	7	46.7	1.57 ± 0.79
	Total	32	16	50.0	2.19 ± 2.01
Subadults	Males	34	20	58.8	3.57 ± 2.77
	Females	22	8	36.4	2.14 ± 1.21
	Total	56	28	50.0	3.21 ± 2.53
Juveniles	Males	16	4	25.0	1.75 ---
	Females	19	3	15.8	3.67 ---
	Total	35	7	20.0	2.57 ± 1.90
TOTAL	MALES	67	33	49.3	3.12 ± 2.61
	FEMALES	56	18	32.1	2.18 ± 1.38
TOTAL		123	51	41.5	2.80 ± 2.31

examined in this study (Table 11). Similar rates of prevalence have been reported for male and female Chaffinches (Fringilla coelebs) and Blackbirds (Turdus merula) (Ash 1960) while 93% of male and 98% of female Bobwhite Quail were infected (Bergstrand and Klimstra 1964). MacKenzie and MacKenzie (1981) reported similar rates of Mallophagan infestation on male and female Eastern Kingbirds (Tyrannus tyrannus) at Delta, Manitoba. As pointed out by Foster (1969) the relationship between host sex and ectoparasite breeding activity (ie. degree of infestation) is probably most evident among blood-feeding parasites, due to the introduction of host reproductive hormones into the parasites. The fact that Mallophaga do not feed on blood may explain in part the lack of any significant sex-related differences in Mallophaga prevalence among Gray Partridge.

August to October and December were months of low prevalence, with a peak (71%) occurring in January (Fig. 17). There is a tendency for ectoparasitic infections to peak in winter just prior to an avian hosts' breeding season, subsequently decrease in late winter and continue at low levels throughout the breeding season (Ash 1960). Gray Partridge, which breed in April and May, exhibited this typical infestation chronology.

3.8.2 ENDOPARISITES

Although thorough necropsies were conducted, less than

1.0% of the partridge examined in this study were infected with helminths. An unidentified adult Acanthocephalan was obtained from the small intestine of a 17 week old female on 17 October. The worm was not attached to the intestinal epithelium nor was there any evidence of haemorrhage or tissue necrosis. Brugger (1941) reported 3.9% of 104 partridge from eastern Washington were infected with *Heterakis gallinae* but attached no significance to this finding. Yeatter (1934) detected *Heterakis* in 14.5% and *Dispharynx spiralis* in 31.6% of 76 Gray Partridge necropsied but did not attribute any mortalities to either parasite. *D. nasuta* has also been found in partridge in Ontario (Bendell and Lisk 1957). Based on these findings, helminthic infections are light or uncommon in Gray Partridge in North America and are not considered a significant mortality factor.

This low incidence may be attributable to one or a combination of factors. Brugger (1941) considered the combination of farming practices, climate and partridge life history characteristics to limit the opportunity for parasitic infection. As well, grasses comprised over 80% of partridge diets on the study area (Melinchuk 1981) and insects were eaten in relatively small quantities. It may be that the insect species commonly eaten by partridge (mainly grasshoppers) were not suitable intermediate hosts for avian helminths or that only a small proportion of them were infected with parasitic larvae.

On their native European range, Gray Partridge harbour a more diverse parasitic fauna than those in North America. *Menopon abdominale*, *Goniocotes dispar*, *G. microthorax*, *G. asterocephalus*, *Ornythomyla avicularia* (*Diptera*) and *Cnemidokoptes mutans* (Sarcoptidae) are common ectoparasites of *Perdix* spp. in Czechoslovakia (Kokes and Knobloch 1947). Par et al. (1966) reported 32.3% of 1,677 partridge from Bohemia and Moravia were infected with 8 species of Nematoda and 6 species of Cestoda. The most common helminth, *Theminx phasianina* (Nematoda) occurred in 9.5% of partridge examined. Other helminths known to infect Old World partridge include: *Syngamus trachea*, *Trichostrongylus tenuis*, *Ascaridia galli*, *A. compar*, *Raillietina tetragena*, *R. echinobethrida*, *Choanotaenia infundibulum*, *Hymenolepis linea*, *H. cantaniana* and *Davainea andrei*. (Kokes and Knobloch 1947, Par et al. 1966).

4. GENERAL DISCUSSION

Gray Partridge have a high fat content relative to other North American gallinaceous birds. Available information indicates partridge in Saskatchewan and Poland have similar amounts of body fat, although this remains to be verified under conditions of controlled temperature, snow cover, food availability, etc. The species is particularly well adapted to exist in cold temperature climates such as

Saskatchewan. This is due largely to the ability of the species to accumulate relatively large body fat reserves. Extensive subcutaneous fat deposits serve to insulate against heat loss during periods of low ambient temperature and to provide a source of reserve energy during periods of high energy demand. Several behavioral and morphological adaptations (see Westerskov 1965) also contribute to winter survival of partridge. The fall and winter diet of partridge is of major significance to winter survival. Their diet consists almost entirely of seeds of cultivated and native plants which represent a concentrated source of fat and protein (Kobriger 1980). In addition, partridge forage nearly continually during the day in the winter (Westerskov 1965, Hunt 1972) thereby ensuring maximum energy intake.

Fat stores may be depleted in mid-winter in response to factors other than climate. Food availability was not restricted during the study period and winter conditions were unchanged or slightly improved by mid-winter. Based on increases in testicular weight and length, male partridge exhibited evidence of breeding activity in February (Appendix F, G). Ovary and oviduct weights also increased in January and February (Appendix H, I). Field observations of covey dissolution, pair formation and the development of secondary sexual characteristics (eg. swollen orbital combs of males - Appendix J) further indicated partridge were entering the reproductive phase at this time. Concomitant with these activities was a decrease in the body fat reserves of both sexes. This reduction occurred universally in all fat depots of the body. It is probable that fat reserves continued to decline in both male and female partridge through August as a result of the energetic demands associated with egg laying, territorial defense and brood-rearing. The reported decline in male body weight from April to August (Kobriger 1980, Weigand 1980) and in females from May to September (Kobriger 1980) supports this hypothesis, assuming the correlation between total body fat and body weight was accurate.

I further hypothesize this seasonal pattern of weight change is consistent from one year to the next. During winters of limited food availability or severe weather, peak weights may be lowered and body energy reserves reduced. Consequently, the rate of fat and protein depletion after January may be accelerated resulting in suboptimum energy reserves prior to egg laying and ultimately lowered reproductive output.

Evidence supportive of this contention was obtained during the relatively severe winter of 1981 - 82 in Saskatchewan (S. Barber, unpubl. data). By mid-February 1982 snow depth approached 50 cm in southeast Saskatchewan. On 10 December 1981 a 1.5 cm ice crust was deposited on the snow surface, severely restricting the availability of food supplies to game birds and deer. Between 29 December 1981 and 12 February 1982, mean covey size decreased by 32% (Appendix K). Employing the technique of abdominal fat depot measurement described herein, abdominal fat weight declined from 2.76 g to 0.59 g (79%) during this 6 week period. Abdominal fat reserves remained constant (3.0 - 3.5 g) and covey size declined by 9.4% during the same period in 1979 - 80, a comparatively mild winter (unpubl. data). It was apparent that partridge were exposed to unusual environmental stress during the winter of 1981 - 82. This stress was manifest in a reduction in peak abdominal fat weight, a relatively large and rapid decline in abdominal fat (hence total body fat) reserves and a mortality rate of approximately 32%. Although birds were not collected after mid-February, it was anticipated that partridge entered the 1982 breeding season with below normal energy reserves. The reproductive output of 1982 is unknown at this time but is expected to be lower than that of either 1980 or 1981 as a consequence of less than optimum prebreeding body condition. Poor physical condition upon entering the breeding season may account, in part, for the reported fluctuations in partridge populations in Saskatchewan. However, the high reproductive potential of the species enables populations to rebound relatively rapidly following years of poor reproduction.

Flies, ants and earthworms function as cestode intermediate hosts in Europe but are not part of the Gray Partridge diet in North America (Kobriger 1980, Weigand 1980, Melinchuk 1981). Thus a lack of suitable intermediate hosts in North America may have resulted in the loss of many of the endoparasites commonly infecting Gray Partridge in the Old World. The prevalence and intensity of both endo- and ectoparasites of Gray Partridge in Saskatchewan were relatively low and appeared of no significance as a mortality factor. In addition, no evidence was found to indicate that parasitic infections were adversely affecting partridge body condition and thereby predisposing individuals to other forms of mortality.

5. PARTRIDGE MANAGEMENT IMPLICATIONS

Through measurement of the abdominal fat depot as described herein, it is possible to assess the body condition of wild partridge at various times during the fall and winter. Using this technique, biologists can determine the necessity for and effectiveness of winter feeding programs. The effects of severe climatic conditions (eg. ice crust, deep snow, etc.) on body condition can similarly be quanitifed. Annual variations in body condition in relation to climatological events may be documented using the data presented in this study as representative of a relatively mild fall and winter.

Gray Partridge body condition, as evidenced by body weight, total body fat and depot fat levels, declines after January even in mild winters. Under severe winter weather conditions, implementation of feeding programs should be considered to increase partridge (and other game bird) survival and ensure optimum reproductive output the following spring. The availability of high energy foods such as cereal grains, particularly in areas of marginal habitat, is necessary for maximum effectiveness of feeding programs. Given the short survival time of partridge without food, grain supplies should be made available in the covey's home range within 4 - 6 days of the onset of adverse conditions. Feed should be replenished weekly or as weather conditions warrant. It is imperative that such feeding programs be continued throughout the prebreeding and egg laying period should natural food supplies remain unavailable.

Partridge live-trapping, stocking and transplanting activities are stressful to individuals and should be undertaken prior to January when partridge are at or approaching peak body condition. Partridge are best able to withstand the stress of capture, handling, confinement and adaptation to new surroundings at a time when energy reserves are maximum.

Gray partridge hunting seasons in Saskatchewan normally end in mid November. Extension or provision of a partridge season in December would yield birds of high carcass quality and culinary appeal. Landowner attitudes, partridge population responses and possibly other factors may have to be evaluated before such a season could be implemented.

6.0 LITERATURE CITED

Anderson, W.L. 1972. Dynamics of condition parameters and organ measurements in pheasants. Ill. Natu. His. Surv. Bull. 30(8):455-498.

Ankney, C.D. 1974. The importance of nutrient reserves to breeding blue geese, _Anser caerulescens_. Ph. D. Thesis, Univ. West. Ont. 211 pp.

____________, and C.D. MacInnes. 1978. Nutrient reserves and reproductive performance of female Lesser Snow geese. Ank 95:459-471.

Ash, J.S. 1960. A study of the Mallophaga of birds with particular reference to their ecology. Ibis 102:93-110.

Association of Official Analytical Chemists. 1975. Official methods of analysis. 12th ed.

Atmospheric Environment Service. 1975. Canadian Normals - temperature. Vol 1-SI, 1941-1970. Environ. Can. Publ., Downsview. 198 pp.

Bailey, R.O. 1979. Methods of estimating total lipid content in the redhead duck (_Aythya americana_) and an evaluation of condition indices. Can. J. Zool. 57(9):1830-1833.

Baldassare, G.A., R.J. Whyte and E.G. Bolen. 1980. Use of ultrasonic sound to estimate body fat depots in the mallard. Prairie Nat. 12(3-4):79-86.

Barrett, M.W. and E.D. Bailey. 1972. Influence of metabolizable energy on condition and reproduction in pheasants. J. Wildl. Manage. 36(1):12-23.

Bendell, J.F. and R.D. Lisk. 1957. _Dispharynx nasuta_ in Hungarian partridge in Ontario. J. Wildl. Manage. 21(2): 238.

Bergstrand, J.L. and W.D. Klimstra. 1964. Ectoparasites of the Bobwhite Quail in southern Illinois. Am. Midl. Nat. 72(2):490-498.

Blank, T.H. and J.S. Ash. 1956. The concept of territory in the partridge _Perdix p. perdix_. Ibis 98(3):379-389.

Breitenbach, R.P., C.L. Nagra and R.K. Meyer. 1963. Effect of limited food intake on cyclic annual changes in ring-necked pheasant hens. J. Wildl. Manage. 27(1):24-36.

Brugger,L. 1941. A survey of the endoparasites of the digestive and respiratory tracts of the Hungarian partridge *Perdix perdix perdix* Linn. in Whitman County, Washington. M. Sc. Thesis. State Coll. Wash. 26 pp.

Cahill, G.F. Jr. 1978. Famine symposium - physiology of acute starvation in man. Ecol. Food Nutr. 6:221-230.

Campbell, R.R. and J.F. Leatherland. 1980. Estimating body protein and fat from water content in Lesser Snow Geese. J. Wildl. Manage. 44(2):438-446.

Canadian Wildlife Service and the United States Fish and Wildlife Service. 1980. North American bird banding techniques. Vol. 2(Part 6). Aging and Sexing.

Child, G.I. and S.G. Marshall. 1970. A method of estimating carcass fat and fat-free weights in migrant birds from water content of specimens. Condor 72(2):116-119.

Coupland, R.T. 1950. Ecology of the mixed prairie in Canada. Ecol. Monogr. 20:271-315.

_________, and J.S. Rowe. 1969. Natural vegetation of Saskatchewan. Pages 73-75 in J.H. Richards and K.I. Fung, ets. Atlas of Saskatchewan. Univ. of Sask., Saskatoon. 236 pp.

Delane, T.M. and J.S. Hayward. 1975. Acclimatization to temperature in pheasants (*Phasianus colchicus*) and partridge (*Perdix perdix*). Comp. Biochem. Physiol. 51:531-539.

Edminster, F.C. 1954. American game birds of field and forest. Charles Scribner's Sons, New York. 490 pp.

Edwards, W.R., P.J. Mikolaj and E.A. Leite. 1954. Implications from winter-spring weights of pheasants. J. Wildl. Manage. 28(2):270-279.

Emerson, K.C. 1951. A list of mallophaga from gallinaceous birds of North America. J. Wildl. Manage. 15(2):193-195.

Ford, J., H. Chitty and A.D. Middleton. 1938. The food of partridge chicks (*Perdix perdix*) in Great Britain. J. Anim. Ecol. 7:251-265.

Formozov, A.N. 1973. Snow cover as an integral factor of the environment and its importance in the ecology of mammals and birds. Univ. of Alberta, Boreal Inst. Occ. Paper No. 1 (transl. from the Russian by W. Prychodko and W.O. Pruitt, Jr.) 176 pp. + App.

Foster, M.S. 1969. Synchronized life cycles in the orange-crowned warbler and its Mallophagan parasites. Ecol. 50: 315-323.

Gates, J.M. 1973. Gray partridge ecology in south-central Wisconsin. Wisconsin Dept. of Nat. Resour. Tech. Bull. 70. 8 pp.

______, and E.E. Woehler. 1968. Winter weight loss related to subsequent weights and reproduction in penned pheasant hens. J. Wildl. Manage. 32(2):234-247.

Gerstell, R. 1942. The place of winter feeding in practical wildlife management. Pennsylvania Game Comm. Res. Bull. 3. 121 pp.

Gower, W.C. 1939. The use of the bursa of Fabricius as an indicator of age in game birds. Trans. N. Am. Wildl. Conf. 4:426-430.

Gray, D.M. 1974. Snow hydrology of the prairie environment. Pages 21-33 *in* Snow hydrology. Proc. Wkshp. Seminar 1968. 82 pp.

Greeley, F. 1953. The relationship of natural and artificial stresses to the function of the endocrine glands in ring-necked pheasants and domestic fowl. Ph. D. Thesis, Univ. of Wisc. 173 pp.

Green, R.G. and J.E. Shillinger. 1932. A natural infection of sharp-tailed grouse and the ruffed grouse by *Pasturella tularense*. Proc. Soc. Exptl. Biol. and Med. 30(3): 284-287.

Hammond, M.C. 1941. Fall and winter mortality among Hungarian partridges in Bottineau and McHenry Counties. N. Dakota J. Wildl. Manage. 5(4):375-382.

Hanson, H. C. 1962. The dynamics of condition factors in Canada geese and their relation to seasonal stresses. Artic Inst. N. Am. Tech. Paper No. 12. 68 pp.

Hawkins, A.S. 1937. Winter feeding at Faville Grove, 1935 - 1937. J. Wildl. Manage. 1:62-69.

Helwig, J.T. and K. A. Council. 1979. SAS user's guide. SAS Institute, Inc. Cary, N.C. 494 pp.

Hine, R.L. and K. G. Flakas. 1957. Stress response and survival time in three wildlife species. Wisc. Dept. of Nat. Resour. J. Wildl. Manage. 21(2):239-240.

Hunt, H.M. 1972. Winter bait trapping of Hungarian partridge in the hedgerow complex around Conquest, Saskatchewan. Wildl. Res. Unit Rep., Sask. Dept. Nat. Res. 52 pp.

________. 1974. Habitat relations and reproductive ecology of Hungarian partridge in a hedge row complex in Saskatchewan. Saskatchewan Dept. of Tourism and Renewable Resour., Wildl. Rep. No. 3. 51 pp.

Jenkins, D. 1961a. Social behavior in the partridge *Perdix perdix*. Ibis 103a(2):157-188.

________. 1961b. Population control in protected partridges (*Perdix perdix*). J. Anim. Ecol. 39(2):235-258.

Johnsgard, P.A. 1973. Grouse and quails of North America. University Nebraska Press, Lincoln. 553 pp.

Jones, P.J. and P. Ward. 1976. The level of reserve protein as the proximate factor controlling the timing of breeding and clutch-size in the Red-billed Quelea (*Quelea quelea*). Ibis 118:547-574.

Kabat, C., R.K. Meyer, K.G. Flakas and R.L. Hine. 1956. Seasonal variation in stress resistance and survival in the hen pheasant. Wis. Conserv. Dept. Tech. Wildl. Bull. 13. 48 pp.

Keith, L.B. 1962. Fall and winter weights of Hungarian partridge and sharp-tailed grouse from Alberta. J. Wildl. Manage. 26(3):336-337.

Kendeigh, S.C. 1945. Resistance to hunger in birds. J. Wildl. Manage. 9(3):217-226.

Knapton, R.W. 1980. Winter mortality in a Gray Partridge population in Manitoba. Can. Field Nat. 94(2):190-191.

Kobriger, G.D. 1980. Food habits of the Hungarian partridge in North Dakota. Fed. Aid to Wildl. Restor. Proj. W-67-R-20, Phase B. No. Dakota Game & Fish Dept., Bismarck. 138 pp. + App.

Kokes, O., and E. Knobloch. 1947. The partridge, its life history, propagation, and hunting. (English translation from the original Czech "Koropteu" by the Can. Wildl. Serv.) Publ. Housing of the Student's Printing Shops. Prague. 135 pp.

Korschgen, C.E. 1977. Breeding stress of female eiders in Maine. J. Wildl. Manage. 41(3):360:373.

Lack, D. 1947. The significance of clutch-size in the partridge (Perdix perdix). J. Anim. Ecol. 16(1):19-23.

Latham, R.M. 1947. Differential ability of male and female game birds to withstand starvation and climatic extremes. J. Wildl. Manage. 11(2):139-149.

Leiffers, V. 1977. Vegetative communities of the Qu'Appelle Valley. Sask. Dept. of Tourism and Renew. Resour. Wildl. Tech. Rept. 77-35. 58 pp.

Looman, J. and K.F. Best. 1979. Budd's flora of the Canadian prairie provinces. Agric. Can. Res. Br. Publ. 1662. 863 pp.

MacKenzie, C.E. and D. I. MacKenzie. 1981. Comparison of the ectoparasite fauna of eastern and western Kingbirds at Delta Marsh, Manitoba. Can. J. Zool. 59(5):717-721.

Malcolmson, R.O. 1960. Mallophaga from birds of North America. Wilson Bull. 72(2):182-196.

Margolis, L., R.C. Anderson and J.C. Holmes. 1981. Recommended usage of selected terms in ecological and epidemiological parasitology. Can. Assoc. Zool. Bull. 12(4):6.

McCabe, R.A., and A.S. Hawkins. 1946. The Hungarian partridge of Wisconsin. Am. Midl. Nat. 36(1):1-75.

McKay, G.A. 1974. Problems of measuring and evaluating snowcover. Pages 49-62 in Snow hydrology. Proc. Wkshop. Seminar 1968. 82 pp.

__________, and H.A. Thompson. 1967. Snow cover in the prairie provinces. Paper presented at joint Can. Soc. Agr. Engr. and Amer. Soc. Agr. Engr. meeting. Saskatoon, June 27-30.

McRae, W.A. and R.W. Dimmick. 1982. Body fat and blood serum values of breeding wild bobwhites. J. Wildl. Manage. 46 (1):268-274.

Melinchuk, R. 1981. Food habits of gray partridge during fall and winter in Saskatchewan. Sask. Dept. Tourism and Renew. Resour. Wildl. Tech. Rept. 81-9. 23 pp.

Middleton, A.D. 1935. Factors controlling the population of the partridge (Perdix perdix) in Great Britain. Proc. Zoo. Soc. London 18(4):793-815.

Moss, H.C. 1965. A guide to understanding Saskatchewan soils. Exten. Div., Univ. of Sask., Saskatoon. 79 pp.

Par, J., D. Zajicek, and I.O. Kotrly. 1966. Helminths of partridges in Czechoslovakia. Symposium Okoropti (with English summ.). Vyzkumny Ustav Lesniho Hospodarstvi A Myslivosti Ceskoslovensky Myslivecky Svaz. pp. 100-108.

Pendergast, B.A. and D.A. Boag. 1973. Seasonal changes in the internal anatomy of spruce grouse in Alberta. Auk 90: 307-317.

Porter, R.D. 1955. The Hungarian partridge in Utah. J. Wildl. Manage. 19(1):93-109.

Potts, G.R. 1970. Recent changes in the farmland fauna with special reference to the decline of the gray partridge. Bird Study 17:145-166.

__________. 1980. The effects of modern agriculture, nest predation and game management on the population ecology of partridges (Perdix perdix and Alectoris rufa). Adv. Ecol. Res. 11:1-82.

Pulliainen, E. 1965. Studies on the weight, food and feeding behavior of the partridge (Perdix perdix L.) in Finland. Annales Academie Scientiarum Fennicae. Series A, IV, Biological 93:1-76.

Robel, R.J. 1965. Differential winter mortality of bobwhites in Kansas. J. Wildl. Manage. 29(2):261-266.

__________. 1972. Body fat content of bobwhites in relation to food plantings in Kansas. Proc. Natl. Bobwhite Quail Symp. 1:139-149.

Roseberry, J.L. and W.D. Klimstra. 1971. Annual weight cycles in male and female bobwhite quail. Auk 88:116-123.

Ryder, J.P. 1970. A possible factor in the evolution of clutch size in Ross' Geese. Wilson Bull. 82:5-13.

Schmidt, A.P. 1980. The ecology of sharp-tailed grouse during winter in Saskatchewan. M.Sc. Thesis. Univ. of Alberta. 101 pp.

Siivonen, L. 1956. The correlation between the fluctuations of partridge and European hare populations and the climatic conditions of winters in southwest Finland during the last thirty years. Finnish Game Found. Bull. No. 17. 30 pp.

Smith, N.S. 1970. Appraisal of condition estimation methods for East African ungulates. E. Afr. Wildl. J. 8:123-129.

Sokal, R.R. and F.H. Rohlf. 1969. Biometry: the principles and practice of statistics in biological research. W.H. Freeman, San Francisco, CA. 776 pp.

Southwood, T.R.E., and D. Cross. 1968. The ecology of the partridge. III. Breeding success and the abundance of insects in natural habitat. J. Anim. Ecol. 38(3):497-509.

Suomus, H. 1958. Wintering of partridge (in Finnish with English summ.). Suomen Riista 12:55-62.

Szwykowska, M.M. 1969. Seasonal changes of the caloric value and chemical composition of the body of the partridge (Perdix perdix L.) (In English with Polish summ.). Ekologia Polska Series A, 17(4):795-809.

Thomas, V.G. and R. Popko. 1981. Fat and protein reserves of wintering and prebreeding rock ptarmigan from south Hudson Bay. Can. J. Zool. 59:1205-1211.

__________, H.G. Lumsden and D.H. Price. 1975. Aspects of the winter metabolism of ruffed grouse (Bonsa umbellus) with special reference to energy reserves. Can. J. Zool. 53:434-440.

Weigand, J.P. 1977. Technique for sexing live Hungarian partridge in the field. Proc. of Perdix I Hungarian Partridge Workshop. Mont. Dept. Fish and Game. 6 pp.

____________. 1980. Ecology of the Hungarian Partridge in north-central Montana. Wildl. Monogr. 74. 106 pp.

Welty, J.C. 1982. The life of birds. Saunders College Publishing. Philadelphia. 754 pp.

West, G.C. and M.S. Meng. 1968. Seasonal changes in body weight and fat and the relation of fatty acid composition to diet in the Willow ptarmigan. Wilson Bull. 80: 426-441.

Westerskov, K. 1964. The recent decline of the partridge in midwestern United States. New Zealand Outdoors 29:4, 16-19.

____________. 1965. Winter ecology of the partridge (*Perdix perdix*) in the Canadian Prairie. Proc. New Zealand Ecol. Soc. 12:23-30.

____________. 1966. Winter food and feeding habits of the partridge (*Perdix perdix*) in the Canadian prairie. Can. J. Zool. 44(1):303-322.

Wishart, R.A. 1979. Indices of structural size and condition of American wigeon (*Anas americana*). Can. J. Zool. 57 (12):2369-2374.

Witherby, H.F., F.C.R. Jourdain, and N.F.Ticehurst. 1944. The common partridge - *Perdix perdix* L. Pages 240-246 in the Handbook of British birds. Rec. H.F. & G. Witherby, Ltd., London. 381 pp.

Woodall, P.F. 1978. Omental fat: a condition index for redbilled teal. J. Wildl. Manage. 42(1): 188-190.

Yeatter, R.E. 1934. The Hungarian partridge in the Great Lakes region. Univ. of Michigan School of Forestry and Conserv. Bull. No. 5. 92 pp.

Yocum, C.F. 1943. The Hungarian partridge in the Polouse region, Washington. Ecol. Monogr. 13(2):167-201.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Englewood Cli-fs, NJ 620 pp.

SNOW STATION REPORT FORM

Date											
Station	Snow Depth										Remarks
1											
2											
3											
4											
5											

	Hardness			Density			Amb. Temp.	Sub. Temp.	Crust Conditions
1									
2									
3									
4									
5									

Photographs:

Remarks:

Appendix B

Number of Gray Partridge collected monthly
on the study area August 1979 to March 1980.

	Juvenile *		Sub-adult		Adult		
Month	Males	Females	Males	Females	Males	Females	Total
August	6	2			1		9
September	4	8				3	15
October	5	7	2	2		2	18
November		1	6	4	2	2	15
December			8	6	1	1	16
January			5	2	4	3	14
February			9	4	5	1	19
March			4	4	3	1	12
TOTAL	15	18	34	22	16	13	118

* Less than or equal to 17 weeks of age

GRAY PARTRIDGE NECROPSY DATA

cimen No.__________ Field Wt.________ Carcass Wt.________ Date Collected__________

ation__________ How Collected________ Age________ Sex-External__________

ernal__________ Covey Size__________ Body Length__________

g Length (RHS)__________ Tarsus Length (RHS)________ Tarsus Color__________

l Length__________ Depth__________ Exposed Culmen__________

th of Beak__________

mage Characteristics: Crown__________ Malar________ Browstreak________

e________ Scapular/Coverts__________ Rump________ Tail________ Breast________

Index : Breast/Neck________ Back________ Axillary________ Flanks________

s________ Heart__________ Gizzard__________ Intestinal__________

ominal________ Intestinal Fullness________ Parasites Ecto________ Endo________

	Full Wt.	Empty Wt.	Contents		Length/Wt.
ventriculus	____	____	____	Skin	____
triculus	____	____	____	Wings	____
estine	____	____	____	Abdom. Fat	____
			Length/Wt.		
Intestine			____	Cutan. Fat	____
on			____	Viscer. Fat (Gizz___ Intest____)	____
ae			____/____	Oviduct	____
rt			____	Lt. Ovary	____
Lung			____	Testes L ____	____
Kidney			____	R ____	____
er			____	Thymus (No.___)	____
een			____	Thyroids (No.____)	____
Breast			____	Adrenals (No.____)	____
Leg			____		
creas			____		

sa Present__________ Dimensions__________

tographs____________________

arks:____________________

Appendix D

Mean covey size and monthly decline in partridge coveys observed on the study area July 1979 to March 1980.

MONTH	MEAN COVEY SIZE	NO. COVEY OBSERVATIONS		PERCENT DECLINE FROM PREVIOUS MONTH	
July	16.3	4			
August	16.0	18		1.8	
September	12.9	24		19.3	
October	11.0	27	52.8*	14.7	Hunting Season
November	9.3	43		15.5	
December	8.5	51	78.5*	8.6	
January	8.3	56	9.4*	2.4	
February	7.7	44		7.2	
March	3.5	35		54.5	← Pair Formation

* During period indicated, inclusive.

Appendix E

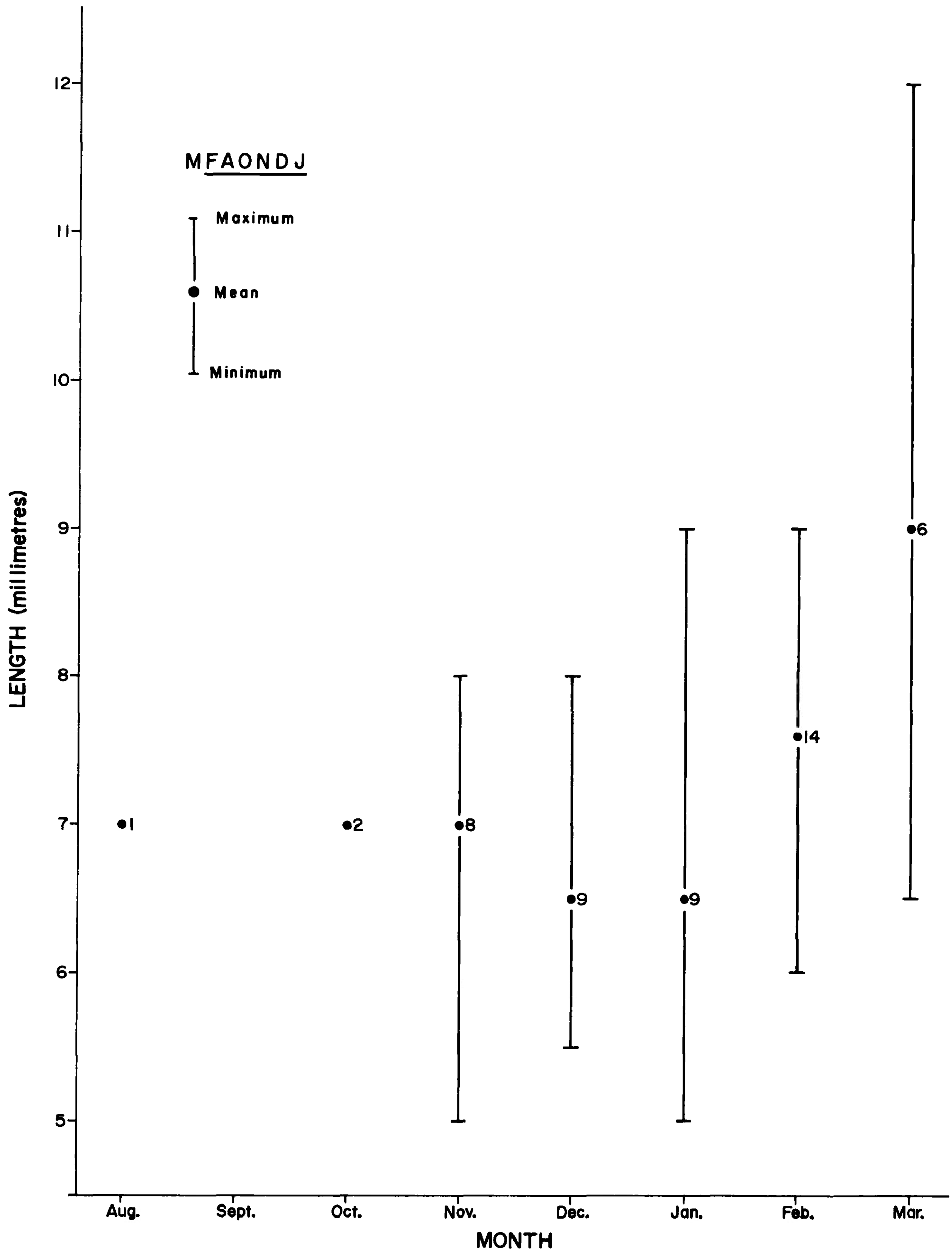
Seasonal changes of the percent content of chemical constituents of the body of partridge.* Data transformed into percent dry weight for comparison with data from this study.

MONTH	N	WATER %	FAT	PROTEIN %	DRY MATTER %
August	10	66.62	15.58	69.65	33.38
September	10	66.70	16.46	68.71	33.30
October	10	63.39	17.75	65.83	36.81
November	10	59.76	29.67	59.19	40.24
December	10	62.27	23.14	62.76	37.73
January	10	60.67	26.65	57.87	39.33
February	10	61.98	26.09	60.26	38.02
March	10	63.68	22.03	64.15	36.32
April	10	64.73	20.75	65.21	35.27
May	9	63.86	23.33	60.51	36.14
June	8	66.96	13.16	70.19	33.04
July	10	67.59	12.80	68.10	32.41

* Extracted from Szwykowska (1969) Table II, pg. 800.

Appendix F

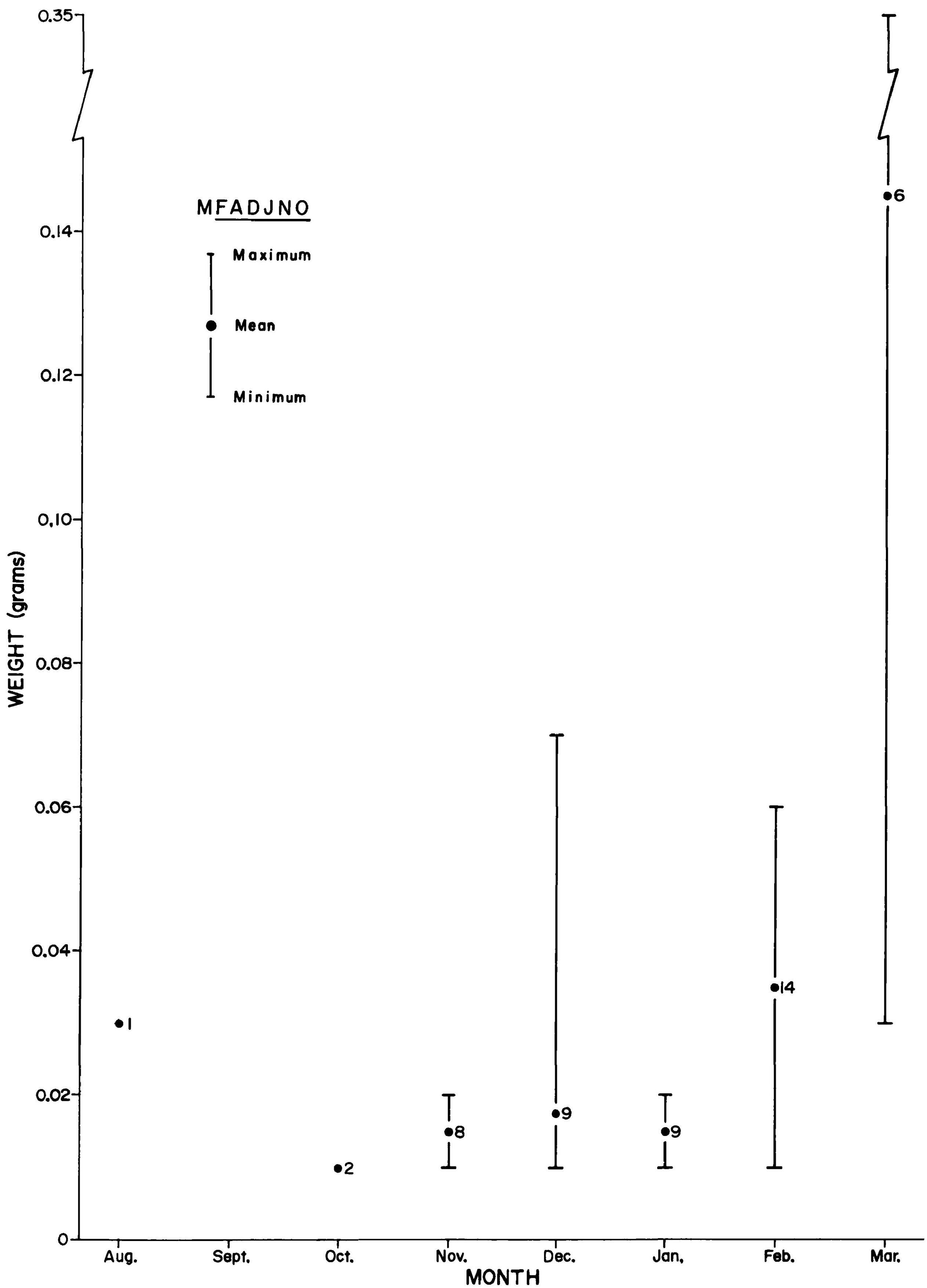
Monthly mean length (mm) of left testis of Gray Partridge August 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.



MFAONDJ
Maximum
Mean
Minimum
LENGTH (millimetres)
12
11
10
9
8
7
6
5
1
2
8
9
9
14
6
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

Appendix G

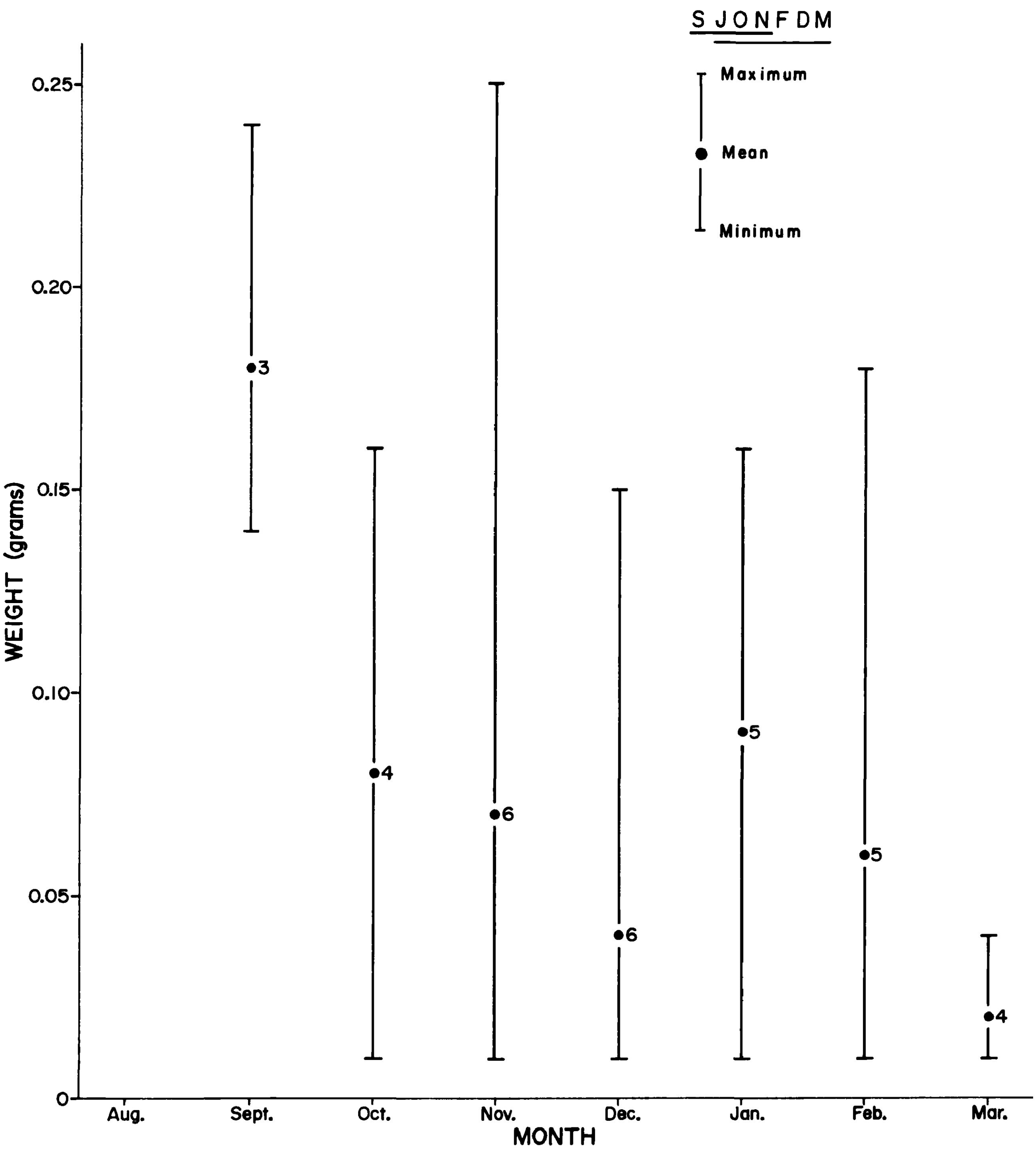
Monthly mean weight (g) of testes of Gray Partridge August 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.



0.35
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
WEIGHT (grams)
MFADJNO
Maximum
Mean
Minimum
1
2
8
9
9
14
6
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

Appendix H

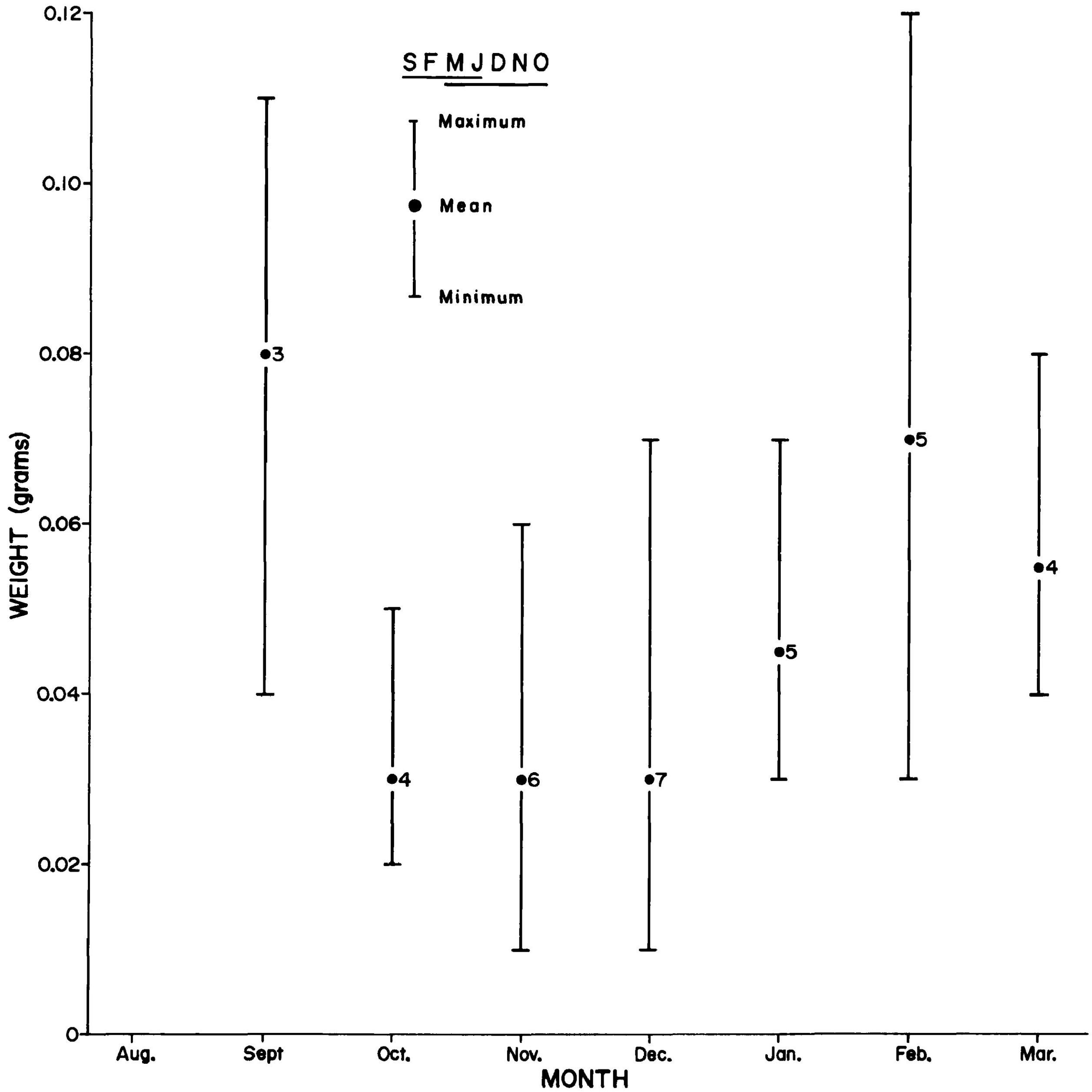
Monthly mean oviduct weight (g) of Gray Partridge September 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.



S J O N F D M
Maximum
Mean
Minimum
0.25
0.20
0.15
0.10
0.05
0
WEIGHT (grams)
3
4
6
6
5
5
4
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

Appendix I

Monthly mean ovary weight (g) of Gray Partridge September 1979 to March 1980. Numbers refer to sample size. Months sharing a line beneath them were not significantly different.



SFMJDNO
Maximum
Mean
Minimum
WEIGHT (grams)
0.12
0.10
0.08
0.06
0.04
0.02
0
3
4
6
7
5
5
4
Aug.
Sept
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
MONTH

Appendix J

Swollen orbital combs of adult male partridge in February 1980 as evidence of reproductive activity.

Appendix K

Mean covey size, body weight and abdominal fat depot weight of Gray Partridge in southeast Saskatchewan December 29, 1981 to February 12, 1982. Data courtesy S. Barber, Saskatchewan Tourism and Renewable Resources.

Date	Depth (cm)	Snow Condition	No. Birds Collected	Covey Size ($\overline{X} \pm SD$) (N)	Abdominal Fat Weight (g) ($\overline{X} \pm SD$)	Body Weight(g) ($\overline{X} \pm SD$)
Dec. 29/81	20 - 25	Hard crust 5 - 7 cm below surface	15	9.4 ± 3.7 (50)	2.76 ± 1.64	402.60 ± 24.06
Jan. 14-28/82	40	Icy crust 1.5 cm thick under snow surface	13	7.5 ± 3.1 (65)	1.15 ± 1.35	390 ± 22.32
Feb. 9-12/82	45 - 50	Icy crust 1.5 cm thick on snow surface	10	6.4 ± 2.4 (68)	0.59 ± 0.29	394.60 ± 26.20