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Evaluations of Techniques for Estimating Fall Age Ratios of Canada and Snow Geese

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EVALUATION OF TECHNIQUES FOR ESTIMATING FALL AGE RATIOS OF CANADA AND SNOW GEESE

BY

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EVALUATION OF TECHNIQUES FOR ESTIMATING

FALL AGE RATIOS OF CANADA AND SNOW GEESE

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Wildlife Management Department

EVALUATION OF TECHNIQUES FOR ESTIMATING

FALL AGE RATIOS OF CANADA AND SNOW GEESE

Abstract

KENNETH FREDERICK HIGGINS

Validity of flock counts, average group-size counts, cannon-net catches, and hunter-bag checks for estimating productivity of lesser snow geese (Anser caerulescens caerulescens) and small Canada geese (Branta canadensis hutchinsii-parvipes complex) was studied at Sand Lake and Tewaukon National Wildlife Refuges during fall, 1965 and 1966. Age-ratios obtained from flock counts varied with the number of flocks sampled, wind velocity and amount of sky cover. If adequate sampling sites are selected and weather conditions are standarized, age ratio data from flock counts are of value for assessing productivity. Variation in group composition and number contributed to the bias in average group-size counts of snow geese. Some groups of snow geese were normal families composed of parents and young while other groups contained parents and young plus yearlings and unknown aged adults, possibly non-breeders. Cannon-net catches and hunter-bag checks were biased and favored immature snow and Canada geese because the young birds were not as wary as adults and were more vulnerable to the net and gun. Therefore, cannon-net catches and hunter-bag checks were not reliable for estimating productivity of snow or Canada geese and average group-size counts were not reliable for estimating productivity of snow geese. If Canada geese have

similar composition in groups of family size, production estimates from average group-size counts may also be in error for that species. Sex ratios of net-trapped geese showed a preponderance of males for adult Canada and adult and immature snow geese while females were predominant in the immature segment of Canada geese. Bursa of Fabricius measurements showed that bursal depths may be used to classify snow and Canada geese into three age classes: immatures, yearlings and 2-year-olds, and more than 2 years old.

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INTRODUCTION

An index to breeding success is desirable before annual hunting regulations are established. However, in geese, which are highly mobile and utilize vast geographical areas for breeding grounds, our present capabilities do not permit this (Nelson 1962). Sampling techniques presently used cannot be employed until fall or winter.

Trapping with cannon-nets (Dill and Thornsberry 1950, Miller 1957) is one of the methods most widely used for obtaining samples from various wild goose populations. The captured geese are sexed, aged, banded, and released. Sex and age ratios of these banded geese are sometimes used for management of the populations. However, banding data used alone have shortcomings and are more historical than current (Boyd 1959).

Recently, people working in the field of waterfowl biology have questioned the reliability of age-ratio data from cannon-net trapped geese. Nass (1964), Funk and Grieb (1965), Raveling (1966), and Vaught and Kirsch (1966) reported on age ratios of cannon-net trapped Canada geese (*Branta canadensis*)[1] in relation to age ratios in the population. Funk and Grieb (1965:259) concluded:

> ...bait trapping efforts, as conducted in the Two Buttes Reservoir area, produce unbiased estimates of age ratios in the population present at the time of sampling.

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[1]Scientific names of geese follow the A.O.U. Check-list (1957) or Delacour (1954).

However, Nass (1964:526) concluded:

> The findings of this 2-year study at Swan Lake indicate that, under normal conditions, the length of time geese spend on bait before a catch influences the age ratios. If this is true in other years and in other places, it is apparent that age ratios of trapped geese are not likely to correspond closely with age ratios in the populations.

Raveling (1966:684) also found that length of time on bait affected age ratios obtained among net-trapped geese. He further suggested other factors affecting age ratios were time of year, time of day, food availability, behavior changes, and weather. Vaught and Kirsch (1966:18) stated that invalid age-ratio information was obtained from net-trap samples at Swan Lake Refuge and suggested plausible explanations.

These four studies were conducted on wintering grounds of three different populations of Canada geese. Nass (1964) and Vaught and Kirsch (1966) studied the Eastern Prairie Population described by Hanson and Smith (1950) and Nelson (1962); Funk and Grieb (1965) studied the Short Grass Prairie Population described by Marquardt (1962a) and delineated by MacInnes (1963, 1966); and Raveling (1966) studied the Mississippi Valley Population described by Todd (1938) and Hanson and Smith (1950). Differences of opinion concerning age-ratio information resulting from these studies suggested the need for further investigation involving a different approach.

Elder and Elder (1949) and Hanson and Smith (1950) proposed that average-group counts could be used to estimate Canada goose productivity in spite of the fact that immatures of this species could not be readily distinguished from adults in the field. Lebret (1956) challenged the proposed average-group size thesis on the premise that sub-adults and unsuccessful breeders could actually comprise pseudo-families and thereby bias the age ratio and productivity estimates. Martin (1964) and Sherwood (1966) reported from observations of marked Canada geese that family-sized groups were at times not true groups of parents plus their young but were comprised of normal family members plus adopted young, yearlings, and 2-year-olds. Weekly flock counts of snow geese at Sand Lake Refuge were used to further test average group-size counts.

The purpose of this thesis is to evaluate different methods of collecting age-ratio data for lesser snow geese (*Anser caerulescens caerulescens*) on an area during migration. Because lesser snow geese, unlike Canada geese, have distinct plumage dimorphism between immature (young-of-the-year) and adult birds, it is possible to get age ratios by flock counts, described by Lynch and Singleton (1964), as well as by average group-size counts, cannon-net trap catches, and hunter-bag checks. A better understanding of variations found between age ratios of snow geese collected by different methods may be useful for improving sampling methods for Canada geese.

STUDY AREA

Field investigations were conducted during the fall of 1965 and 1966 at Sand Lake National Wildlife Refuge, Brown County, South Dakota. In 1965 supplementary data were collected at Tewaukon National Wildlife Refuge, Sargent County, North Dakota. Both refuges are "stopover" areas for geese during spring and fall migration and are in the Central Flyway (Lincoln 1935).

Sand Lake Refuge

Sand Lake National Wildlife Refuge lies along the James River Valley within the shores of glacial Lake Dakota in north-eastern South Dakota. Three distinct topographic divisions exist in the area: glacial uplands, the bed of glacial Lake Dakota, and the James River flood plains (Watkins and Larson 1925).

The refuge, about 2 miles wide and 17 miles long, includes 13,421 acres of marsh and open water, 3,018 acres of cultivated land, and 5,012 acres of prairie grasslands and shelterbelt plantings. Marsh and water areas are included in two large pools formed by low earthen and rock dams on the James River. Refuge personnel farm 700 acres of the cultivated land. The remaining 2,318 acres are share-cropped. Except for grain needed for waterfowl trapping operations, the refuge's share is generally left unharvested to provide food for wildlife. Principal crops grown on the refuge are corn, rye (mainly green browse), barley, oats, millet, and milo, in that order of abundance and importance.

Kincer (1941) described the climate of Brown County as subhumid with comparatively long, cold winters and short, warm summers. Temperatures range from -46 F to 115 F. The average growing season of 139 days extends from May 14 to September 24. Average annual precipitation is 23.96 inches. Frequent high winds, characteristic of the plains, are most pronounced in the spring.

Tewaukon Refuge

Tewaukon National Wildlife Refuge, 40 air miles northeast of Sand Lake Refuge, is situated in southeastern North Dakota along the Wild Rice River Valley near Cayuga, North Dakota. The refuge lies in "stagnation" moraine just north of the prairie pothole region known as the "Coteau des Prairies" (Flint 1955, Coulton et al. 1963).

The refuge includes 2,500 acres of marsh and open water, 2,000 acres of cultivated land, and 3,000 acres of tame grass-land and shelterbelt plantings. Marsh and water areas are included in four natural lakes, six large impoundments and several smaller pools formed by placement of control structures on the Wild Rice River. The cultivated land is managed on a share-cropping basis. Principal crops grown are wheat, oats, barley, rye, millet, and corn.

The climate of Sargent County (Kincer 1941) is one of long, cold winters and short, warm summers. Temperatures range from -45 F to 110 F and the growing season averages 128 days. Average annual precipitation is 20.20 inches.

AREA GOOSE POPULATIONS

Lesser snow geese using the refuges migrate south via the Southampton Island route (Cooch 1955). Two main populations of Canada geese use the refuges, one is the "giant" Canada goose (B. c. maxima) which was reported extinct by McAtee (1944), Delacour (1951, 1954) and A.O.U. Check-list (1957) but later recognized as still extant by Hanson (1965). The other is the "small" Canada goose (B. c. hutchinsii-parvipes complex) described by Aldrich (1946), Delacour (1954), Marquardt (1962a), and Nelson (1962) and further delineated as the Tall Grass Population by MacInnes (1966) and Schoonover and Reeves (1966). The present study was concerned with "small" Canada and lesser snow geese. Cooch (1964:127 In Linduska), Delacour (1954:126) and Johnsgard (1965:349) have taxonomically accepted white- and blue-phase lesser snow geese as one species.

TERMINOLOGY

Throughout this thesis the term "snow" geese refers to both the white- and blue-phases and the term "small" Canada geese refers to the subspecies parvipes and hutchinsii.

Lesser snow and small Canada geese in their first year of life after hatching have juvenile plumage (Bent 1925, Kortright 1953, Marquardt 1962b) and are called immatures. Geese other than immatures are classified as adults. Where further breakdown of adults is possible geese in their second, third, and fourth years of life after hatching, respectively, are called yearlings, 2-year-olds, and 3-year-olds (Vaught and Kirsch 1966).

Intermittently, I refer to assemblages of geese as a "group", "flock", "population", and "concentration". The term group describes assemblages of geese ranging from 1 to 50 in number. Fifty was chosen as the maximum size of a group because this was the greatest number of snow geese which I could confidently age during flight by plumage color differentiation. One-thousand or more geese using a specific portion of a refuge constituted a flock. Nelson (1962) pointed out that each population may be comprised of several flocks and he used the term population to designate geese utilizing defined breeding grounds, migration routes, and wintering grounds. The small Canada geese stopping at Sand Lake and Tewaukon Refuges are major flocks of the Tall Grass Prairie Population. Flocks of snow geese stopping at the refuges are from populations described by Cooch (1955, 1958). All geese at either refuge at one period constitute a concentration.

The term "family" refers to any group of nine or less with at least one adult and one immature. Groups greater than nine with at least two adults and two young are called "multiple-family groups". Groups containing only adults or only immatures are called "pseudo-families".

"Age ratio" refers to percent immatures. Raveling (1966) pointed out that this type of ratio is used by most people for estimating Canada goose productivity.

METHODS AND MATERIALS

Weekly flock counts described by Lynch and Singleton (1964) were used to estimate age ratios of snow geese. Because the snow geese on each of the refuges were in several flocks, it was necessary to sample each flock to get an age ratio estimate of the concentration.

Six sampling sites were used for flock counting at Sand Lake Refuge (Fig. 1) and two at Tewaukon Refuge (Fig. 2). Each site was situated near "travel lanes" utilized by a single flock at the time of sampling. All groups were recorded while passing in one direction to avoid counting the same geese twice during each sample period. Time of day, date, relative amount of food available on the refuge, wind velocity, disturbance factors, and estimated flock size were recorded for each flock count.

Standard cannon net-trapping procedures (Dill and Thornsberry 1950) were employed throughout the study. Usually four 35 x 75 ft, 1 1/4-inch mesh nets with an 18-inch peripheral skirt were used to trap geese at each site (Fig. 1). Three 8 1/2-pound modified Miller-type cannons projected each net. Trapping sites were baited with a mixture of shelled corn and barley. Time of year, estimates of flock size, relative amount of food available on the refuge, weather conditions, and behavior of geese were recorded at the time of trapping.

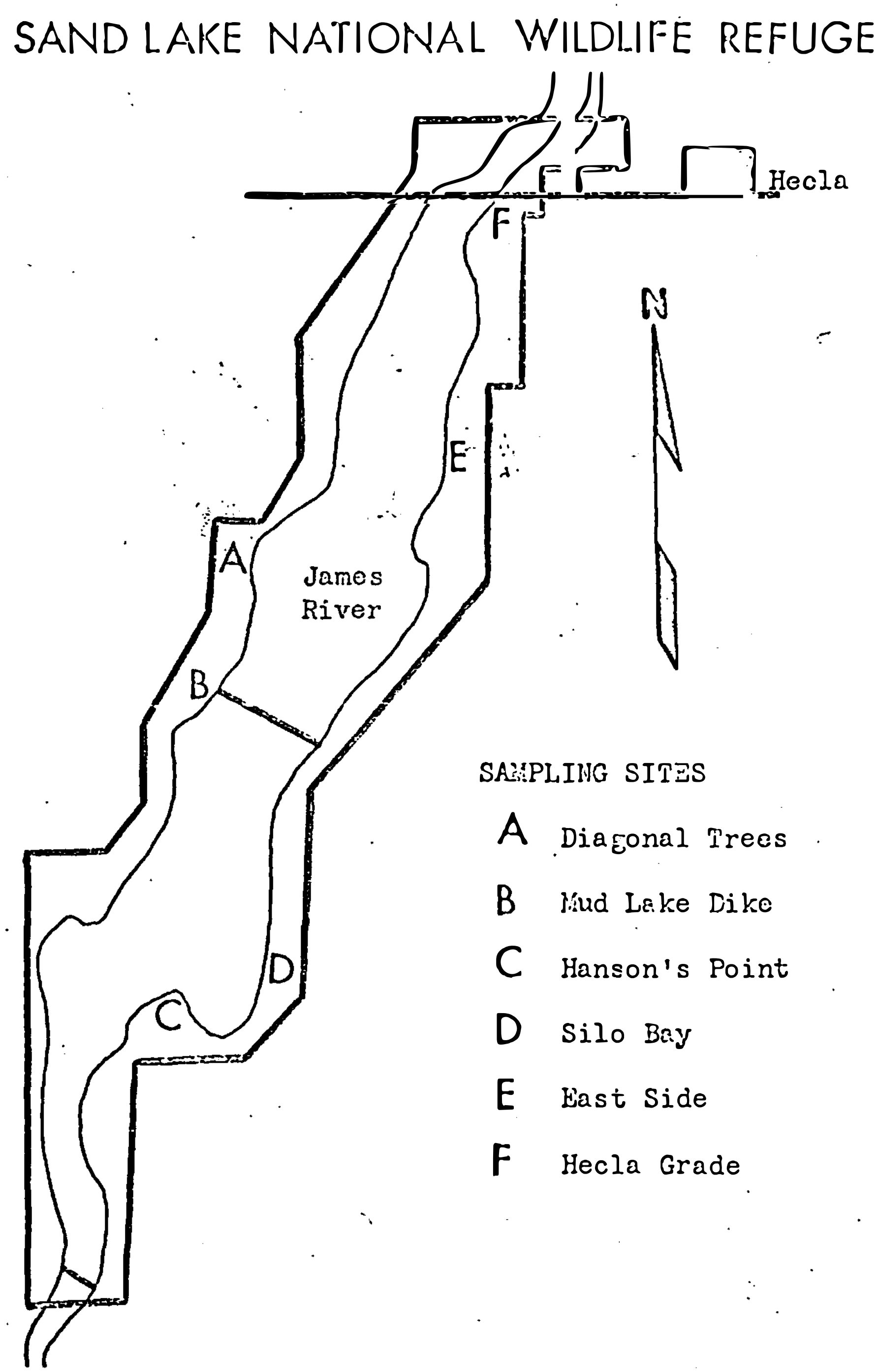

Fig. 1. Sites on which flock counts and cannon-net trapping were conducted at Sand Lake Refuge.

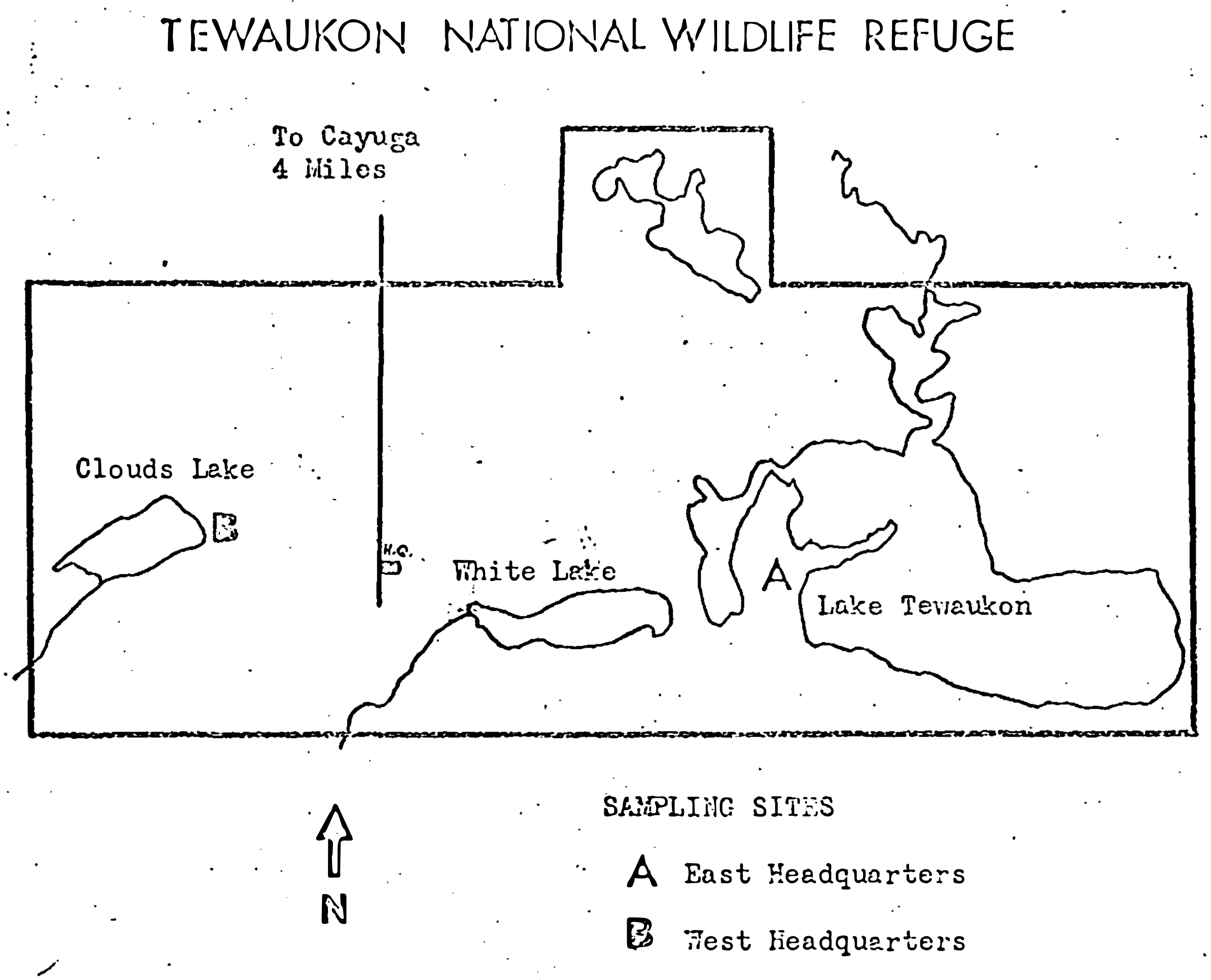

Fig. 2. Sites on which flock counts were made at Tewaukon Refuge.

Pit (decoy), fenceline (pass-shooting), and field stalking were the main types of goose hunting in the Sand Lake area. Hunter-kill checks were used to sample these various types of hunting throughout the hunting season. The checks included hunter contacts in the field, inspection of hunters' bags at voluntary road blocks, and examination of tail feathers removed by local goose pluckers. Pluckers placed the feathers of each tail in a separate cellophane bag for species identification and aging at a later date. Tail feathers collected by goose pluckers probably came from the three types of hunting but the proportions were unknown. Tail feathers collected in the field were segregated by hunting type.

A notched tip on the tail feathers of immature waterfowl, shown to be a reliable aging technique by Schiøler (1924), has been widely used by biologists as a criterion of age (Elder 1946, Hanson 1949 and 1962). This aging technique was used to determine immature-adult ratios from tail fan collections. Bursa of Fabricius measurements as described by Gower (1939), Kirkpatrick (1944), and Hanson (1962) were made on known-age geese to determine if this technique could be used to identify immatures, yearlings, 2-year-olds, and 3 or more years old geese.

Age ratios of Canada geese examined in the hand were determined from plumage differences of the neck and breast feathers and substantiated by cloacal and tail feather characteristics. Adult geese showed a distinct color demarcation, often accompanied by a white band, between the black neck "stocking" and the gray breast plumage. The black neck plumage of immatures gradually merged into the gray plumage of the breast (Fig. 3).

Sex ratios of geese were determined by cloacal examination (Hochbaum 1942, Hanson 1949 and 1962, Elder 1946, Carney and Geis 1960).

Kozlik et al. (1959) and Miller and Dzubin (1965) successfully used color dyes for marking geese. During this study, 18 snow and 4 Canada geese were color dyed and released at Sand Lake Refuge. Dyes used were Rhodamine "B" (pink), malachite green, and picric acid (yellow). All dyes were diluted in isopropyl alcohol and applied with a hand-operated spray gun as reported by Wadkins (1948). Red, blue, and yellow Master Flo ink were also used for color marking in late fall of 1966. Dye was applied to the entire plumage of each goose marked.

Because of plumage difference between immature and adult snow geese, it was expected that age ratios of snow geese could be estimated from photograph enlargments. Aerial and ground photographs of flocks of snow geese were taken with color and black and white film at Sand Lake during late fall in 1965. Pictures were taken with 35mm and 2 1/4 x 2 1/4-inch single lens reflex cameras and with 300 and 500mm telephoto lenses. Aerial photographs were taken from a Cessna 180 airplane at 500 and 1000 ft altitudes.

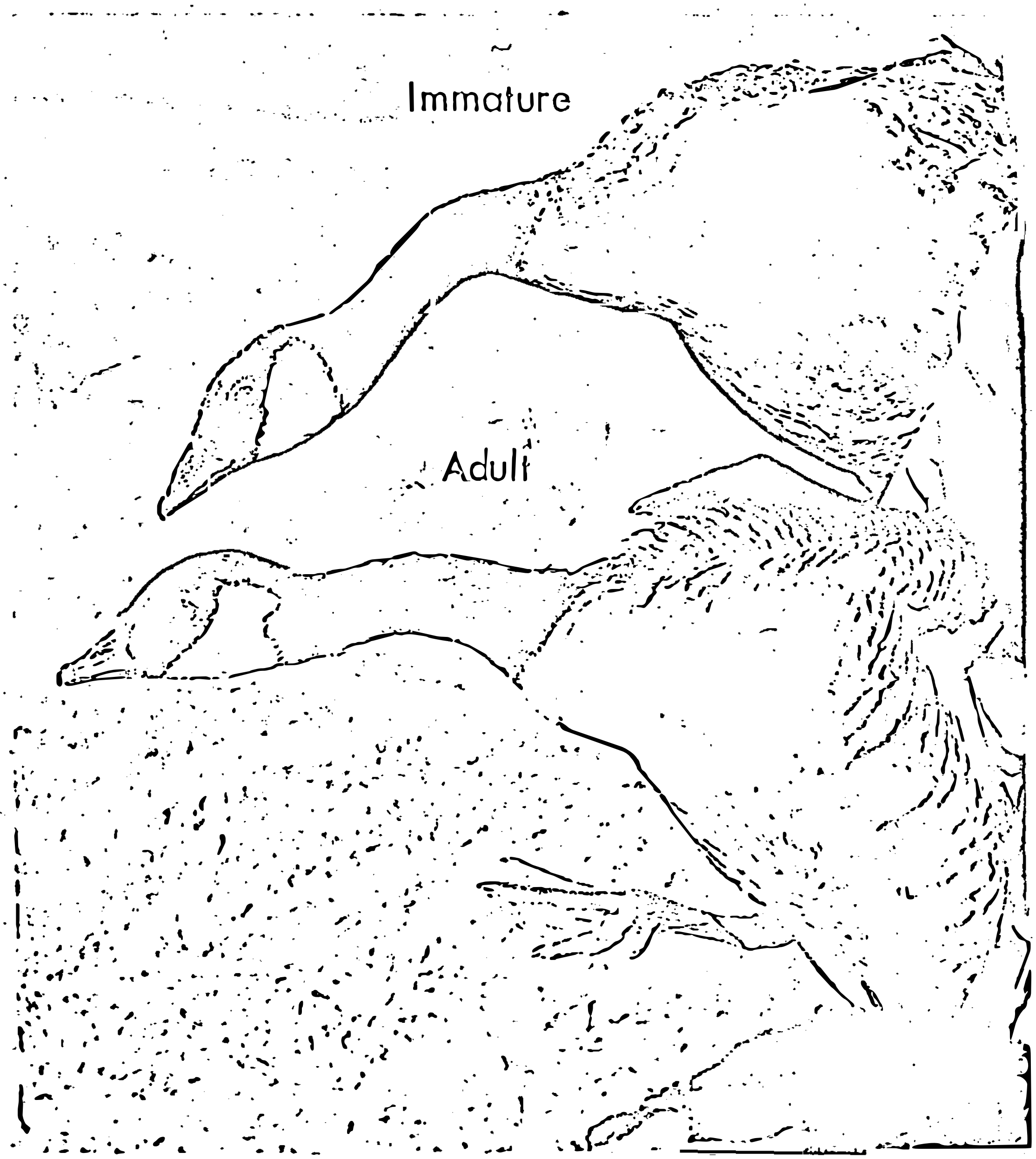

Fig. 3. Color demarcation between black neck stocking and gray breast plumage of immature and adult small Canada geese.

Fig. 3. Color demarcation between black neck stocking and gray breast plumage of immature and adult small Canada geese.

Statistical procedures employed for all analyses followed Steel and Torrie (1960).

RESULTS AND DISCUSSION

Goose Behavior Observations

Observations of the movements and behavior of marked and unmarked groups and flocks of geese from late September to late November in 1965 and 1966 were used as the basis for identifying factors causing variability within and among sampling methods.

Marked Groups of Family Size

Forty-nine observations were made of 7 family-sized groups of snow geese with one or more marked individuals present. Composition of these groups was as follows: (a) two adults and one immature male, (b) two adults and one immature, (c) two adults and three immatures, (d) three adults (one blue phase) and two immatures, (e) three adults and six immatures (one blue phase), (f) five adults (one blue phase and one known yearling) and one immature, and (g) three adults (one known yearling) and six immatures (one blue phase).

All three members of group (a) were marked in a manner that allowed individual recognition in the field. This group was seen 13 times during a 22-day period. In four of five sightings of the group in flight the adult male was leader, in the other instance the adult female led. The group retained integrity at all times while resting and feeding, and during intra-refuge and mass flights.

Groups (d), (e), and (f) gained or lost members during the fall period. At different times group (d) was seen to gain an adult and lose one immature, group (e) lost an immature on one day and gained an immature 3-days later, and group (f) gained two adults. These gains and losses occurred when the entire flock flushed or during intra-refuge flights. Later sightings of the groups showed they had reunited into their original units. Eight observations of the groups with yearlings, groups (f) and (g), showed their entity and behavior were similar to that found in other family-sized groups.

In summary, the observations revealed that of seven marked snow-goose groups, two were normal family groups of parents and young. The other five groups, however, were composed of parents and young plus yearlings and unknown adult geese, possibly non-breeders. Three marked snow geese did not join a group.

Flock Dispersion and Integration

September 24 is the average date for first fall arrivals of geese at Sand Lake Refuge. During the 2-year study the first flock to arrive began feeding in fields near the Diagonal Trees area (Fig. 1). Later-arriving flocks remained segregated on other refuge areas. As the food supply diminished flocks tended to integrate on the better feeding areas. During both years the main exodus of geese occurred between October 10 and October 30. The concentration at Sand Lake normally peaks on October 20.

Marked groups changed to different feeding flocks as many as five times in one day after integration began. Five marked geese sighted on November 2, 1966, in a flock of about 5,000 were identified as having been captured at two different trap sites, representing two separate flocks, on three different dates. This observation showed free mixing of groups among flocks in late fall on a migration-stopover area.

Geese marked earliest in the fall were among the last geese to leave. Six marked geese in 1965 and 12 marked geese in 1966 were observed almost daily on the Sand Lake Refuge from early fall until the concentration peak was reached. This indicated that there was little or no population turnover at Sand Lake until after the concentration peak.

Average Group-Size Counts

Groups of Family Size

According to nesting studies by Cooch (1958), two adults and seven young was a large family group. One adult and one young would be the smallest recognizable family during migration. Therefore, average-group size was calculated by dividing the total number of geese observed in groups of two to nine by the total number of such groups. An increase in average-group size over the previous year would indicate a more productive nesting season for the species (Lynch 1963). The average group of snow geese at Sand Lake was slightly smaller in 1966 than in 1965, indicating a decrease in production (Table 1). However, age ratios of snow geese determined from three other sampling methods indicated an increase in production from 1965 to 1966 (Table 2).

Lebret (1956) found 14 (20 percent) of 73 family-sized groups of white-fronted geese (Anser albifrons) were pseudo-families of adult birds and concluded that average-group counts should not be used as indices of productivity. At Sand Lake Refuge pseudo-families of adult geese made up 40 and 20 percent of the family-sized groups of snow geese counted during 1965 and 1966, respectively, and the average size of the pseudo-families decreased from four to three during the same years (Table 3). The age ratio increased 18 percent when a 20 percent decrease in pseudo-families of adults occurred between 1965 and 1966. However, during this same time period, the average-group size decreased instead of increasing with an increase in percent immatures and a decrease in occurrence and size of pseudo-families of adults (Table 3). Thus, average group-size counts were misleading for estimating productivity of snow geese. If Canada geese have similar composition in groups of family size, production estimates from average-group counts may also be in error for that species.

Multiple-Family Groups

Elder and Elder (1949) and Hewitt (1950) reported that groups larger than 10 were usually multiples of family groups. Lebret

Table 1. Average group sizes of snow geese observed in groups ranging from two to nine birds.

YEAR	REFUGE	TOTAL NO. GEESE	TOTAL NO. GROUPS	AVG. GROUP SIZE
1965	Tewaukon	2,880	758	3.8
1965	Sand Lake	13,601	2,966	4.6
1966	Sand Lake	13,248	3,264	4.1
Total or Average		29,729	6,988	4.3

Table 2. Age ratios of snow geese at Sand Lake Refuge determined by three sampling methods.

YEAR	FLOCK COUNTS		CANNON-NET TRAP		HUNTER-KILL	
	No.	% Imm.	No.	% Imm.	No.	% Imm.
1965	19,345	26	2,118	49	532	57
1966	16,299	46	1,396	59	732	66

Table 3. Group size, age ratio, and composition of groups of two to nine snow geese at Sand Lake Refuge, 1965-66.

YEAR	ALL GROUPS OF TWO TO NINE			PSEUDO-FAMILIES OF ADULTS ONLY		
	No. Groups	Avg. Group Size	% Imm.	No. Groups	% Occurrence	Avg. Group Size
1965	2,966	4.6	26	1,190	40	4.0
1966	3,264	4.1	44	648	20	3.0

(1956) suspected that groups larger than 10 probably contained a higher percentage of yearlings and unsuccessful breeders than the smaller family-sized groups. At Sand Lake and Tewaukon Refuges the age ratio decreased as the group size increased during 1965, a poor production year, while during 1966, a high production year, age ratios showed little or no change as the group size increased at Sand Lake Refuge (Table 4). Since there was a greater percentage of groups of adults in 1965 than in 1966 (Table 3), evidence suggests that the composition of groups larger than 10 varies directly with the proportion of adults and immatures present each year.

Flock Counts

Observer Bias

Boyd (1952:14) proposed that errors in sampling could result from faulty identification of first-winter birds. However, he found agreement within 1 to 3 percent between counts made by different observers on the same groups of geese. At Sand Lake, observer bias was similarly tested by placing observers at different sites to count the same flock of geese. No differences were detected by Chi-square test of independence (Table 5). Thus observer bias was apparently not important.

Table 4. Relationship of age ratios to group sizes of snow geese, 1965-66.

YEAR	REFUGE	GROUP SIZES	TOTAL GROUPS COUNTED No.	% Occurrence	% Imm. (Age Ratio)
1965	Tewaukon	1-9	841	93	30
		10-19	52	6	36**
		20+	4	1	22
			897		
1965	Sand Lake	1-9	3181	89	29
		10-19	358	10	25
		20+	25	1	17
			3564		
1966	Sand Lake	1-9	4091	96	46
		10-19	161	3	43
		20+	19	1	45
			4261		
	Total		8722		

** Includes two groups of 18 immature blue-phase snows with no adults.

Table 5. Age ratios of snow geese determined by different observers counting the same flock, Oct. 29-Nov. 6, 1965.

OBSERVER	NO. GROUPS	AVG. GROUP SIZE	ADULTS	IMM.	TOTAL	% IMM.	Chi-sq. Value*
1	56	5.5	251	58	309	19	x^2 = 1.89(NS)
2	56	5.4	257	44	301	15	
1	178	3.9	508	177	685	26	x^2 = 1.22(NS)
2	131	4.1	417	125	542	23	
1	156	4.8	665	89	754	12	x^2 = 1.005(NS)
2	110	5.1	505	56	561	10	

* x^2 at P 0.05 = 3.84

Age Ratios

Boyd (1952:15) noted that age ratios observed at different times during one season resulted in comparison of non-equivalent data. He assumed this discrepancy was due to population differences, i.e. migration changes and flock mixing, rather than to faulty sampling. There was a significant difference ($P<0.01$) among age-ratio means obtained during different time periods at Sand Lake Refuge in 1965 and 1966 (Tables 6-9). No difference ($P<0.05$) was detected between age ratios for the two periods of migration sampled at Tewaukon Refuge (Table 10 and 11).

In summary, these findings showed variation between age ratios collected from several different flocks during various periods of migration. It is impossible to know which or if any of the age-ratio means found were true estimates.

Factors Affecting Age-Ratio Estimates

Seven factors thought to influence age ratios obtained by flock counts were tested at Sand Lake Refuge. Each factor measured was broken to sub-factors. An analysis of variance of age-ratio means for the seven factors and sub-factors (Tables 12 and 13) detected a significant difference ($P<0.01$) among means of counts taken at different sampling sites, during different wind velocities, under different degrees of sky cover and in different years. No difference ($P<0.05$) was detected among means of counts taken at different times of daylight, on non-rainy or light-rainy days, or during periods of differing food availability on the refuges.

Table 6. Age ratios of snow geese derived from flock counts at Sand Lake Refuge, 1965.

NO.	TIME PERIOD	ESTIMATED POPULATION	NUMBER OF COUNTS	MEAN PERCENT IMMATURES (YOUNG PER TOTAL)
1.	Sept. 27 - Oct. 4	19,000	4	43.2
2.	Oct. 5 - Oct. 11	48,000	4	31.2
3.	Oct. 12 - Oct. 22	32,000	7	23.3
4.	Oct. 23 - Nov. 5 (AM)	10,000	6	21.5
5.	Nov. 5 (PM) - Nov. 22	3,000	3	12.7
6.	Nov. 23 - Nov. 30	2,000	1	22.3

Table 7. Analysis of variance among means for six migration periods shown in Table 6.

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F
Time Periods	5	0.200	0.04000	29.41**
Error	19	0.026	0.00136	

** Significant at P (0.01) level.

Table 8. Age ratios of snow geese derived from flock counts at Sand Lake Refuge, 1966.

NO.	TIME PERIOD	ESTIMATED POPULATION	NUMBER OF COUNTS	MEAN PERCENT IMMATURES (YOUNG PER TOTAL)
1.	Sept. 25 - Oct. 1	3,000	2	28.5
2.	Oct. 2 - Oct. 8	25,000	3	37.2
3.	Oct. 9 - Oct. 15	45,000	3	48.3
4.	Oct. 16 - Oct. 25 (AM)	90,000	5	49.5
5.	Oct. 25 (PM) - Nov. 5	40,000	2	48.2
6.	Nov. 5 - Nov. 12	5,000	1	57.8

Table 9. Analysis of variance among means for six migration periods shown in Table 8.

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F
Time Periods	5	0.102	0.0204	10.74**
Error	10	0.019	0.0019	

** Significant at P (0.01) level.

Table 10. Age ratios of snow geese derived from flock counts at Tewaukon Refuge, 1965.

NO.	TIME PERIOD	ESTIMATED POPULATION	NUMBER OF COUNTS	MEAN PERCENT IMMATURES (YOUNG PER TOTAL)
1.	Oct. 9 - Oct. 19	6,000	2	34.5
2.	Oct. 20 - Nov. 9	8,000	3	28.3

Table 11. Analysis of variance among means for two migration periods shown in Table 10.

SOURCE OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
Time Periods	1	0.005	0.00500	7.463(NS)
Error	3	0.002	0.00067	

NS = Non-significant.

Table 12. Age-ratio means of flock counts taken at Sand Lake and Tewaukon Refuges, 1965-66.

FACTORS TESTED	AGE-RATIO MEANS	FACTORS TESTED	AGE-RATIO MEANS
Sampling Sites		Precipitation	
Diagonal Trees	31.0	None	35.3
Mud Lake Dike	38.1	Rain	32.7
Hanson's Point	37.0		
Hecla Grade	26.8	Sky Cover	
State Pits	32.9	Clear	36.9
West Headquarters	32.3	Partly Cloudy	31.0
East Headquarters	30.4	Overcast	34.0
Silo Bay	43.3	Food Availability	
		Abundant	35.5
Time of Counts		Moderate	33.2
Dawn - 11:00 AM	34.3	Critical	33.1
11:00 AM - 2:00 PM	33.0		
2:00 PM - Dusk	34.6	Year	
		1965	27.5
Wind Velocities		1966	40.4
Calm	31.1		
Light (1-4 mph)	34.4		
Moderate (5-10 mph)	36.1		
Strong (≥ 11 mph)	34.3		

Table 13. Age-ratio analysis of variance of 1965-66 flock-count means in Table 12.

FACTORS	DF	SS	MS	F
Sampling Sites	7	79232.088	11318.869	11.894**
Time of Day	2	1573.166	786.583	0.826 NS
Wind Velocity	3	19424.857	6474.952	6.804**
Precipitation	1	1354.584	1354.584	1.423 NS
Sky Cover	2	17582.133	8791.067	9.238**
Food Availability	2	2210.911	1105.456	1.161 NS
Between Years	1	160136.720	160136.720	168.281**
Experimental Error	8703		951.601	

** Significant at P (0.01) level.
NS = Non-significant.

Each flock of geese was segregated and the age-ratio means from different sampling sites were considered means from independent flocks. Age-ratio means of these sampled flocks were found to be significantly different ($P<0.01$). This suggests differing nesting success among the migrating flocks. These results corroborate those of Cooch (1958:156) and Lynch and Singleton (1964) who theorized that lesser snow geese tend to be colonial yet allopatric in habit on both the breeding and wintering grounds. Cooch (1958) further noted that different segments of the same breeding colony may have different nesting success. Therefore, it is necessary to sample each flock of a concentration to reliably estimate age ratio.

Differences in counts obtained with various wind and sky-cover conditions were attributed to goose behavior and discrepancies in visibility. On warm, calm days, geese, especially immatures, spent extensive periods of time resting, feeding, and preening. Low age-ratio means were obtained on those days (Table 12), probably the result of less frequent feeding-flights of immatures. This was a departure from the behavior and higher age-ratio means observed on days of adverse weather when geese were more active in their feeding-flights.

Lynch and Singleton (1964) found that terrestrial and cloud background could influence the accuracy of flock counts and recommended that counts be conducted at times when visibility was favorable. At both refuges, the lowest and highest age ratios were observed on partly cloudy and clear days, respectively (Table 12). This was because color distinction between adult and immature plumage was poorest against uneven backgrounds such as broken sky or partially-shadowed landscape.

Age ratios are usually biased to favor adult geese, because immature geese are the most difficult to identify (Lynch and Singleton 1964). Therefore, counts should not be taken on calm, partly-cloudy days. The best time and conditions for making age-ratio counts are the early morning or late evening of clear or completely overcast days with moderate wind.

Cannon-Net Trap Catches

Age Ratios

An analysis of variance detected no significant differences ($P<0.05$) in age-ratio means for either snow or Canada geese net-trapped during different time periods either year (Tables 14-21). This was contrary to results from flock counts where the means varied significantly with time periods (Tables 6-9).

Age ratios from the same flock were collected by flock-counting and net-trapping. Results showed age ratios from net-trapped samples of snow geese were generally higher than age ratios from flock counts (Table 22). Data from flock counts of snow geese are believed more nearly representative of the actual age ratio.

Observations of marked geese partially explain the bias in age ratios obtained from net-trapped geese. Marked immature snow and

Table 14. Age ratios of snow geese captured by cannon-net shots at Sand Lake Refuge, 1965.

TIME PERIOD	ESTIMATED POPULATION	NUMBER OF SHOTS	MEAN PERCENT IMMATURES (YOUNG PER TOTAL)
Oct. 5 - Oct. 11	48,000	3	50.7
Oct. 12 - Oct. 22	32,000	5	48.7
Oct. 23 - Nov. 5	10,000	4	55.7

Table 15. Analysis of variance among means for three migration periods shown in Table 14.

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F
Time Periods	2	0.011	0.0055	1(NS)
Error	9	0.140	0.0156	

NS = Non-significant.

Table 16. Age ratios of Canada geese captured by cannon-net shots at Sand Lake Refuge, 1965.

TIME PERIOD	ESTIMATED POPULATION	NUMBER OF SHOTS	MEAN PERCENT IMMATURES (YOUNG PER TOTAL)
Oct. 18 - Oct. 21	8,000	3	22.8
Oct. 22 - Oct. 28	4,000	5	17.3
Oct. 29 - Nov. 8	2,000	1	18.9

Table 17. Analysis of variance among means for three migration periods shown in Table 16.

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F
Time Periods	2	0.003	0.0015	1(NS)
Error	6	0.110	0.0183	

NS = Non-significant.

Table 18. Age ratios of snow geese captured by cannon-net shots at Sand Lake Refuge, 1966.

TIME PERIOD	ESTIMATED POPULATION	NUMBER OF SHOTS	MEAN PERCENT IMMATURES (YOUNG PER TOTAL)
Oct. 9 - Oct. 15	45,000	2	50.2
Oct. 16 - Oct. 25 (AM)	90,000	8	59.4
Oct. 25 (PM) - Nov. 5	40,000	5	61.5

Table 19. Analysis of variance among means for three migration periods shown in Table 18.

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F
Time Periods	2	0.018	0.0090	3.33(NS)
Error	12	0.032	0.0027	

NS = Non-significant.

Table 20. Age ratios of Canada geese captured by cannon-net shots at Sand Lake Refuge, 1966.

TIME PERIOD	ESTIMATED POPULATION	NUMBER OF SHOTS	MEAN PERCENT IMMATURES (YOUNG PER TOTAL)
Oct. 9 - Oct. 15	5,000	1	66.7
Oct. 16 - Oct. 25 (AM)	10,000	9	61.0
Oct. 25 (PM) - Nov. 5	2,000	4	60.7

Table 21. Analysis of variance among means for three migration periods shown in Table 20.

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F
Time Periods	2	0.003	0.0015	1(NS)
Error	11	0.140	0.0127	

NS = Non-significant.

Table 22. Comparison of age ratios obtained at the same site by two methods.

TIME PERIOD	SAMPLING METHOD	AGE RATIOS Adults	Imm.	% Imm.
1965 Oct. 5-11	Flock Counting	449	224	33
	Net Trapping	356	370	51
Oct. 12-22	Flock Counting	499	121	20
	Net Trapping	392	359	48
Oct. 29 - Nov. 5	Flock Counting	2721	447	14
	Net Trapping	266	62	19
1966 Oct. 9-15	Flock Counting	1057	998	49
	Net Trapping	159	152	49
Oct. 25 - Nov. 5	Flock Counting	283	328	54
	Net Trapping	97	158	62
Total or Average	Flock Counting	5009	2118	30
	Net Trapping	1270	1101	46

Canada geese alike were seen to approach the trap site ahead of the adults on nearly all occasions. Such behavior implies that immatures are less wary of bait and trapping equipment than adults. These findings corroborate closely the results on Canada geese by Nass (1964:523) who found that juvenile geese moved onto the bait before adults. Raveling (1966:685) and Vaught and Kirsch (1966:19) concluded that immatures in family groups were considerably less wary than adults.

Marquardt (1962a:120), Nass (1964:526), and Raveling (1966:689) have suggested that population structure at the trap site was related to behavior. Observations of one family group of snow geese at Sand Lake partially explain this behavior. This group of two adults and one immature was cannon-net trapped at the Mud Lake site on October 17, 1966. They were dyed entirely pink excepting the gander's head which was dyed blue. At 5:15 PM, October 21, the family was sighted on the mud flat at the Mud Lake site. The immature goose walked ahead of the adults and upon arrival at the site immediately began to eat. Both adults stopped about 15 yards from the bait and neither fed. The immature fed almost 6 minutes before the gander called and the immature rejoined the pair. The three walked about 5 yards from the trap site then flew to a nearby barley field. On October 22 at 5:00 PM this family group was again sighted at the Mud Lake site. The immature was feeding about 7 yards closer to the net than the parents, which were feeding at the edge of the bait. The trap was fired at this time and the family was recaptured along with 154 other snow geese and 6 Canada geese, redyed, and released for further observation.

Hanson (1953) concluded that families of Canada geese in winter exhibit a size-rank dominance of large families, small families, pairs, and single geese in descending order. Findings by Raveling (1966:685) confirmed this conclusion. However, family-size dominance was not observed among small Canada or snow geese at Sand Lake trap-sites during my study.

Sex Ratios

Except for lesser snow geese in 1966, there was a preponderance of adult males in the geese cannon-net trapped at Sand Lake during 1965 and 1966 (Table 23). Hanson and Smith (1950) pointed out that this was normal because adult females probably experienced a higher mortality than adult males during the nesting season. During both years, males were predominant in trapped samples of immature snow geese. Conversely, the females were predominant in the samples of immature Canada geese (Table 23). Nass (1964:526) reported uneven sex-ratios favoring adult male and immature female Canada geese at Swan Lake Refuge during late winter when food shortage was critical. Vaught and Kirsch (1966) observed a preponderance of immature female Canada geese in net-trap samples at Swan Lake Refuge. They suggested this may have resulted from a differential mortality earlier in the year or a bias in net-trap samples.

Table 23. Sex ratios of geese from 50 cannon-net trap samples at Sand Lake Refuge.

YEAR	SPECIES	TOTAL ADULTS SEXED	MALES PER 100 FEMALES	TOTAL IMM. SEXED	MALES PER 100 FEMALES	TOTAL NUMBER SEXED	MALES PER 100 FEMALES
1965	Snow	1081	109	1037	127	2118	118
	Canada	1037	120	337	96	1374	113
1966	Snow	579	92	817	107	1396	101
	Canada	573	119	821	86	1394	98

Findings of this study and those of Nass (1964) and Vaught and Kirsch (1966) indicate that sex segregation of immature geese and adult geese may exist on baited trap-sites. However, because the true population sex ratio was unknown, these sex ratios may or may not have been representative.

Bursal Measurements

In 1965, bursal depths of 66 immature snow and 49 immature small Canada geese ranged from 10 to 21 mm (Table 24). Seventeen of these geese were placed in captivity for measurement the following year. Parameters for bursal depths of the surviving 11 snow and 2 Canada geese one year later were 4 to 9 mm and 2 to 9 mm, respectively, (Table 24). The sample was small but it indicated that immatures and yearlings of snow and Canada geese may be distinguished by bursal measurements.

Adult-plumaged geese with bursal depths within the parameters of yearlings were found in every net-trap sample in 1966. This suggested that yearling geese were present during the entire migration stopover on the refuge. Because cannon-net samples were not obtained from every flock on the refuge, no attempt was made to estimate total numbers or percentages of yearlings in the refuge population.

Table 24. Bursa of Fabricius measurements of geese at Sand Lake Refuge, 1965 and 1966.

SPECIES	NO. BIRDS MEASURED	AVERAGE DEPTH IN MILLIMETERS	RANGE IN MILLIMETERS
ALL GEESE*			
At 5-months Age (Immatures)			
Canada	49	14.7	10 - 21
Snow	66	13.1	10 - 21
CAPTIVE GEESE			
At 5-months Age (Immatures)			
Canada	4	13.5	10 - 16
Snow	13	11.1	10 - 13
At 17-months Age (Yearlings)			
Canada	2	6.5	4 - 9
Snow	11	5.6	2 - 9

* Included the immature captive geese.

Hanson (1962:11) stated that absence of the bursa was quite certain evidence a goose was 2 1/2 or more years old and that this usually coincided with sexual maturity. Snow geese 2 years or more old are also sexually mature (Cooch 1958). Only two known 2-year-old snow geese were probed for bursal depths at Sand Lake. The bursae were 2 mm and 4 mm deep, thus overlapping the bursal parameters of yearlings. However with a larger sample, it may be possible to identify 2-year-old geese from yearlings by bursa of Fabricius measurements. No bursal openings were found among seven geese known to be 3-year-olds.

Regrouping of Net-trapped Geese

A family (two adults and one young) of snow geese net-trapped, banded, dyed, and individually released on October 17, 1966 were observed together 22 hours after release. This family was retrapped on October 22, redyed, held over-night in cages, and released as a group 3 miles from the trap site. Within 10 hours the family had rejoined the flock associated with prior to their capture. On November 2, 1966, at 5:00 PM another family of two adults and three young was net-trapped, banded, and individually released. Only the female was dyed. At 2:00 PM on November 7, the female with one adult and two immatures was sighted feeding in a field. At 3:30 PM, I sighted the female with one adult and three young on the ice near the point of capture. All five geese were wearing shiny leg bands.

Four other dyed geese were observed to join functional non-family groups within 2 days after being net-trapped. They were observed to maintain integrity as a group while on the refuge.

Reunification of these family groups of snow geese connotes the strong bond between the members. Bond persistence and degree of family integrity for Canada, white-fronted and snow geese had previously been discussed by Elder and Elder (1949), Hanson (1953), Lorenz (1959), and Sherwood (1966). In marked groups of snow geese, regrouping occurred within 1 to 5 days. These results closely corroborate those of Boyd (1955), who observed that separated family members of rocket-netted pink-footed geese (Anser fabalis brachyrhynchus) reassembled soon after release, and the results of Miller and Dzubin (1965) who found that disrupted families of net-trapped white-fronted geese reunited within 1 day after banding.

Cooch (1958:189) reported that at least 90 percent of all family groups reassemble following drive-trapping and banding operations in the arctic. He further stated that at the time these geese were banded the goslings were large enough to fend for themselves and that unattached young formed self-sufficient groups whose rate of survival to flying age was high. My observations and those of others (Cooch 1958, Miller and Dzubin 1965) showed that geese have a strong family bond and reassemble following capture. However, a more intensive study of these factors throughout the year is suggested.

Hunter-Bag Checks

Age Ratios

During the 4-year period from 1963-1966, immature lesser snow geese were shot in greater proportion than they existed in the population as determined by flock counts (Table 25). These results agree with those of Hanson and Smith (1950), Hewitt (1950), Boyd (1952), and Vaught and Kirsch (1966) who reported immature geese were more vulnerable to the gun than adults. Vaught and Kirsch (1966) also observed a constant decrease in the proportion of immatures in the hunters' bags as the hunting season progressed.

Hanson and Smith (1950), Cooch (1958), and Bellrose et al. (1961) noted that age ratios of geese in hunters' bags varied with different types of hunting. Two main methods of hunting were used in the Sand Lake area and age ratios from bag checks were determined for each. A greater percentage of immature snow and small Canada geese were taken by pit (decoy) hunters during 1965-66 than by fenceline hunters (Table 26). However, the difference between age ratios of Canada geese was small. This was perhaps due to the small sample obtained from fenceline hunters.

Cooch (1958:209) noted that groups of adult snow geese were much more difficult to decoy than were groups with juveniles. At Sand Lake similar behavior contributed to the differential age ratios found between fenceline and pit hunters' bags.

Table 25. Comparison of age ratios of snow geese obtained by hunter-bag checks and flock counts.

YEAR	HUNTER-BAG CHECKS		FLOCK COUNTS	
	No. Geese	% Immature	No. Geese	% Immature
1963	250	61	7,361	50
1964	197	54	7,599	36
1965	615	57	19,345	26
1966	948	66	16,299	46

Table 26. Age ratios of hunter-killed geese from Brown County, South Dakota, 1965-66.

SPECIES	AGE	METHOD OF HUNTING			
		Fenceline		Pit or Decoy	
		No. Geese	% Imm.	No. Geese	% Imm.
Canada	Ad.	22	62	117	65
	Imm.	36		215	
Snow	Ad.	131	49	163	68
	Imm.	126		344	
Total	Ad.	153	51	280	67
	Imm.	162		559	

Differential Color-Phase Selectivity

Cooch (1958:180) reported that both tourists and Indians selectively harvested white-phased snow geese in the James Bay area of Canada. His thesis was that white-phase geese, because of their color, were more striking in appearance and in mixed flocks were probably selected by hunters.

Such hunter selectivity of blue- or white-phase snow geese was not observed at Sand Lake Refuge. The overall average of blue-phase geese in the Sand Lake population of snow geese in 1966 as determined from three sampling methods was 21.4 percent (Table 27). The percent of blue-phase geese found in hunters' bags in 1966 was 24.6 percent (Table 27) and the average for a 9-year period at the State-controlled pits at Hecla was 25 percent (Table 28). These percentages were only slightly higher than the estimated proportion of blue-phase geese in the population as determined by flock counts (Table 27). Thus, blue-phase geese were harvested in about the proportion that they existed in the Sand Lake area.

Further evidence that the blue- and white-phase snow geese are harvested generally in the proportion that they exist in the population was presented by Cooch (1958:178-9;202). He reported that band recovery rates from shot blue- and white-phase snow geese west of the Mississippi River was on the order of a 1:4 ratio (20 percent) and that the total band recoveries for South Dakota from

Table 27. Percentages of blue-phase snow geese found in the Sand Lake populations, 1966.

SAMPLING METHOD	TOTAL BIRDS SAMPLED	NUMBER OF BLUE-PHASE	PERCENT BLUE-PHASE
Hunter-Kill	948	234	24.6
Cannon-net Traps	1,401	234	16.7
Flock Counts	17,674	3,811	21.6
Total or Average	20,023	4,279	21.4

Table 28. Geese killed at the State controlled hunting pits at Hecla, South Dakota. Data contributed by Roderick C. Drewein, South Dakota Department of Game, Fish and Parks.

YEAR	SNOW GEESE		CANADA GEESE	SNOW AND CANADA GEESE		
	Total Killed	% Blue Phase	Total Killed	Total Killed	% Snows	% Canadas
1958	73	26	226	299	24	76
1959	526	18	616	1142	46	54
1960	34	18	789	823	4	96
1961	287	27	393	680	42	58
1962	227	33	76	303	75	25
1963	100	26	112	212	47	53
1964	124	27	105	229	54	46
1965	183	25	159	342	53	47
1966	325	26	218	543	60	40
Total or Average	1879	25	2694	4573	41	59

1952 to 1957 showed blue-phase geese made up 24.2 percent of the harvest. These recovery rates were based on populations of snow geese banded in the ratio of 1.0 blue- to 3.3 white-phase geese.

Differential Species Vulnerability

Hunter-bag checks and questionnaire surveys showed a differential mortality between lesser snow and small Canada geese at Sand Lake. During a 4-year period the population was made up of 15 percent Canadas and 85 percent snows. During the same period, the harvest in the area was 35 percent Canadas and 65 percent snows (Table 29). Similar results were found by Vaught and Burgess (1966, unpublished) at Squaw Creek National Wildlife Refuge in Missouri where surveys showed hunters harvested 30, 18, and 36 percent, respectively, of the peak fall concentration of Canada geese in 1964, 1965, and 1966, while only 6, 8, and 11 percent respectively, of peak concentration of snow geese were harvested in the same years.

Differential harvest rates between snow and Canada geese at Sand Lake resulted in part from feeding-flight behavior. Harrold (1928), Craighead and Stockstad (1956), Hunt et al. (1962), and Lynch and Singleton (1964) noted that snow and Canada geese usually maintained early-morning and late-afternoon feeding flights and that hunters increased their hunting success by concentrating along these flight lanes. Major feeding-flights of snow geese off the Sand Lake Refuge were curtailed after 4 days of hunting in 1965

Table 29. A comparison of the percentages of geese present in the Sand Lake populations to hunter-kill.

YEAR	HUNTER-KILL SURVEY METHODS								
	Hunter-Bag Checks			Questionnaire Survey*			Weekly Population Censuses**		
	Total Geese Checked	% Canadas	% Snows	Total Geese Killed	% Canadas	% Snows	Weekly Average	% Canadas	% Snows
1963	420	40	60	13,560	42	56	36,385	19	81
1964	369	46	54	14,872	45	55	31,385	14	86
1965	888	31	69	10,841	34	65	18,250	13	87
1966	1393	32	68	24,549	26	73	30,928	12	88
Average or Total	3070	35	65	63,822	35	65	117,498	15	85

* Based on duck stamp sales in the area and returns from questionnaires mailed to a random sample of these hunters.

** Estimates of population numbers by species were obtained by aerial and ground surveillance.

and 3 days in 1966 because of heavy gunning pressure along the refuge boundary. Only occasional snow goose feeding flights off the refuge, usually on stormy or extremely windy days, were seen thereafter. Conversely, Canadas maintained off-refuge feeding flights throughout the hunting season.

Hunter preference (selectivity) was considered important in differential species-harvest rates at Sand Lake. Hunters were questioned during bag checks as to which species, snow or Canada geese, was preferred. Most hunters preferred to hunt small Canada geese, while others were opportunists and harvested the species most available at that time.

Most hunters reported that, in their opinion, small Canada geese decoyed more readily than snow geese. If this is true, snow and Canada goose harvest rates may also vary in relation to their response to decoys.

Photography

Aerial and ground photography were tried as an age-ratio sampling method at Sand Lake Refuge in 1965 but failed to yield reliable data. Contrast was not sufficient on either black and white or color pictures to identify immature snow geese. Aerial photography did show promise and if the contrast can be made sufficient to enable the separation of immature from adult blue-phase snow geese, it would be a rapid method of sampling age ratios of large flocks of geese.

CONCLUSIONS

Age-ratios obtained from flock counts were evaluated. Ratios varied with the number of flocks sampled, wind velocity and amount of sky cover. If adequate sampling sites are selected and weather conditions are standardized, age-ratio data from flock counts are of value for assessing productivity.

Average group-size counts, one technique presently used to estimate productivity of Canada geese, were not reliable in estimating productivity of snow goose flocks on Sand Lake Refuge. I believe this resulted from variation in group composition and number. Furthermore, in the poor production year, 1965; adult geese, probably yearlings and unsuccessful breeders, were aggregated into pseudo-family groups which averaged greater in size and occurred more frequently than during years of moderate to high production.

Cannon-net catches and hunter-bag checks of Canada and snow geese yielded age ratios which were biased because of behavioral characteristics of the geese. Immatures were less wary of trap equipment and were more vulnerable to the gun than adults. Therefore, percentages of immatures were higher in the samples than in the population.

Scattered families of snow geese regrouped following trapping and banding operations at Sand Lake Refuge and rejoined the flocks they associated with prior to capture.

Measurement of the depth of the bursa of Fabricius may be used as a technique to separate young-of-the-year from sexually-mature adults in most species of game birds. Measurements of bursal depths on a limited number of geese from the fall population on Sand Lake Refuge indicated that bursal depths may be used to classify geese into three age classes: young-of-the-year, yearlings and 2-year-olds, and more than 2-years old. Bursa measurements were not reliable for segregating possible breeders and non-breeders in the population. However, since only two 2-year-old geese were measured for bursal depth, measurement of a larger sample may reveal that yearling and 2-year-olds can be separated.

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APPENDIX

Appendix A. Age ratios of cannon-netted snow geese at Sand Lake Refuge during fall, 1965.

DATE	ADULT MALE	ADULT FEMALE	IMMATURE MALE	IMMATURE FEMALE	% IMMATURE	AREA
Oct. 6	39	48	54	44	52.9	Mud Lake
Oct. 11	95	80	104	77	50.0	"
Oct. 11	45	49	56	35	49.2	"
Oct. 12	109	88	67	63	39.8	"
Oct. 14	70	78	52	43	39.0	"
Oct. 15	28	19	77	57	74.0	"
Oct. 18	5	5	5	5	50.0	Hecla Grade
Oct. 21	42	31	26	25	41.1	Diagonal Trees
Oct. 25	63	67	65	51	47.1	Hecla Grade
Oct. 26	26	14	24	18	51.2	"
Oct. 27	3	2	6	9	75.0	"
Oct. 28	39	36	45	29	49.6	Diagonal Trees
Total or Average	564	517	581	496	49.0	

Appendix B. Age ratios of cannon-netted Canada geese at Sand Lake Refuge during fall, 1965.

DATE	ADULT MALE	ADULT FEMALE	IMMATURE MALE	IMMATURE FEMALE	% IMMATURE	AREA
Oct. 18	51	63	15	15	20.8	Hecla Grade
Oct. 21	157	108	51	39	25.3	"
Oct. 21	14	10	2	5	22.5	Diagonal Trees
Oct. 25	32	24	10	11	27.2	Hecla Grade
Oct. 26	92	75	20	22	20.1	"
Oct. 27	9	8	3	8	39.2	"
Oct. 27	64	50	42	32	39.3	"
Oct. 28	8	6	0	0	00.0	Diagonal Trees
Nov. 2	138	128	22	40	18.9	Hecla Grade
Total or Average	565	472	165	172	24.6	

Appendix C. Age ratios of cannon-netted snow geese at Sand Lake Refuge during fall, 1965.

DATE	ADULT MALE	ADULT FEMALE	IMMATURE MALE	IMMATURE FEMALE	% IMMATURE	AREA
Oct. 11	47	52	38	42	44.7	Mud Lake
Oct. 13	26	34	39	33	55.8	"
Oct. 17	21	33	33	40	57.5	"
Oct. 18	19	25	38	22	57.7	East Side
Oct. 19	6	4	11	4	60.0	Diagonal Trees
Oct. 20	16	15	29	16	59.2	East Side
Oct. 21	23	24	39	37	61.8	Diagonal Trees
Oct. 22	5	7	10	8	60.0	"
Oct. 22	27	19	60	48	70.1	Mud Lake
Oct. 25	14	16	16	17	49.3	"
Oct. 25	3	2	5	4	64.3	Diagonal Trees
Oct. 26	1	2	3	2	62.5	"
Oct. 28	7	6	8	9	58.1	Hecla Grade
Nov. 1	12	16	20	28	60.8	"
Nov. 2	51	46	73	85	62.0	Silo Bay
Total or Average	278	301	422	395	58.5	

Appendix D. Age ratios of cannon-netted Canada geese at Sand Lake Refuge during fall, 1966.

DATE	ADULT MALE	ADULT FEMALE	IMMATURE MALE	IMMATURE FEMALE	% IMMATURE	AREA
Oct. 11	0	1	0	2	66.7	Mud Lake
Oct. 16	24	19	24	32	56.6	East Side
Oct. 18	26	21	19	13	40.5	"
Oct. 19	19	29	26	47	60.3	Diagonal Trees
Oct. 20	25	21	22	25	50.5	East Side
Oct. 21	5	3	5	8	61.9	Diagonal Trees
Oct. 22	6	5	9	10	63.3	"
Oct. 22	1	0	0	5	83.3	Mud Lake
Oct. 23	11	9	13	15	58.3	East Side
Oct. 25	1	1	2	4	75.0	Mud Lake
Oct. 25	25	22	25	30	53.9	Diagonal Trees
Oct. 26	33	24	31	49	58.4	"
Oct. 28	118	88	164	161	61.2	Hecla Grade
Nov. 1	17	19	40	41	69.2	"
Total or Average	311	262	380	441	58.9	

Appendix E. Age ratios of snow geese determined by flock counts at Tewaukon Refuge during fall, 1965.

DATE	NO. ADULTS	NO. IMMATURES	% IMMATURES	AREA
Oct. 12	360	169	31.9	West Headquarters
Oct. 19	281	166	37.1	"
Oct. 24	812	339	29.4	East Headquarters
Nov. 3	343	125	26.7	West Headquarters
Nov. 9	851	344	28.8	"
Total or Average	2,647	1,143	30.2	

Appendix F. Age ratios of snow geese determined by flock counts at Sand Lake Refuge during fall, 1965.

DATE	NO. ADULTS	NO. IMMATURES	% IMMATURES	AREA
Sept. 27	673	534	44.2	Diagonal Trees
Sept. 29	182	167	47.8	"
Sept. 30	156	92	37.1	"
Oct. 1	345	271	43.9	"
Oct. 5	449	224	33.3	Mud Lake
Oct. 7	196	94	32.4	Diagonal Trees
Oct. 8	977	392	28.6	"
Oct. 10	488	214	30.5	Hanson's Point
Oct. 12	534	151	22.0	"
Oct. 13	1,060	434	29.0	"
Oct. 15	496	147	22.9	"
Oct. 15	499	121	19.5	Mud Lake
Oct. 16	694	202	22.5	Hanson's Point
Oct. 19	920	266	22.4	"
Oct. 22	1,138	378	24.9	East Side
Oct. 27	740	221	23.0	Diagonal Trees
Oct. 29	251	58	18.7	"
Oct. 29	257	44	14.6	"
Nov. 1	417	125	23.1	"

Appendix F. (continued)

DATE	NO. ADULTS	NO. IMMATURES	% IMMATURES	AREA
Nov. 1	508	177	25.8	Diagonal Trees
Nov. 5	492	155	23.9	"
Nov. 5	1,551	302	16.3	Hecla Grade
Nov. 6	665	89	11.8	"
Nov. 6	505	56	10.0	"
Nov. 25	185	53	22.3	Diagonal Trees
Total or Average	14,378	4,967	25.7	

Appendix G. Age ratios of snow geese determined by flock counts at Sand Lake Refuge during fall, 1966.

DATE	NO. ADULTS	NO. IMMATURES	% IMMATURES	AREA
Sept. 26	224	93	29.3	Diagonal Trees
Sept. 27	448	187	27.7	"
Oct. 2	1,014	638	38.6	"
Oct. 4	564	302	34.8	"
Oct. 5	772	480	38.3	"
Oct. 12	566	575	50.4	Mud Lake
Oct. 12	469	438	48.2	Diagonal Trees
Oct. 13	491	423	46.3	Mud Lake
Oct. 20	378	377	49.9	Silo Bay
Oct. 23	343	368	51.8	Hanson's Point
Oct. 24	330	252	43.3	"
Oct. 24	917	870	48.7	Silo Bay
Oct. 25	787	927	54.1	"
Nov. 3	283	328	53.8	"
Nov. 4	575	426	42.6	Hanson's Point
Nov. 9	613	841	57.8	"
Total or Average	8,774	7,525	46.2	