Distribution and breeding biology of the Lesser Snow Goose in central Arctic Canada

JOHN P. RYDER

Introduction

This paper reports the known nesting distribution and aspects of the breeding biology of the Lesser Snow Goose *Anser caerulescens caerulescens* in central Arctic Canada (Figure 1). Although previous biological work in the area is sparse, the available literature indicated a substantial increase in numbers of Lesser Snow Geese during the last 30 years.

Gavin (1947) reported that the white-phase was uncommon in the Perry River region (Figure 1) between 1937 and 1941. Some 10 to 12 pairs nested each year at the only known colony located 3.2 km. (2 miles) inland from the mouth of the Perry River (67° 42′ N., 102° 15′ W.). On 21st June 1941 he found three nests with two, three and five eggs. The same author reported four blue-phase pairs nesting at Discovery Lake (67° 33′ N., 101° 49′ W.) (Figure 2) on 2nd June 1940. The blue-phase was not known by the Perry Island Eskimos and Gavin's observations extended the known breeding range of this colour phase about 950 km. (600 miles) west.

Hanson *et al.* (1956) conducted ground and aerial surveys east from the Ellice to the Simpson River between 18th July and 1st August 1949 (Figure 1). They reported 120 white-phase, 13 blue-phase geese and two nests, one along the Perry River and one at Arlone Lake (67° 22′ N., 102° 10′ W.) (Figure 2). They also saw 18 Lesser Snow Goose broods averaging 2.9 goslings per brood and two Blue × Lesser Snow Goose pairs with two downy young each. On 30th July, 36 Lesser Snow Geese and four Blue Geese were seen near Nelson Hill (66° 46′ N., 102° 35′ W.).

Barry (1961) made aerial surveys of the western and eastern Arctic from the Anderson (69° 45′ N., 129° 00′ W.) to Sherman Basin (68° 00′ N., 98° 21′ W.).

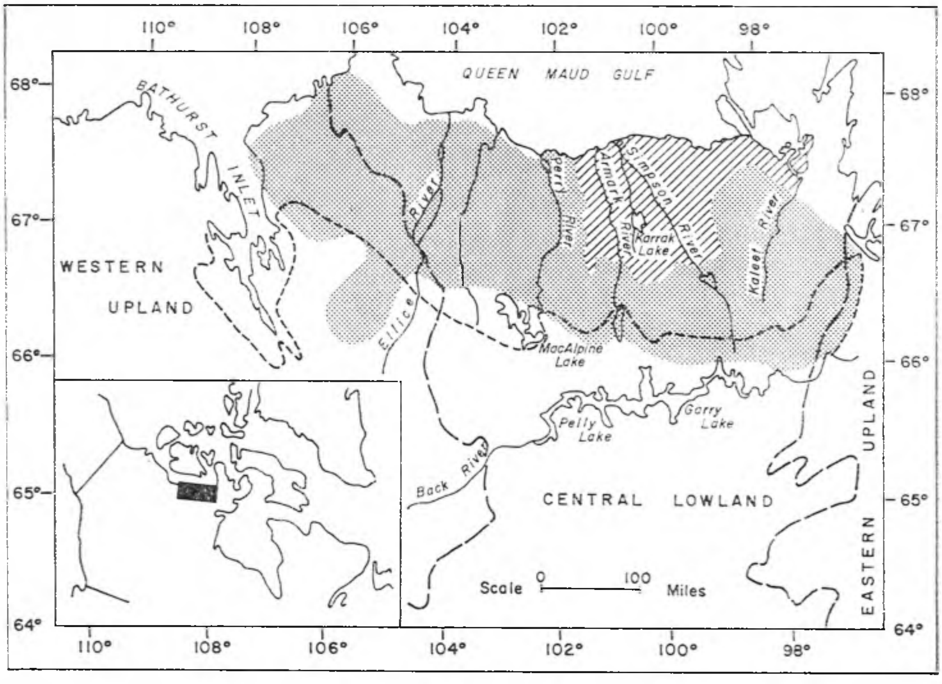

Figure 1. Map of aerial survey area (stippled) in the western upland, central lowland and eastern upland portions of the central Arctic. The Simpson River Rock Plain (diagonal lines) is within the survey area. The heavy broken lines separate the physiographic regions. The thin broken line is southern limit of post-glacial marine transgression. (Map modified from Ryder (1969a).)

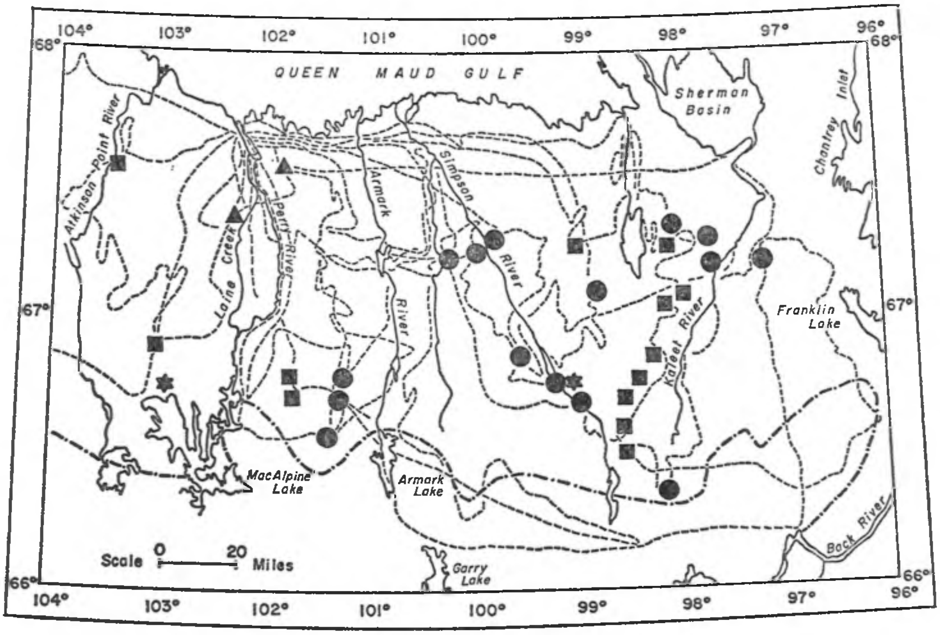

Figure 2. Distribution of Lesser Snow Goose nesting colonies in central Arctic Canada. Circles, squares and stars represent colonies discovered in 1965, 1966 and 1967 respectively. Triangles show location of Arlone Lake near Laine Creek and Discovery Lake east of Perry River. Broken lines are daily flight routes of 1965 and 1966 survey. The 1967 survey route is not shown (see text). The heavy dot-dash line is the southern limit of post-glacial marine transgression. (Map modified from Ryder (1969a).)

Although most of the geese had left their nesting areas by the time of his survey (16th-22nd August), he estimated 20,000 adult and young Lesser Snow and Blue Geese (10% blue-phase) on the mainland south of the Queen Maud Gulf.

Methods

Information in this paper was collected incidentally while conducting research on the Ross's Goose *Anser rossii* (Ryder 1969b). Field work consisted of ecological studies at Karrak Lake (67° 15′ N., 100° 15′ W.) (Figure 1), the location of the largest known colony of Ross's Geese (Hornby 1967), and of aerial surveys. Investigations at Karrak Lake lasted from 27th May to 10th July 1966, 29th May to 18th July 1967 and 1st June to 17th July 1968. We flew surveys on 9th-12th July 1965 and 14th-15th July 1966. On 3rd-4th July 1967 we inspected from the air 15 Lesser Snow Goose colonies discovered in 1965 and 1966 to see if geese were still using them. The aerial survey method (Ryder 1969a) involved marking potentially suitable colony sites on a map of the central Arctic before going into the field. The characteristics of the two known colony sites at Discovery and Arlone Lakes indicated lakes with islands as the most probable nesting sites. For the studies at Karrak Lake, we arrived at the colony site before the geese and noted their arrival dates and numbers. In 1968, histories were compiled from Lesser Snow Goose nests to augment clutch size data collected in 1966 and 1967. On the largest nesting island (18.57 hectares or 45.9 acres) in Karrak Lake, each new nest (i.e. with one clean or unstained egg) was marked with a numbered wooden stake placed about one metre (3 feet) away. The history was recorded until the hatching or disappearance of all the eggs. Marked nests were visited daily during the egg-laying period but only once every two or three days during incubation, to minimize disturbance. Daily visits were resumed during the hatching period, weather permitting. Nest checks were not conducted on unduly cold or rainy days. It was assumed that disturbance under such conditions would be detrimental to the hatching or newly-hatched young. An egg was recorded hatched if the young was almost or fully emerged. Eggs remaining in a nest after the others had hatched were broken open and classified as being addled, infertile (no embryo development), with a dead embryo or destroyed (cracked shell or hole in egg).

Study area

Aerial surveys

In 1965 the aerial survey boundaries were 66° 10′ to 67° 59′ N. and 96° 55′ to 104° 15′ W. These were expanded to 66° 09′ to 68° 10′ N. and 96° 05′ to 108° 14′ W. in 1966. We flew 2,815 km. (1,750 miles) in 1965 and 3,260 km. (2,026 miles) in 1966.

The survey area is within the 'Barren Lands' of the Canadian Arctic and incorporates parts of the western and eastern uplands and the northern sector of the once-inundated central lowland (Figure 1). The lowland slopes down to the north about 0.5 m./km. (2.5 feet per mile) (Bird 1967). Relief is less than 6 m. (20 ft.) except for an occasional Precambrian rock outcrop. The western upland is a plateau 300-600 m. (1,000-2,000 ft.) above sea level The eastern upland is a lower plateau characterized by hill ridges, protruding rocks and extensive boulder fields. Vegetation in the central lowland consisted of wet meadow and marsh tundra dominated by frost-heaved tussocks of *Eriophorum vaginatum*, *Carex* spp., *Betula glandulosa*, *Ledum decumbens* and *Rubus chamaemorus*. On outcrops and other elevated areas, *Hierochloe alpina*, *Salix* spp., *B. glandulosa*, *Papaver radicatum*, *Cassiope tetragona*, *L. decumbens*, *Vaccinium vitis-idea* and *Dryas integrifolia* were dominants. The boulder fields and well-drained areas of the eastern and western uplands had an impoverished lichen-moss-vascular plant association.

Karrak Lake

This lake is situated in part of the central lowland known as the Simpson River Rock Plain (Figure 1). Drumlins form the dominant topographical feature. These hills rise from 3-15 m. (10 to 50 ft.) above the surrounding terrain and their steep slopes face south, the direction from which glacial ice moved. They are composed of glacial till, a variety of different sized earth materials (silt, sand, gravel, rocks, large boulders) left behind by moving ice. A second important feature of the Simpson River Rock Plain is the badland topography along river banks. Water erosion has exposed marine silts and sands deposited during the post-glacial marine transgression. These small-grained sediments along with glacial till, form the third topographical feature, patterned ground, in the form of mud circles and polygons. These consist of silt and sand deposits, most of which are covered with tussock tundra.

Karrak Lake is approximately 6 km. (4 miles) long and 5 km. (3 miles) wide with an average depth of 1.3 m. (4 ft.). It has 47 islands, 16 of which were used by Ross's and Lesser Snow Geese for nesting. The occupied islands ranged in size from 820 m. (2,700 ft.) long by 365 m. (1,200 ft.) wide, with an altitude of 8 m. (27 ft.) above the July water level, to 60 m. (200 ft.) long by 23 m. (75 ft.) wide and 4.5 m. (15 ft.) above water level. Unoccupied islands were smaller than occupied ones and consisted entirely of rocks. Their low elevation, usually less than 1.5 m. (5 ft.) above the July water level, resulted in their being flooded in early or mid-June when the lake water rose about 1.0 m. (3 ft.) during the peak melting period. Vegetation on nesting islands was kept close to ground level by the geese using it for nest material and food (Ryder 1969b). Very little vegetation reached the flowering or fruiting stage. On the nesting islands, three habitats were visually separable on plant associations. 'Rock habitat' was found on the raised, dry rock and gravel areas which remain exposed throughout the winter and well drained all summer. Except for a variety of crustose lichens, this habitat was virtually devoid of vegetation. 'Moss habitat', a blanket of *Aulacomnium palustre*, *A. turgidum*, *Sphagnum rubellum*, *S. teres*, and *Dicranum angustum*, occurred on the moist lower portions of the islands. 'Mixed habitat' occurred in between. Dominant species were *Empetrum nigrum*, *L. decumbens*, *Potentilla hyparctica*, *C. tetragona*, *Rhododendron lapponicum*, *Pedicularis sudetica*. *B. glandulosa* and *Salix* spp. occurred in small patches and *Hippuris vulgaris* grew in melt pools. *Petasites frigidus* and *Senecio congestus* were common at old nest sites from the accumulation of goose droppings.

The rocky islets were devoid of vegetation. They provided nest sites for Glaucous Gulls *Larus hyperboreus*, Herring Gulls *L. argentatus* and Arctic Terns *Sterna paradisaea*.

Results

Aerial surveys

In 1965 we estimated 8,429 nesting Lesser Snow Geese at 16 colonies in the central Arctic. Their locations and sizes are detailed by Ryder (1969a). In addition 1,473 Lesser Snow Geese not associated with nesting colonies were observed and classified as non-breeding birds in the post-nuptial moult. All of the colonies but one (Arlone Lake) were previously unrecorded and all had mixed populations of Ross's and Lesser Snow Geese. Five colonies with only Ross's Geese were also found (Ryder 1969a). In 1966 our Ross's Goose studies at Karrak Lake prevented us from doing the survey until after the nesting season. In that year 13 newly recorded colony sites were determined by the presence of freshly used nests on islands and of geese with broods nearby. No population estimates were made in 1966 because the numbers of geese near the islands were not considered to represent the colony population. Near the Kaleet River (Figure 2) for example, it was impossible to establish from where the flocks originated. We found that all of the colonies discovered in 1965 were occupied again in 1966. In 1967 two other colonies were found and 14 of 15 colonies discovered in 1965 and 1966 were again occupied.

Geese used islands which were not flooded in spring (summits higher than 1.5 m. (5 ft.)) but which were not too steep-sided (summits higher than 9 m. (30 ft.)) and rocky to provide adequate nest sites and food. Suitable nesting islands had a varied topography with dry gravel areas 3 to 6 m. (10 to 20 ft.) above the lake surface and a variety of plants and rock cover. All nesting islands were in shallow lakes estimated 0.6 to 1.8 m. (2 to 6 ft.) deep. The ice in shallow lakes melts earlier than in deep ones, preventing Arctic Foxes *Alopex lagopus* from getting to the islands after the geese start to nest (Ryder 1969a).

All colonies were within the limit of post-glacial marine inundation. This is also true for nesting Canada Geese *Branta canadensis* in the Hudson Bay Lowlands (Hanson and Smith 1950; MacInnes 1966) and may indicate the availability and quality of food in such areas. During the post-Wisconsin marine inundation, marine organisms and minerals sedimented on the central lowland (Bird 1967). Beneath these fine-grained deposits, organic soil layers developed which are today reflected, in part, by the dense cover of wet tundra vegetation. The relatively restricted drainage in the central lowlands, as evinced by the many small, shallow lakes, waterlogged substrate and shallow active layer, less than 30 cm. (1 ft.) in the Perry River region (Hanson *et al.* 1956), has also been an important factor in the development of the wet tundra association. Typically, Arctic soils are unfavourable for plant growth because they are shallow, acidic and subject to little biochemical reaction (Bird 1967). It is possible, however, that organic and mineral nutrients were deposited in greater quantities on the old sea bottom of the central lowland than in areas which had no marine history. This abundance of nutrients allows increased plant growth and goose food. The fact that Arctic plants grow vigorously in areas rich in nutrients is strikingly shown near bird cliffs, dens of Arctic Fox and Arctic Ground Squirrel *Citellus parryi*, and goose colonies. After the spring melt the many, often continuous, wet tundra meadows and marshes in the central lowland furnish an abundance of goose food. Food may be an important limiting factor in the western and eastern uplands which have little vegetation.

Breeding biology

Lesser Snow Geese arrived at Karrak Lake in late May or early June, in groups of two to 100 individuals. Within about one week they dispersed over the islands and began nesting (Table I). In all three seasons nesting habitat was available when the geese arrived. Based on aerial surveys on 9th July 1965, 14th July 1966 and 3rd July 1967, the average nesting population at Karrak Lake was estimated at 6,000 Lesser Snow Geese and 12,000 Ross's Geese.

The interval between first arrival and nesting of Lesser Snow Geese was shorter than reported elsewhere in the Arctic. The average interval, calculated from the data of Uspenski (1965) for Lesser Snow Geese at Wrangel Island (74° N., 180° W.) and of Barry (1967) for the Anderson River Delta (69° 40′ N., 129° 00′ W.), was 12 days. Lemieux (1959) reported

Table I. Interval between arrival and start of nesting of Lesser Snow Geese at Karrak Lake, N.W.T., 1966-68. Number of Lesser Snow Geese in brackets.

Year	*Date first Lesser Snow Geese seen*	*Peak arrival date*	*Date of first nest*	*Peak nest initiation date*
1966	28 May (2)	3 June (115)	1 June	6 June (est.)
1967	6 June (20)	13 June (134)	14 June	16 June (est.)
1968	2 June (14)	8 June (129)	8 June	11 June

that Greater Snow Geese *Anser caerulescens atlanticus* on Bylot Island (73° N., 80° W.) started nesting 15 days after the first arrival in 1957. The above authors reported that nesting habitat was usually snow covered when their geese arrived. Barry (1962) observed that Atlantic Brant *Branta bernicla hrota* waited two weeks after their arrival at East Bay, Southampton Island in Hudson Bay, during 1957 when the season was late, with nearly 100% snow cover at arrival. Similar conditions were noted by Cooch (1961) in 1957 and 1959 at Blue Goose nesting areas in the Hudson Bay drainage. Norderhaug *et al.* (1964) specified snow cover as being the most important factor delaying the onset of laying in Pink-footed Geese *Anser brachyrhynchus* in West Spitsbergen. MacInnes (1962) found that flocks of Canada Geese arriving early on the west coast of Hudson Bay in 1959 congregated for 15 days on the few patches of snow-free ground.

The start of the nesting season was taken as the day on which the first egg was found on the study island (Table I). Figure 3 shows the overall distribution of egg-laying in 1968. Figure 4 presents the distribution of clutch initiation and completion. For a single clutch the interval between successive eggs averaged 1.3 ± 0.32 days (Table II). Other workers have reported that geese usually lay eggs at 1- to 1.5-day intervals (Barry 1967; Brakhage 1965; Delacour 1964; Klopman 1958; Kossack 1950; Lemieux 1959; MacInnes 1962). There was no relation between the number of eggs laid per clutch and the mean interval (days) between the laying of successive eggs. On the average, 6-egg clutches took twice as long to complete as 3-egg clutches. As noted by Cooch (1958) this may be important at hatching in view of the restricted amount of time available for nesting.

The most frequent laying patterns in the commoner clutch sizes (3, 4 and 5 eggs per nest) are given in Table III. The two most frequent sequences were to lay two or three eggs then miss a day before completing the clutch. Cooch

Table II. Distribution of clutch completion periods for Lesser Snow Goose clutches at Karrak Lake, 1968.

Days to complete clutches	*Number of nests by clutch size* 2	3	4	5	6	7	8	9	10	*Total*
2	2		1							3
3	1	5								6
4		12	3	1						16
5		2	20	5						27
6		1	9	9	3					22
7		1	1	2	2					6
8			1		2					3
9			2		1					3
10				3	1	1			1	6
11										—
12					1			1		2
Total	3	21	37	20	10	1	—	1	1	94
Mean no. of days between successive eggs	1.2	1.4	1.4	1.3	1.3	1.4	—	1.2	1.0	
Number of days to complete clutch	2.4	4.2	5.6	6.5	7.8	9.8	—	10.8	10.0	
Mean no. of days between successive eggs = 1.3 ± 0.32										

Table III. Most commonly occurring egg-laying patterns in Lesser Snow Goose clutches in marked nests at Karrak Lake, 1968.

Egg-laying pattern Days after laying of first egg 0	1	2	3	4	5	*Number of clutches*
1	2	3				6
1	2	—	3			8
1	2	3	4			4
1	2	3	—	4		7
1	2	—	3	4		10
1	—	2	3	—	4	5
1	2	3	4	5		4
1	2	3	—	4	5	6

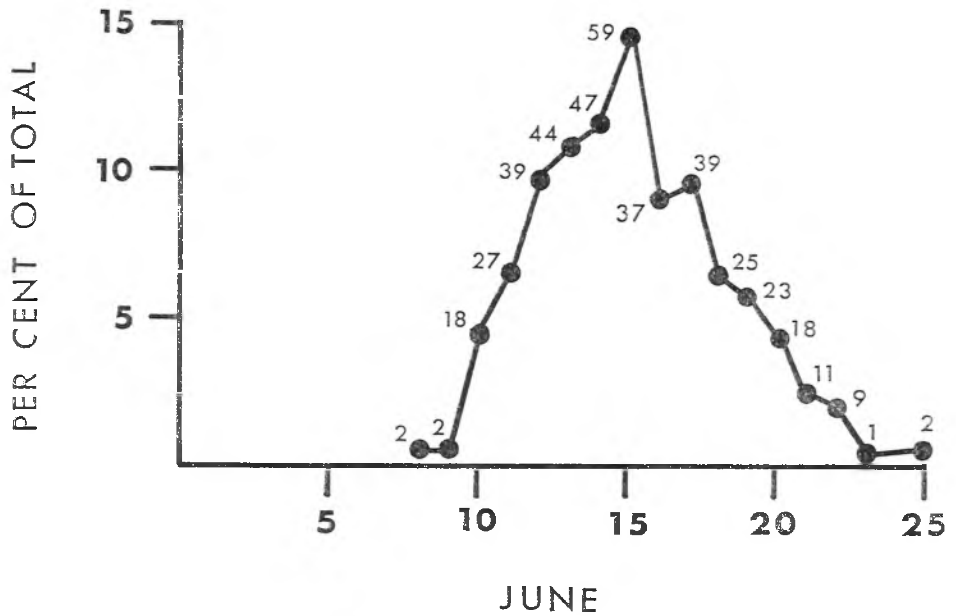

Figure 3. Distribution of egg-laying in 94 marked Lesser Snow Goose nests at Karrak Lake, 1968. Figures on graph equal number of eggs laid each day.

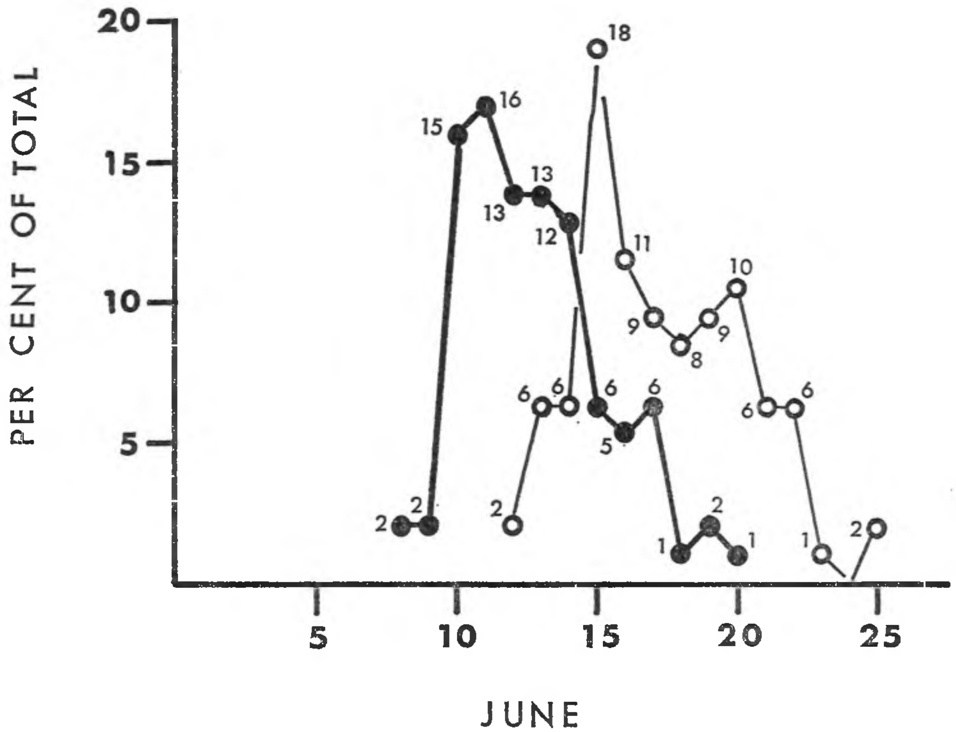

Figure 4. Distribution of clutch initiation and completion in 94 marked Lesser Snow Goose nests at Karrak Lake, 1968.

(1958) reported that Blue Geese generally lay 3-egg clutches on consecutive days but the most common pattern in larger clutches (four-seven eggs) was to lay four eggs, skip a day and then complete. Barry (1967) reported similar egg-laying patterns in Pacific Brant *Branta bernicla orientalis*, White-fronted Geese *Anser albifrons* and Lesser Snow Geese nesting at the Anderson River Delta. It is not clear why the species at Karrak Lake lay two or three eggs, rather than four, before missing a day. The difference may be related to regional, annual or seasonal phenology.

Clutch size

Hilden (1964) noted that clutch size data are one of the easiest types of information to collect. However, they are subject to errors depending on when and how they are collected. In 1968 all the clutch size information was based on the number of eggs found in each study nest at each daily nest check. The data cannot include eggs laid which disappeared between two consecutive daily nest checks. Incomplete clutches have, of necessity, been included in the material because it was not possible visually to separate incomplete from complete clutches. This problem is not, however, unique to this study (see also Sowls 1949).

The distribution of Lesser Snow Goose clutch sizes are given in Table IV. In each of the three seasons, the modal clutch size was 4 eggs and the combined average for the total nest sample (437 nests) was 4.16 ± 1.5 eggs. There were no significant differences in mean annual clutch sizes ($P>0.05$) and no correlation existed between clutch size and the starting date of the nesting season (Table I). However, the smallest average clutch size recorded in 1967 agrees with the findings of Barry (1962, 1967), Cooch (1958), Dementiev *et al.* (1952) and Uspenski (1965) that smaller clutches may result from resorption of some preovulatory follicles possibly stimulated by the lack of nesting habitat. Barry (1962) contended that atresia of ovarian follicles, resulting in smaller than average clutches or, in extended late seasons, failure to nest, may be an adaptation to the short Arctic nesting season, eliminating nesting and incubation that are a physical drain on the female. Thus atresia would enhance the chances of survival of both the females and of the young produced from her smaller clutch size (see Ryder 1970).

Incubation period

Incubation was taken to be complete in nests in which chipping was complete around the blunt end of the last laid egg or in which the newly hatched gosling was still wet. This was done because it was not possible to determine the hatching date of dry goslings. The distribution of incubation periods so calculated for 1968 is given in Table V. The modal period for 1968 was 23 days (54% of 48 clutches) and the average was 22.4 ± 0.89 days.

Table IV. Clutch sizes from Lesser Snow Goose nests at Karrak Lake.

	Number of nests by clutch sizes													Mean ± 1 standard deviation	
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*		
1966	—	—	34	53	72	41	25	8	2	2	1	2	1	4.17 ± 1.4	(n = 24
1967	—	—	8	32	33	14	12	—	2	1	—	—	—	4.03 ± 0.90	(n = 10
1968*	—	—	3	21	37	20	10	1	—	1	1	—	—	4.29 ± 1.3	(n = 94
	**(13)	(3)	(9)	(29)	(32)	(5)	(3)	—	—	—	—	—	—	(2.97 ± 1.5)	(n = 94
Totals	—	—	45	105	142	75	47	9	4	4	2	2	1	4.16 ± 1.5	(n = 43

* Data from marked nests of known history. ** Clutch size at hatching.

Table V. Incubation period in relation to clutch size in marked Lesser Snow Goose nests at Karrak Lake, 1968.

	Incubation period (days)						
Clutch size	*19*	*20*	*21*	*22*	*23*	*24*	*Mean ± 1 S.D.*
2					1		23.0
3				5	6	1	22.7 ± 0.48
4	1		1	9	8	1	22.3 ± 1.0
5		1	1		9		22.5 ± 1.1
6		1		1	2		22.0
Total	1	2	2	15	26	2	22.4 ± 0.89

The data presented in Table V indicate that there was a trend towards shorter incubation periods with increased clutch size, agreeing with the results reported by Cooch (1958) for Blue Geese. He postulated that the trend resulted from behavioural differences among the females. Apparently females laying large clutches incubated before the clutch was complete, thus subjecting the last egg to fewer cool spells than in the case of small clutches which the females did not incubate until after the last egg was laid. Cooch (1958) also noted that the nest site of large clutches had had longer to dry out before the last egg was laid. The eggs were then more likely to be kept warmer when incubation began. The attentiveness of birds with replacement clutches (eggs laid after previously laid eggs have been destroyed) may also be a factor. Nelson (1966) showed from his study of known-age Gannets *Sula bassana* that birds which laid and incubated replacement clutches had a diminished urge to incubate. Geese with (smaller) replacement clutches may likewise be less attentive than geese with first clutches.

Hatching

The hatching distribution is given in Figure 5. The daily distribution of hatching initiation and completion in 1968 clutches is shown in Figure 6. The shapes of the two curves are virtually identical indicating a high degree of hatching synchrony. The average number of days required for a single clutch to hatch was 1.4 ± 0.58 days (Table VI) and there was no consistent relation between the number of eggs in a nest at hatching and the amount of time required for a clutch to hatch. Over 60% of the clutches hatched completely in one day (i.e. during the interval between two consecutive nest checks).

Nest and hatching success

The proportion of marked nests producing at least one hatched egg (nest success) was 86.2 ± 3.5% and the number of eggs hatched from the total number marked (hatching success) was 69.2 ± 2.2% (Table VII). Standard deviations were calculated using the normal approximation method and checked with values

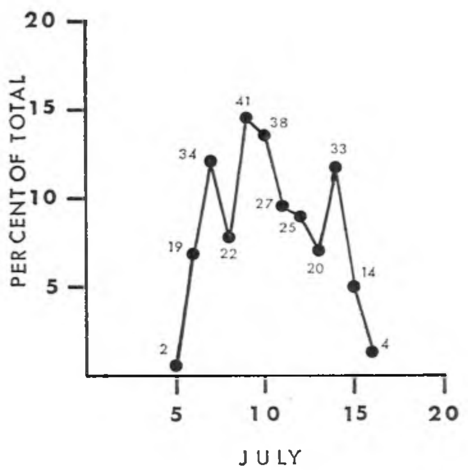

Figure 5. Distribution of egg hatching in 81 marked Lesser Snow Goose nests at Karrak Lake, 1968.

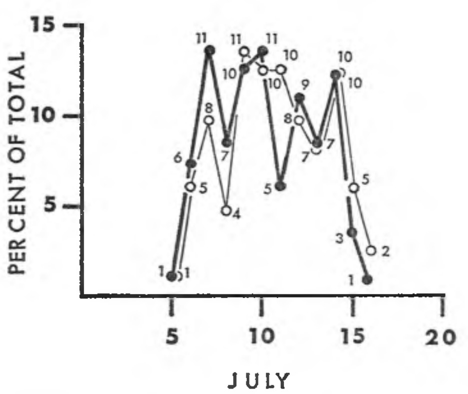

Figure 6. Distribution of hatching initiation and completion in 81 marked Lesser Snow Goose nests at Karrak Lake, 1968.

Table VI. Frequency of hatching times for Lesser Snow Goose clutches at Karrak Lake, 1968.

Days to hatch clutch	*Clutch size (eggs)* 1	2	3	4	5	6	*Total*
1	3	8	20	16	4	1	52
2		1	8	14	1	1	25
3			1	2		1	4
Total	3	9	29	32	5	3	81
Average no. of days per clutch size	1.0	1.1	1.3	1.6	1.2	2.0	1.4 ± 0.58

given in the Clopper and Pearson Charts for the 95% confidence interval (Steel and Torrie 1960).

Variation in nest and hatching success with clutch size is also given in Table VII. Nests containing 2 eggs were the least successful. Clutches of 3, 4, 5 and 6 eggs showed about equal success, because of the relatively large standard deviations. The complete success of the larger clutches (7, 9, 10 eggs) has little meaning because of the small sample size. Similar results were calculated for hatching success in relation to clutch size. The smallest clutches of 2 eggs had the lowest egg success and the most common clutches (3, 4 and 5 eggs) had about equal success. The hatching success in 6+ egg clutches is again difficult to interpret because of sample size. Table VIII compares the average number of eggs hatched per nest in relation to clutch size. More eggs tended to be hatched per nest as the clutch size increased. However, when the frequency of each clutch size is considered, the modal number of eggs per nest (4) hatched more eggs than any other clutch size. As a result, about 40% of the total number of goslings came from females which laid four eggs. The significance of the preponderance of 4-egg clutches has yet to be demonstrated. In geese fledging periods are not well documented and no long term studies have shown which clutch size produces the greatest number of young surviving to breeding age.

Egg loss

The fate of all unhatched eggs in marked nests is recorded in Table IX. In most cases it was not possible to differentiate between eggs which had disappeared and ones which had been destroyed by a specific avian predator. Gulls (Glaucous and Herring) typically carry an egg from a nest and eat it away from the colony. When a gull destroys an egg at the nest site, a large hole is usually left and the contents are gone. Jaegers (Skuas) *Stercorarius* spp. leave a much smaller hole

Table IX. Fate of 124 unhatched Lesser Snow Goose eggs in marked nests at Karrak Lake, 1968.

Fate	*Number*	*% of total*
Disappeared	91	73.4
Destroyed	16	12.9
Broken in nest	8	6.5
No embryo	4	3.2
Out of nest	4	3.2
Hole in egg	1	0.80

Table VII. Nest and hatching success of Lesser Snow Goose in relation to clutch size, 1968.

Clutch size	*Nest success* %	*Hatching success* %
2	33.3 (3)	33.3 ± 27.2 (6)
3	85.7 ± 7.6 (21)	77.8 ± 5.2 (63)
4	86.5 ± 5.6 (37)	74.3 ± 3.5 (148)
5	95.0 ± 4.9 (20)	71.0 ± 4.5 (100)
6	80.0 ± 12.6 (10)	50.0 ± 6.4 (60)
7	100.0 (1)	85.7 ± 13.2 (7)
8	—	—
9	100.0 (1)	55.5 ± 16.6 (9)
10	100.0 (1)	60.0 ± 15.5 (10)
	86.2 ± 3.5 (94)	69.2 ± 2.2 (403)

Table VIII. Average and total number of eggs hatched in relation to clutch size in Lesser Snow Goose nests, Karrak Lake, 1968.

Clutch size	*Average no. eggs hatched per nest*	*Total no. of eggs hatched*	*% of total eggs hatched*
2	0.67 (3)*	2	0.70
3	2.3 (21)	49	17.6
4	3.0 (37)	110	39.4
5	3.6 (20)	71	25.4
6	3.0 (10)	30	10.7
7	6.0 (1)	6	2.2
8	—	—	—
9	5.0 (1)	5	1.8
10	6.0 (1)	6	2.2

* Total sample size

and do not normally carry eggs from the nest site. As shown in Table IX, most unhatched eggs either disappeared or were destroyed by gulls. In only one case was predation by Jaegers definitely identified. The brooding females were generally the cause of eggs being broken in the nest or found outside. I have seen incubating geese break eggs when startled from the nest, treading on them or pushing them out in their efforts to take flight as fast as possible. Egg fertility was high, as only four of 124 eggs showed no embryo development. Cooch (1958) found that infertile, crumpled and rolled out eggs seldom exceeded 1% of the total loss of Blue Goose eggs.

Colour ratios

The little information I have on colour-phase ratios was collected during post-nesting ringing operations. In 1966, 1967 and 1968 a total of 380 Lesser Snow and 20 Blue Geese were banded on the Perry and Simpson Rivers (Figure 1). Although the sample size is small, the observed proportion, 5% blue-phase geese, is much less than the 22% blue-phase predicted by Cooch (1963) for the Perry River (east) region in 1970. Kerbes (1969) found a similar difference from Cooch's prediction of 88% blue-phase geese for Baffin Island in 1970. From a ringed sample of 7,361 Lesser Snow and Blue Geese, Kerbes reported 76% blue-phase geese. He postulated that the departure of present blue-phase frequencies on his study area from the predictions of Cooch may have resulted from a reversal of the warming trend in the Arctic climate. Cooch (1961, 1963) reported that the blue-phase was more successful than the white-phase except in extremely retarded seasons. If the present cooling trend in the Arctic is sufficient to affect the breeding biology of the two colour phases of *A. c. caerulescens*, it is conceivable that white-phase geese are more successful than blue-phase birds at present, thus decreasing the proportion of the latter in the total population.

Discussion

Relative to the findings of Gavin (1947) and Hanson *et al.* (1956), our aerial surveys in central Arctic Canada revealed a definite increase in the numbers of Lesser Snow Geese in the last 20 years. Based on the characteristics of occupied colony sites, there were many unused islands potentially suitable for nesting geese. Unless mortality on other parts of the species' range is limiting their numbers, I expect a continued increase in the population. In view of this, it is of considerable importance that studies of the Lesser Snow and Blue Goose be undertaken in the central Arctic, particularly in regards to their nesting relationships with Ross's Geese. Although the larger Lesser Snow and Blue Geese were not displacing Ross's Geese at Arlone Lake (Ryder 1967), studies are required to confirm this from other locations. Nests of Ross's and Lesser Snow Geese were interspersed at 18 of 23 (78%) of the nesting colonies in the aerial surveys of 1965 and 1967 (Ryder 1969a). The significance of this relationship, especially in view of the limited numbers and restricted nesting distribution of Ross's Geese would be a most fruitful line of research. Wynne-Edwards (1962) summarizes the need for investigating this type of sympatric relationship, 'There is nothing novel to the ecologist in the finding that related species compete with one another for resources and affect each other's success: what needs to be carefully noted is that in habitats where one does not completely dominate and eliminate the other but where both can live side by side more or less precariously balanced, selection appears to favour their incorporation into a single social dispersionary unit, in which they compete together for the same conventional possessions.'

Acknowledgements

I would like to thank the Canadian Wildlife Service for financial support of this and related research.

Summary

Distribution and aspects of the nesting biology of the Lesser Snow Goose *Anser caerulescens caerulescens* in central Arctic Canada are reported. Aerial surveys in 1965, 1966 and 1967 revealed 30 previously unrecorded nesting colonies. The total estimated nesting population in 1965 and 1967 was 8,299 Lesser Snow Geese. All the colonies were located on islands in shallow tundra lakes in the once inundated central lowland portion of the Arctic. It is suggested that food availability may be an important factor limiting goose distribution.

Nesting studies at Karrak Lake (67° 15′ N., 100° 15′ W.) in 1966, 1967 and 1968 showed that the geese arrived in late May or early June and that nesting started about a week later. Clutch sizes in the three years were 4.2, 4.0 and 4.3 eggs. Data from 94 marked nests in 1968 showed that, on the average, successive eggs are laid every 1.3 days. Generally two or three eggs were laid then a day missed before completion. Incubation periods averaged 22.4

days, with a mode at 23 days. Incubation periods tended to decrease with increased clutch size. Over 60% of the marked clutches took less than a day to hatch. There was no relation between clutch size at hatching and the time taken to hatch. Nest and egg success was 86% and 69% respectively. About 40% of the goslings hatched from four-egg clutches. Most egg loss resulted from gull predation. Colour ratios suggest that the blue-phase frequency (5% of 400 ringed geese) is lower than predicted (22%) from earlier studies in the central Arctic. Similar results in Baffin Island may reflect a general cooling trend in the Arctic.

In view of an expected continued increase in nesting Lesser Snow Geese in the central Arctic and the importance of the area as the major nesting grounds of the relatively scarce Ross's Goose *Anser rossii*, studies are needed to determine the relationship between the two species during the nesting season.

References

BARRY, T. W. 1961. Waterfowl reconnaissance in the western Arctic. *Arctic Circ.* 13 : 51-58.

BARRY, T. W. 1962. Effect of late seasons on Atlantic Brant reproduction. *J. Wildl. Mgmt.* 26 : 19-26.

BARRY, T. W. 1967. The geese of the Anderson River Delta, N.W.T. Unpub. Ph.D. Thesis, Univ. of Alberta, Edmonton.

BIRD, J. B. 1967. *The physiography of Arctic Canada.* Baltimore: John Hopkins Press.

BRAKHAGE, G. K. 1965. Biology and behaviour of tub-nesting Canada Geese. *J. Wildl. Mgmt.* 29 : 751-71.

COOCH, F. G. 1958. The breeding biology and management of the Blue Goose (*Chen caerulescens*). Unpub. Ph.D. Thesis, Cornell Univ., Ithaca, New York.

COOCH, F. G. 1961. Ecological aspects of the Blue-Snow Goose complex. *Auk* 78 : 72-89.

COOCH, F. G. 1963. Recent changes in distribution of color phases of *Chen c. caerulescens. Proc. Int. Orn. Congr.* 13 : 1182-94.

DELACOUR, J. 1964. *The Waterfowl of the World*, Vol. 4. London: Country Life.

DEMENTIEV, G. P., N. A. GLADKOV *et al.* 1952. *Birds of the Soviet Union*, Vol. IV. Transl. by Israel Program for Scientific Translations, 1967.

GAVIN, A. 1947. Birds of the Perry River district, Northwest Territories. *Wilson Bull.* 59 : 195-203.

HANSON, H. C. and R. H. SMITH. 1950. Canada Geese of the Mississippi Flyway with special references to an Illinois flock. *Bull. Illinois Nat. Hist. Surv.* 25 : 67-210.

HANSON, H. C., P. QUENEAU and P. SCOTT. 1956. The geography, birds and mammals of the Perry River region. *Arctic Inst. N. Amer.*, Spec. Publ. No. 3: 96 pp.

HILDEN, O. 1964. Ecology of duck populations in the island group of Valassaaret, Gulf of Bothnia. *Ann. Zool. Fenn.* 1 : 153-279.

HORNBY, G. 1967. A biological bonanza—Karrak Lake. *North* 14 : 2-6.

KERBES, R. H. 1969. Biology and distribution of nesting Blue Geese on Koukdjuak Plain, N.W.T. Unpub. M.Sc. Thesis, Univ. of Western Ontario, London, Ont.

KLOPMAN, R. B. 1958. The nesting of Canada Geese at Dog Lake, Manitoba. *Wilson Bull.* 70 : 168-83.

KOSSACK, C. W. 1950. Breeding habits of Canada Geese under refuge conditions. *Amer. Mid. Nat.* 43 : 627-49.

LEMIEUX, L. 1959. The breeding biology of the Greater Snow Goose on Bylot Island, Northwest Territories. *Canadian Field-Naturalist* 73 : 117-28.

MACINNES, C. D. 1962. Nesting of small Canada Geese near Eskimo Point, Northwest Territories. *J. Wildl. Mgmt.* 26 : 247-56.

MACINNES, C. D. 1966. Population behaviour of eastern Arctic Canada Geese. *J. Wildl. Mgmt.* 30 : 536-53.

NELSON, J. B. 1966. The breeding biology of the Gannet *Sula bassana* on the Bass Rock, Scotland. *Ibis* 108 : 584-626.

NORDERHAUG, M., M. A. OGILVIE and R. J. F. TAYLOR. 1964. Breeding success of geese in West Spitsbergen. *Wildfowl Trust Ann. Rep.* 16 : 106-110.

RYDER, J. P. 1967. The breeding biology of Ross's Goose in the Perry River region, Northwest Territories. *Canadian Wildl. Serv. Rep.* No. 3 : 56 pp.

RYDER, J. P. 1969a. Nesting colonies of Ross's Goose. *Auk* 86 : 282-92.

RYDER, J. P. 1969b. Timing and spacing of nests and breeding biology of Ross's Goose. Unpub. Ph.D. Thesis, Univ. Saskatchewan, Saskatoon.

RYDER, J. P. 1970. A possible factor in the evolution of clutch size in Ross's Goose. *Wilson Bull.* 82 : 5-13.

SOWLS, L. K. 1949. A preliminary report on re-nesting in waterfowl. *Trans. N. Amer. Wildl. Conf.* 14 : 260-75.

STEEL, R. G. D. and J. H. TORRIE. 1960. *Principles and procedures of statistics.* London: McGraw Hill.

USPENSKI, S. M. 1965. The geese of Wrangel Island. *Wildfowl Trust Ann. Rep.* 16 : 126-9.

WYNNE-EDWARDS, V. C. 1962. *Animal dispersion in relation to social behaviour.* Edinburgh: Oliver and Boyd.

Dr. J. P. Ryder, Department of Biology, Lakehead University, Thunder Bay "P", Ontario, Canada.