BREEDING BIOLOGY OF THE SOUTHERN BLACK-BACKED GULL I: PRE-EGG AND EGG STAGE

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ABSTRACT

It is shown that for the 1961-62 season, the number of adults at the breeding colony on Somes Island, Wellington Harbour, began to increase in July 1961, and that nest building commenced about the same time. Pair-forming behaviour is described and some evidence is produced which indicates that established pairs probably re-form before winter, and some pairs do not effectively part at all after breeding. The male builds the nest practically alone, most activity occurring in the late afternoon. The nest is made of whatever material is handy and plentiful, and preferred nest sites include bare rock or soil, and amongst long grass and rushes. No strange gulls or other vertebrates are tolerated near the nest. Maximum and minimum nesting densities were respectively 109 and 65 nests/acre; average nesting density was 84 nests/acre. Laying started 18th October and continued for 99 days until 24th January. Peak laying occurred in the second week of November. The laying of two- and three-egg clutches was spread over two to eight, and four to nine days respectively. The average clutch size was 2.3 eggs, and the number of one- and two-egg clutches increased as the season progressed. Weights, measurements and colours of eggs have been described and renesting occurrences summarised.

INTRODUCTION

This paper is an account of the breeding cycle of the Southern Black-backed Gull *(Larus dominicanus)* recorded during the 1961-62 breeding season on Somes Island in Wellington Harbour, and includes descriptions of the arrival of breeding birds at the colony, nest building and the egg stage. (In a second paper on the breeding cycle (Fordham, 1964) there are descriptions of incubation and the chick stage, the breeding success of the colony is outlined, and mention is made of breeding adult mortality and the behaviour of non-breeding birds.) The colony on Somes Island was chosen for the study because of its size (more than 1400 pairs) and because the island is closed to unauthorised persons in its capacity as the New Zealand Stock Quarantine Station, so the birds are not often disturbed by people. Also there are no mammalian predators present, except probably one feral cat.

No detailed work has been published on the breeding biology of the Southern Black-back up to the present time, but general accounts have been supplied by Stead (1932), Falla (1937), Wilkinson (1952) and Oliver (1955). The remainder of the literature exists in brief notes mainly appearing in "Notornis." Calls and postures that are mentioned have been defined in an earlier paper (Fordham, 1963). On the first occasion in which an animal or plant is introduced into the text, the accepted common name (if in existence) as well as the scientific name is given, but on subsequent occasions, except where ambiguity may arise, only the common name is used. In addition the word "gull" refers to the Southern Black-back unless otherwise stated.

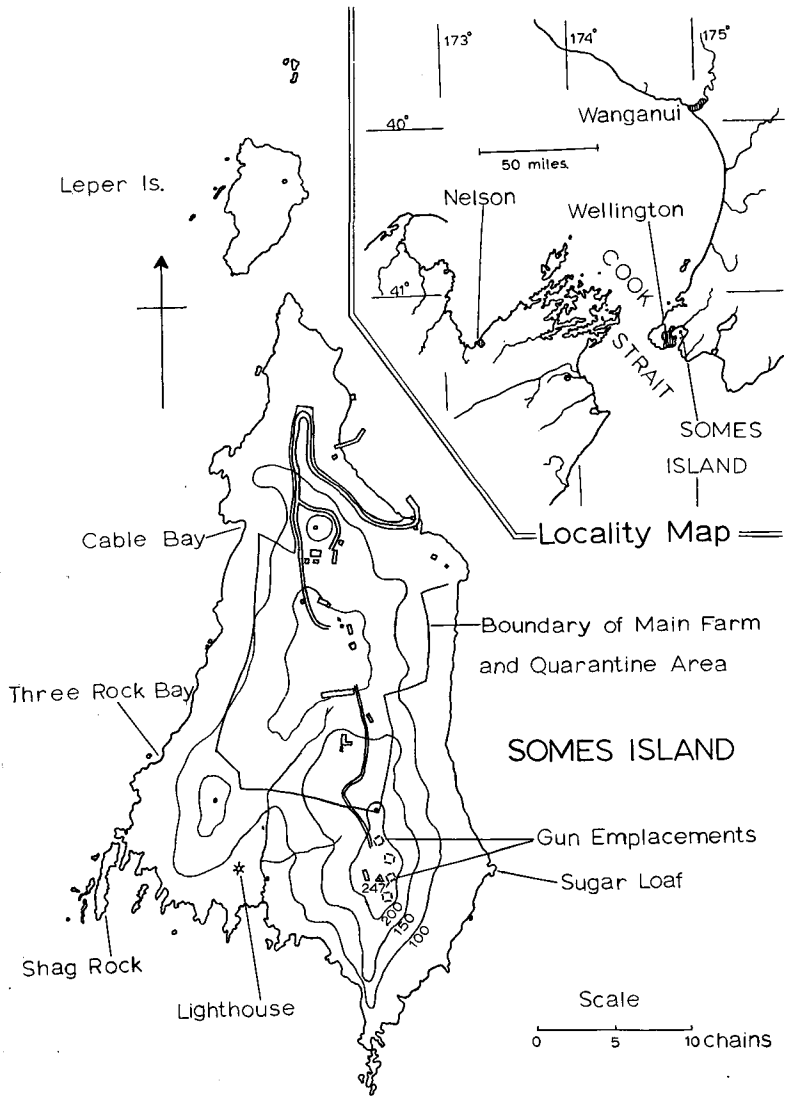


Fig. 1 — Locality map of Somes Island

SOMES ISLAND AND THE COLONY

Somes Island is an approximately pendant-shaped mass of weathered greywacke with an area of a little over 61 acres (see Fig. 1). It is roughly two-thirds of a mile long, has a maximum width of one-third of a mile, and rises 247 feet in height. Cliffs averaging 50 feet in height, but reaching 100 feet in some areas of the south end, exist on the north, south and west sides, and steep grassy slopes form the east side of the island. The cliffs and slopes arise from rocky beaches and pass into more gently graded upper slopes. The uplift caused by the 1855 Wellington earthquake has formed many beach terraces, off-shore peninsulas and islets, while numerous caves have appeared and now dissect the coast line. The N.W.-S.E. strike of the greywacke strata has encouraged the formation of many small bays. The soil layer over the bed-rock is pebbly, crumbles readily, and is usually about one foot in depth. In several exposed areas, especially on the south and west slopes, all soil has eroded away to leave bare rock. One small stream which drains the island at the southern end flows strongly after rain, but is reduced to a trickle during summer. Various other seepages exist, mainly at the north and south ends at the bases of cliffs and slopes.

Maori shell-middens are visible in several places and Best (1918) records the presence of bird bones (which may have been those of gulls) as well as fish bones and shells, possibly deposited between 1825 and 1840. Southern Black-backed Gulls were a food item of the early Maori, and their bones have been recorded in Maori middens elsewhere in New Zealand e.g. Smart *et al.* (1962). The house belonging to the Stock Quarantine Officer, and various buildings concerned with the quarantine animals, stand more or less together on the central flat area of the island. At the south end is an automatic flashing lighthouse. Seventy-five yards off the northern tip lies the much smaller Leper Island, which is a bird sanctuary, and the site of a small roosting and breeding colony of gulls.

The climate of the island is basically mild, but is modified by exposure. West to N.W. winds prevail, and relatively frequent gales strike from the N.W. and the south. Few places are sheltered from the wind, and salt spray flies over parts during storms. During the 1961-62 breeding season the birds experienced a fairly typical Wellington summer. The usual unsettled equinoctial weather gave cool, sometimes cold and rainy days from late October to nearly mid November, but the distribution of laying was unaffected, since peak laying occurred during that time. Most of the island is under sown pasture, and much of the land is fenced off into paddocks. Rows of *Pinus* sp.,*Cupressus macrocarpa,* taupata *Coprosma repens,* karo *Pittosporum crassifolium* and *Olearia paniculata* form shelter belts for some exposed paddocks. In the inter-tidal zone *Ulva* and *Hormosira banksii* are present, and these species plus portions of *Carpophyllum maschalocarpum* and *Macrocystis pyrifera* cast ashore during storms, are used by some gulls in nest building. On beach terraces the dominant plants are sand poppy *Glaucium flavum, Salicornia australis,* rushes *Scirpus nodosus, Carex* spp., flax *Phormium colensoi* and toe-toe *Arundo conspicua,* while *Muehlenbeckia complexa,* flax and rushes are prominent on the coastal

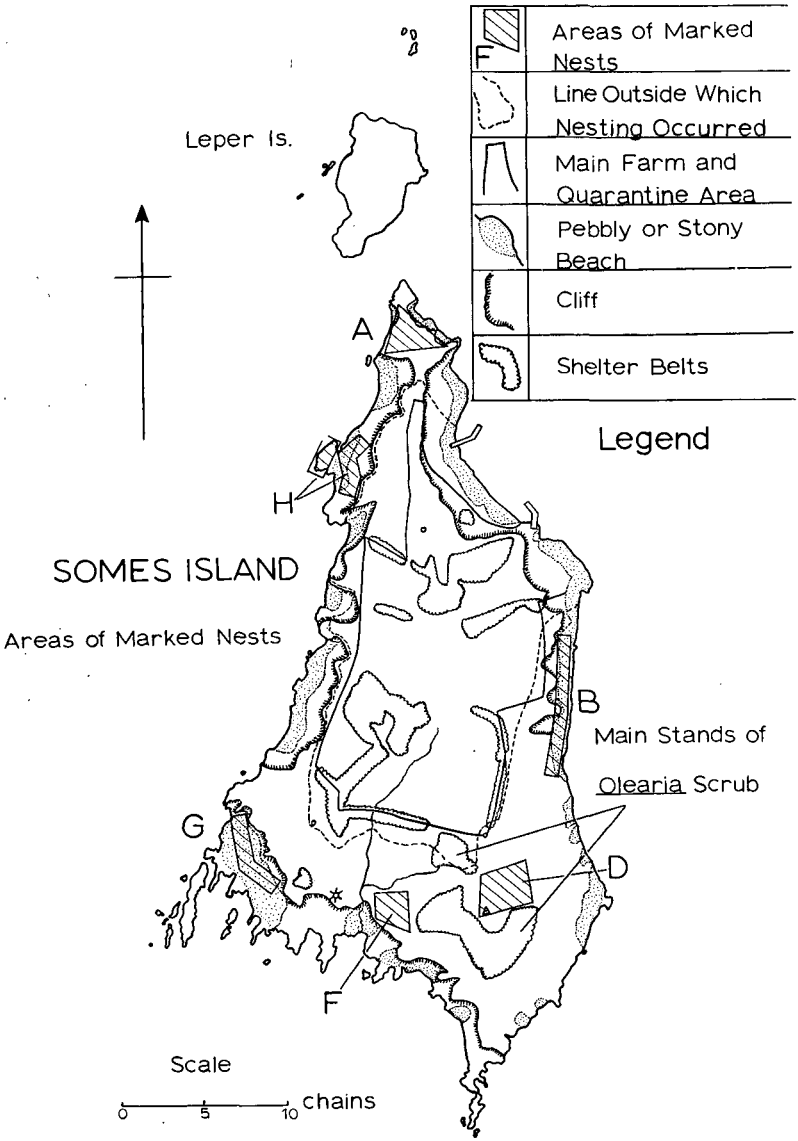


Fig. 2 — Somes Island — areas of marked nests.

cliffs and slopes. The main cover on the upper slopes is provided by tauhinu *Cassinia leptophylla,* horehound *Marrubium vulgare,* rushes and *Muehlenbeckia.* A stand of *Olearia* together with some ngaio *Myoporum laetum* and pohutukawa *Metrosiderous perforata* forms a wide belt of scrub up to 12 feet in height extending round the top of the island.

Apart from sheep which roam the island the gulls come into contact with very few vertebrates other than birds. The frog *Hyla aurea,* skinks *Leiolopisma zelandica,* geckos *Hoplodactylus pacificus* and Field Mice *Mus musculus* are present, and Elephant Seals *Mirounga leonina* pay occasional visits. Northern Blue Penguin *Eudyptula minor* and various passerines breed on the island, while many Red-billed Gulls *L. scopulinus* and Starlings *Sturnus vulgaris* roost there during the non-breeding season.

METHODS OF STUDY

Throughout the breeding season, i.e. between 16th October 1961 and 17th January 1962, the author lived on Somes Island. Thereafter visits of several days' duration were made at about weekly intervals up to 17th March, after which time short visits were made once a month until June. Following a preliminary survey of the island during numerous trips before the breeding season, six areas were pegged out (Fig. 2) which, though varying in size because of the topography, gave a thorough sample of the colony with respect to nesting density, aspect, slope, altitude and vegetative cover. The high tide mark was taken as one boundary for beach areas. The areas were patrolled daily, new nests being marked with a numbered peg and subsequently plotted on a map of the area. No nest was marked until it contained an egg, since a number of nests are built, but never laid in. As each egg was laid in a nest it was numbered with lime-yellow BALM DUCO paint which dried instantly but did not wear off. Marking ink was also tried, but found to be unsatisfactory, as it quickly rubbed off. Complete records were kept of the 328 nests so marked. Two hides were erected; one for the observation of an entire marked area and the "club" (the group of non-breeding adults), and another for the close study of the behaviour of a smaller number of pairs. Specimens of breeding, non-breeding and juvenile birds were captured under special permit at fortnightly intervals for measurement, and to provide data on food, plumage, and gonad development. Numerous birds dead or dying from natural causes were collected for similar purposes, and specimens of chicks were taken at about weekly intervals for growth studies. Two breeding birds were trapped on the nest to test the durability of a pigment stain, and 574 chicks were colour-banded in continuation of a banding programme started in the winter of 1961.

A count of the total number of nests on the island and off-shore peninsulas was made in early January (i.e. towards the end of the breeding season). By dividing the whole island into small sections, it was possible to count almost every nest that either had been used, or was well formed and unused. The result of this census was 1,419 nests, which indicates that probably no more than 1,450 breeding pairs made up the colony during the 1961-62 season. Distribution of the nests is shown in Fig. 3b.

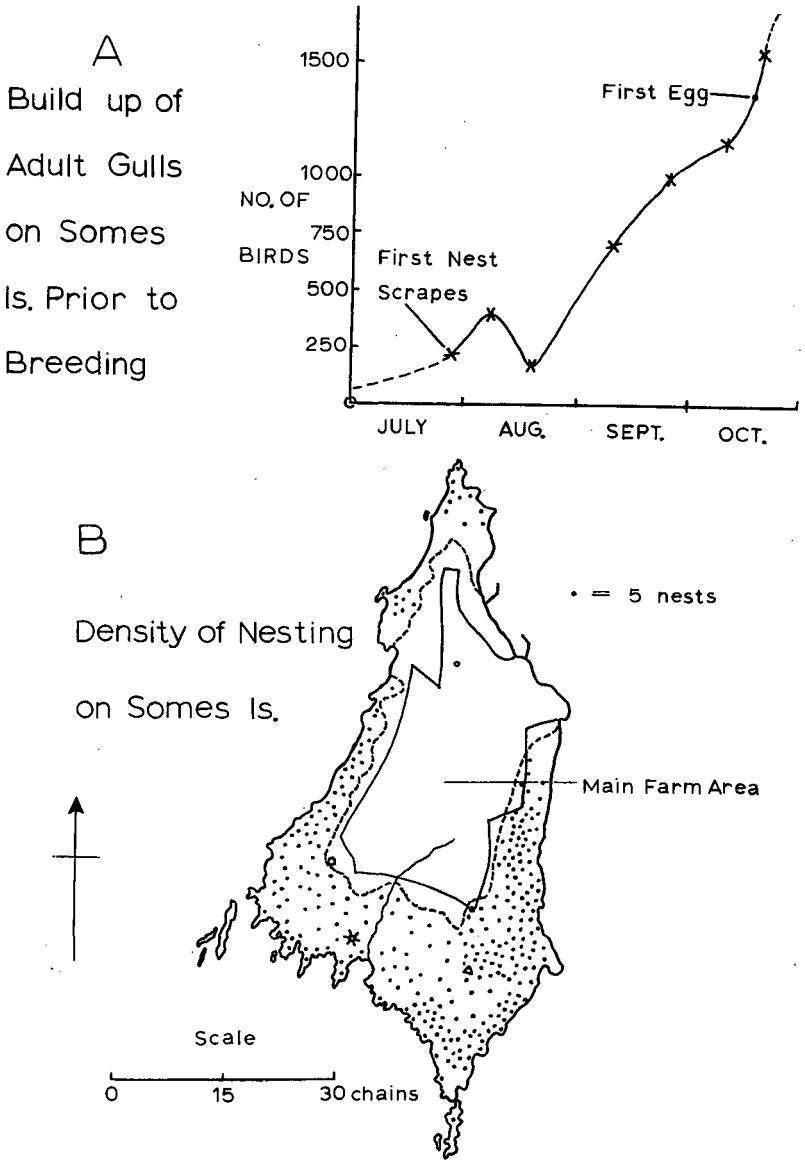


Fig. 3 — (a) Build up of adults prior to breeding
(b) Density of nesting on Somes Island

PRE-EGG STAGE

Arrival at the Colony

The number of adult birds present on or around Somes Island during the day steadily increased over the months before the start of laying (Fig. 3a). A clear distinction was made between adults present during the whole day, and juvenile and non-breeding birds which arrive from late afternoon onwards to roost for the night. Before July few adults were present, but by the end of July the first build-up in numbers was noted, and the first nest-scrapes were found. Nest-scrapes are partly shaped bowls in the earth or grass, which usually contain nest material, but do not always indicate the site of the final nest. It was noticeable at this stage that adult birds occupying a certain area on the island during the day did not always roost in that place at night. This remained true for birds with almost completed nests, but no eggs, after laying had begun in the colony. Following the initial formation of scrapes, there was a lull, in both general activity and numbers of adults present at the island, until late August and early September when steadily increasing numbers of scrapes and re-excavated old nests were found.

In other New Zealand colonies the numbers of adult birds present begin to rise appreciably at least one or two months before laying commences. Stead (1932) mentions that gulls take up their positions on the nesting grounds in Canterbury at the beginning of September, and Mr. C. P. Gallop told the author that gulls had begun to congregate at the Baring Head colony, east of Wellington Harbour mouth, by the middle of August. Also an adult gull banded by the author on Somes Island was recovered in the Wairau River, Marlborough, near a breeding colony on the 25th September. Presumably this gull had been making its way to the colony for the breeding season. With regard to colonies outside New Zealand, Murphy (1936) states that nest building at South Georgia had started in October, and at the South Orkneys gulls had arrived in numbers by the end of September, the first eggs being laid on November 15th. This is a month later than the start of laying at Somes Island, and is explainable by the fact that birds in higher latitudes usually start breeding later in the season than those in lower latitudes (Lack, 1954).

By early October nest building was advanced and some gulls were sitting on nests. Up until late September any disturbance in the colony had caused the adults to fly out and sit on the water where they could be counted, but by early October, a week before laying began, a number of adults would, after being disturbed, remain circling overhead giving the alarm call and return to their places a few minutes later. As laying progressed, fewer and fewer birds would abandon their nesting areas when disturbed; instead, they would remain wheeling overhead; so that by late October it became impossible to estimate the numbers present.

Pair Formation and Territory Establishment

This can be separated into two types: the re-formation of established pairs, and the formation of new pairs. There is abundant evidence that in the Herring Gull *(L. argentatus)* individuals are monogamous (Paludan, 1951; Tinbergen, 1953) and it is reasonable to assume that this is also the case in the closely related Southern Black-backed Gull. Tinbergen (1953) considered that for the Herring Gull established

pairs separated in autumn and recombined in spring. While there is formation of loose flocks of Southern Black-backs of all ages after breeding (i.e. from February onwards), bond-forming displays such as head-tossing, mewing and choking can be seen between pairs of gulls in a flock from at least April onwards. During regular trips round Wellington Harbour the author continually noted pairs of adults standing apart from the flock (and head-tossing) from June onwards, i.e. winter. By July pairs were beginning to arrive at Somes Island, and the first (unsuccessful) copulation was seen on 22nd September. On Somes Island a pair of banded adults was consistently found roosting together in the same place from 9th June onwards, and during winter several other pairs were caught at night, roosting apart from other birds. While it is realised that the exhibition of breeding behaviour early in the year need not indicate a cemented pair-bond, these data suggest that if established pairs do break up after breeding many are probably reformed before winter. Moreover it seems probable that many pairs do not effectively part at all.

Formation of new pairs is less obvious but in most cases must occur during the time that the number of birds is building up at the colony before breeding. The main resting place at the colony for non-mated adults and a very few immature gulls was found to be the grassy slopes by the lighthouse at the southern end of the island. This group and area is equivalent to the area in Herring Gull colonies named the "neutral area" by Darling (1938), "where any or all the birds sit amicably within a few inches of each other"; and the "club" by Tinbergen (1953), which is the group of (as yet) non-breeding birds, and also the ground they occupy. The "club" grows in numbers before breeding starts and is the place where pair formation can be most readily seen.

The complete series of postures which lead to copulation and which are associated with cementing the bond between the new pair may be seen only during the early stages of the pair's association, since shortened displays become more common as the season progresses. When one member of a new pair lands beside the other or when both birds fly in and land together they may immediately break into the long call and/or assume the upright posture quickly followed by the face-away attitude. Both birds then face the front and begin to mew while walking together. The male appears to direct his walking to some particular spot, i.e. he seems to take the lead in choosing an area which then becomes the site of vigorous, sometimes prolonged choking. Following choking there may be a slight pause, but sooner or later the female begins head-tossing, which becomes more intense if the male responds by head-tossing. This activity culminates in copulation. If the male does not begin head-tossing in response to the female, or if he begins head-tossing and then stops, the activity usually results in the female being fed by the male. Probably the best explanation of such cases is that the threshold of intensity necessary to bring about copulation is not reached. Pair-forming displays as outlined rarely if ever evoke interest from neighbouring birds. The sequence of postures leading to copulation is then: long call, upright, face-away, mew call, choking, head-tossing, copulation. Tinbergen (1960 a) has described the series of displays involved in the formation of pairs in the Herring Gull. This sequence is: long call, mew call, choking, face-away, and is similar for

all the large gulls so far as is known (Tinbergen 1960 b). The only difference between the two sequences is that in the Southern Black-back the face-away attitude is usually assumed before mewing and choking, not after. Variation in pair-formation displays can be intraspecific as well as inter-specific since Moynihan (1958) states that pair-forming displays in the N. American Herring Gull tend to be somewhat different from those of the European Herring Gull.

Once pairs are established they eventually settle into an area and take up territories. It is not known for certain if both members of the pair choose the territory together, but it seems likely that the male takes the lead at least in choice of the actual nest-site. To begin with nests are scattered and the territories are large in size. However, as more pairs arrive in an area the gulls are forced to withdraw their boundaries until eventually they have a minimum territory at the height of the breeding season. The minimum territory size varies with the aggressiveness of each male. From observations over a period of weeks the boundaries of several territories were progressively marked out and it was possible to discover the approximate area of three territories which happened to be in line. They were respectively 28, 33 and 154 square yards in extent. Tinbergen (1952) mentions that, after mating, a Herring Gull pair selects a territory and from then on fights almost exclusively in defence of this territory. Further, Tinbergen (1953) states that each gull has a tendency to claim a territory about 30 - 50 yards in diameter. Territories of such size are far larger than those of Southern Black-backed Gulls and must have been part of a widespread colony. Nesting densities in the marked areas varied greatly, so that some pairs which nested far away from most other birds held territories larger than those measured, but the vast majority of pairs did not hold territories smaller than 28 square yards. Nesting densities will be discussed in more detail later.

Defence of the Territory

Noble (1939) defined territory as "any defended area." At the beginning of the season the territory comprises the nest and surroundings, but shortly after the eggs hatch the nest loses its significance as the centre of territory and it is only the chicks that are defended. Defence of the nesting area and defence of the brood involve largely the same actions, but they differ basically in that quite different circumstances arise from the defence of wandering chicks as opposed to the static nest and eggs. Defence of the brood will be described in the section dealing with chicks (see Fordham, 1964). There are two types of territorial defence — intra-specific and inter-specific.

1. *Intra-specific.* Male birds repeatedly spar with their neighbours. This sparring ranges from the adoption of aggressive postures such as choking or grass pulling, to actual combat involving pecking and wing blows delivered by the region of the junction of the brachium and ante-brachium. Sparring between owners of long-established neighbouring territories occurs less frequently as the season advances and most attacks are directed against strange gulls. Yet strange gulls are not often involved in a fight because, provided they see the territory owner behaving aggressively and starting to charge, they are usually able to escape in time. Such birds may, however, be chased in flight for up to 100 yards. Usually strange gulls, both young and old, are very

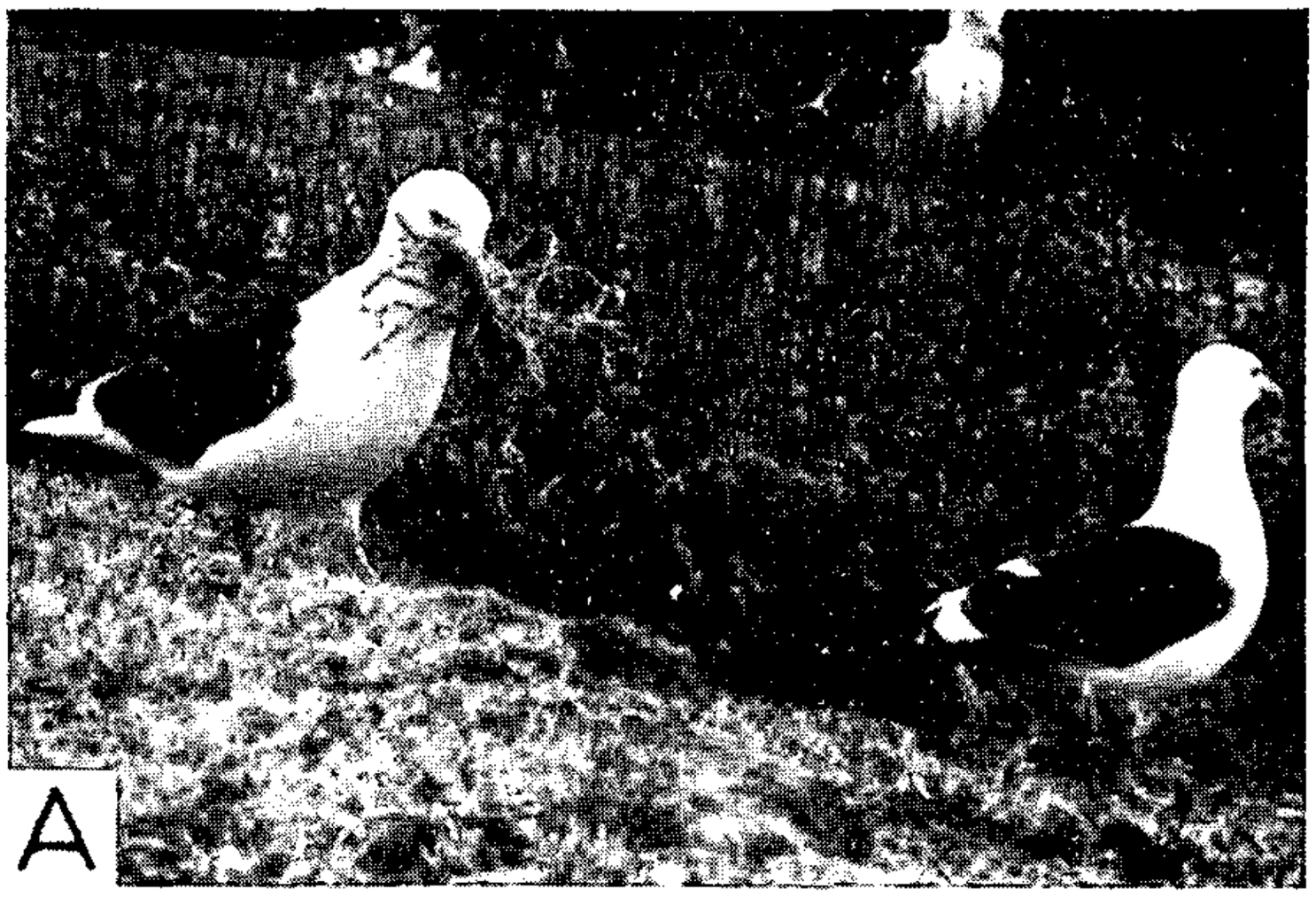
wary when they land in a group of incubating gulls, and start at the slightest display of aggression. But some walk slowly among the nests inspecting them carefully, and on occasions approach very close to sitting birds whose mates are absent. It is likely that these gulls are searching for stray eggs, or chicks incompletely covered by the sitting birds, who rapidly become intolerant of the strangers near them.

When breeding gulls are disturbed by the presence of a human they wheel and hover overhead and repeatedly attack one another. Some of these attacks are between neighbouring gulls and are thus part of intra-specific territorial defence. If one gull dives at another in the air the attacking bird does not give the charge call, which is used only inter-specifically. Detailed descriptions of aerial hostile behaviour in six species of N. American gulls have been given by Moynihan (1956). He considers the range of such behaviour probably to be essentially similar in all gulls, but recognises that different species have different patterns of display.

If a territory is deserted for some reason, neighbouring gulls very soon occupy it. The following observation illustrates how completely the nest loses importance after eggs or small chicks have been destroyed. Four days after a single six-day-old chick disappeared from nest 313, the male bird was observed sitting three feet from the nest. A second-year bird (non-breeding) approached, stepped on to the edge of the nest and looked steadily into it two or three times. It then moved to the opposite side and repeated the action. After about three minutes male 313 walked slowly to the nest and looked in while the second year bird moved away. Four days previously male 313 would not have tolerated a strange bird in his territory, let alone *in* the nest.

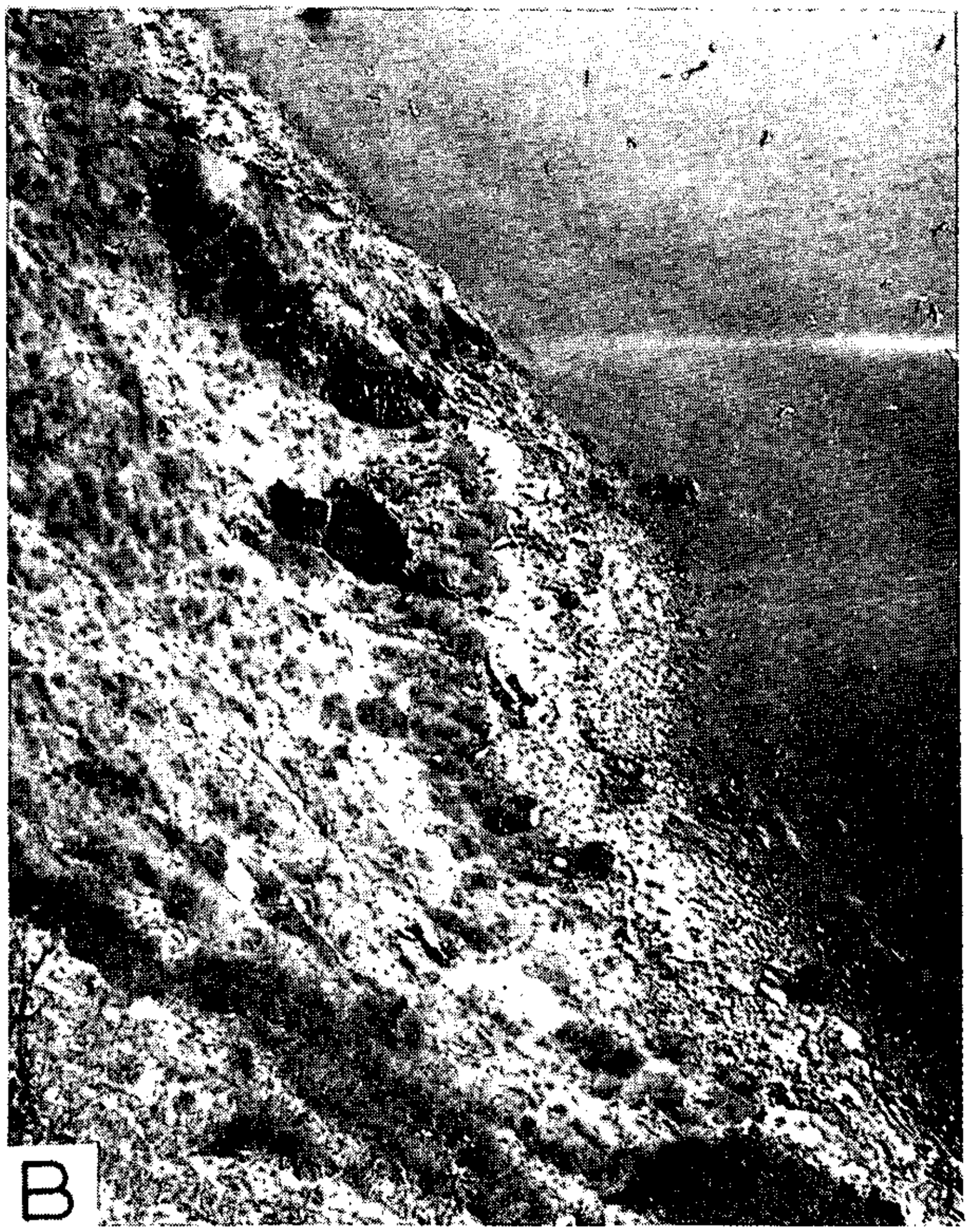
2. *Inter-specific.* Methods of defence against predators other than gulls are varied. The gulls will always circle close overhead giving the alarm call and sometimes swoop down on the intruder giving the charge call. In general the charge call is not given by a bird until incubation is well advanced. Some birds never dive at an intruder but merely hover overhead giving the anxiety call. When swooping, one or both feet may be lowered so that the intruder may be struck with the feet as well as the beak or a wing. A blow from the beak is often sufficient to break the skin of the human scalp. The appearance of a predator in the flock will put all birds to flight and bring a light rain of faeces from those circling above. These discharges appear at first sight to be unintentional, but some birds will fly low down and from close range defecate directly on the intruder. Other unpleasant defensive actions include the occasional dropping on the intruder of food from the crop, as well as stones or bits of earth. Diving attacks at a predator constitute defence by the individual, but social attacks by a group of adults do occur when, for instance, a Harrier *(C. approximans)* is driven off.

No birds are tolerated near the nest and animals such as sheep are driven away. An extraordinary happening between a Blackbird *(T. merula)* and a gull was observed on Somes Island by Mr. R. Mander, and is to the author's knowledge the first account of a small bird showing aggression towards a Southern Black-back. The gull was sitting on a nest under trees, and a Blackbird was seen making repeated runs at it. The gull half rose each time to repulse the "attack," but did not itself attack the Blackbird. When sheep have approached too close to a nest or chicks, gulls have been observed to adopt the grass-pulling



I (a) —

Male bringing a large load of material to the nest site.



I (b) —

Steep slopes above area B. Nesting was dense on these slopes.

threat posture, before attacking in the manner usually adopted against a predator. The sheep's habit of cropping grass and raising its head may have been interpreted as grass-pulling by the gull. A case of lack of aggression towards a potentially dangerous predator was provided by the reaction of the gulls to the sheep dogs on the island which had been trained not to touch gulls, their eggs, or chicks. On one occasion a dog walked through part of the colony where chicks were running, whereupon the adults showed some concern but did not join in a social attack on the dog, as is described by Tinbergen (1953) in Herring Gulls.

Nest Building

In the early stages of nest building the male collects beakfuls of nest material from various places, carries them to the female mewing as he does so, and together they move to some place where, with vigorous choking, the material is strewn around. The next load he brings may be dropped somewhere else close by, but eventually over a period of days or weeks one spot begins to receive all the material, and this is the site of the final nest. The other places which may have received some material early in the season may be partially formed into nests in the way described below and are called scrapes. In one scrape more than a pound weight of fresh grass plants was used to form the bowl. While the female does bring occasional loads of material to the nest, the male builds the nest practically alone. During a bout of vigorous nest-building activity he hurries around collecting load after load of material while the female makes little or no contribution (Plate I A). In general the birds select the nearest available material, so that pairs nesting on beaches usually have nests made of seaweed, sticks, occasional mollusc shells and debris from the sea, while nests on the slopes of the island are made of grass, sticks, leaves, fresh shoots of herbaceous plants such as horehound, or succulents, as well as bits of wool, feathers and old bones. However nests have been found composed almost entirely of one material such as pine needles or moss, far away from the nearest supply of pine needles and moss. One nest in a bare rocky outcrop near the sea was formed largely from sprigs of cut tauhinu up to 15 inches in length, which must htve been carried in flight for about 50 yards. Other birds have been seen flying at least several hundred yards with beakfuls of nest material. Occasionally a nest-building gull removes material from nearby nests while the owners are absent. Such a bird is sometimes seen eagerly gathering a huge beakful of grass, only to lose all but a few wisps on the way back to his own nest because he treads on the stalks trailing from his beak. This behaviour is not intentional "stealing," for the bird usually does not return to the readily available supply and any further searching is undirected.

Collection of material can become a strenuous activity when a gull chooses to tug out small, whole grass plants, or to drag an awkwardly shaped twig backwards and forwards in attempts to turn it over so that it can be carried directly to the nest. As the male approaches the nest with a load of material in his beak he mews loudly and, when the nest site is reached, he either drops or carefully places the material on the edge of the bowl. He then chokes, and if his mate is nearby she may join him and begin choking. Usually it is

the male who then steps into the nest, sometimes choking as he does so, and after squatting down begins to pat his feet alternately against the sides of the bowl. The patting compresses the material forming the sides of the nest and tends to work it upwards, depending on how high the feet are raised. Often material is placed on the nest edge after the bird has stepped into the bowl so that, on sitting down, the bird faces the material it has just brought, and the patting which then begins does not mould this new material into the old but helps build into the nest the material brought on earlier trips. It is common therefore to see a gull patting in the nest with his chin resting on a heap of loose material just dropped. While sitting in the nest the gull may further distribute the material in front of it by lifting and placing pieces of grass and twigs with its beak. The body is kept comparatively still while the feet pat the nest material into place, i.e. the bird does not turn in the nest, but some slight tilting movements of the head may accompany the rearrangement of twigs with the beak. The sequence of events outlined is nearly always modified in many small ways by repetition or emphasis of one or more of the activities.

One afternoon the very beginning of a nest was observed (Plate II A). Between 2 p.m. and 7.30 p.m. (i.e. till just before dark), a male bird was seen plucking leaves and shoots from a small horehound plant and dropping them near its base, where previously there had been no sign of a nest. He tugged at the plant quite strenuously, sitting down in the small pile of material every now and then, and choking occasionally; but he did not pat. At intervals throughout the afternoon there were bursts of activity during which more material was collected, so that a small lopsided ring formed, and after approximately four hours he was seen to pat with his feet for the first time. The female occasionally picked up odd twigs, but simply dropped them, and did not join in the choking at any stage. The following morning the male was already picking up bits of grass around the nest by 5.30 a.m. and there was sporadic activity until midday. Further material was added to this nest in the course of the following weeks until, 21 days after building started, the first egg was laid (Plate II B). The majority of nests are completed before the first egg appears, but sometimes eggs are laid in what appear to be untidy, incomplete nests. In these cases the nest is tidied up during the following days and is often added to. One nest was found with fresh moss added to it after the eggs had pipped; however, any material added to the nest during incubation is connected with nest relief, which will be discussed in the section dealing with incubation. After the chicks have hatched no material is ever added to the nest, which rapidly becomes fouled and neglected, even before the chicks have left it.

A nest is built generally in three main stages. There is an initial, active stage during which a large part of the nest is formed; this is followed by a pause in building; then there is a final burst of activity during which the nest takes shape and the first egg is laid. Imposed on this broad plan is the diurnal rhythm of the birds in which nest building, as with most other breeding activities, occurs with greatest intensity at certain times of the day. In general the first nest-building activity of the day is not seen until about an hour after sunrise, and lasts with moderate intensity for approximately three hours, so that

II (a) — A "nest" after one day of building. (b) — The same nest as in (a), 21 days later. (c) — Nest under 12ft. **Olearia** scrub; this nest later contained two chicks. (d) — A secondary nest. The original nest was beside the peg.

from mid-morning till sometime in mid-afternoon practically no nest building occurs, and the birds are mainly preening or sleeping. However, after this time a steady increase in nest building activity is witnessed until well into dusk, which is followed by a sudden drop in activity. Although there is some morning activity, most nest building is done in the period of late afternoon and early evening and, as is the case with all other breeding behaviour, nest building may occur at night, especially during the phase of full moon. The increase of nest-building activity during the afternoon is shown clearly by the following abridged set of observations from the hide:

1.15 p.m. In the hide, weather fine and warm, birds preening or dozing.

3.00 p.m. There has been virtually no nest building up till now.

3.50 p.m. Since 3 p.m. one or two birds have been sitting in empty nests or picking up bits of grass from the ground.

4.30 p.m. A male (later the male of nest 313) picked up a load of grass and choked in response to the female who was standing in the nest choking. Shortly after this male 313 sat in the nest drowsing, and choking gently.

5.30 p.m. Other birds are now sitting on empty nests, occasionally choking and picking up bits of material; general activity has increased.

5.45 p.m. Numbers of birds are bringing loads of material to their nests.

6.00 p.m. Male 313 has now started building. He began walking quietly around pecking at grass and twigs and bringing the bits back to the nest. His mate appeared beside him and choked, and a little later he was attacked by a neighbouring male.

6.30 p.m. Shadows are lengthening and nest building is now fairly common everywhere.

6.40 p.m. Male 313 is now working hard, but the female is taking no part; she walks about, preens, or makes short flights.

6.50 p.m. Male 313 is making trip after trip for material; he collects huge beakfuls of horehound, etc., brings it to the nest mewing quietly, drops it, then pats in the nest; patting finished, he leaves straight away for another load.

6.55 p.m. The sun has disappeared behind the hills, but nest building, mewing, choking and head-tossing are common everywhere.

7.00 p.m. Male 313 is working hard, unaided by his mate. Sometimes, after he has gathered a load he almost runs back to the nest to drop it.

7.10 p.m. Dusk. Male 313 and another male are standing in their respective nests preening.

7.20 p.m. Male 313 is standing with shoulders hunched and eyes shut near the nest; a little nest building is going on in other nests, but the intense activity is over.

7.35 p.m. Darkness approaching. Male and female 313 have been head-tossing by the nest and the male is now on the nest; there is very little nest building now occurring; left the hide.

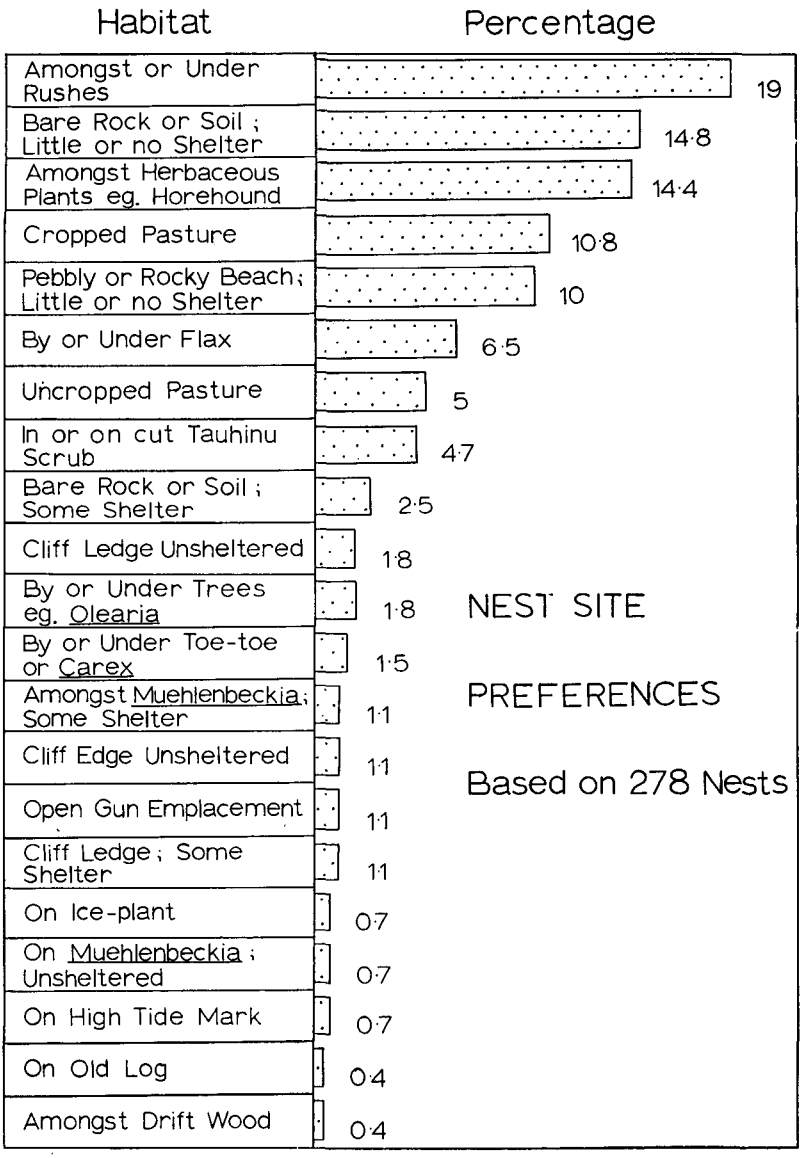


Fig. 4 — Nest site preferences

THE NEST

1. *Nest Sites.* Nests were found all over the beaches and slopes where disturbances caused by man (i.e. the quarantine staff) were at a minimum (Plate I B). In general, cliffs were not favoured by the birds and caves were very rarely used. Only one nest was found in a cave-like place — just inside the mouth of a disused concrete gun-shelter, but in subsequent seasons nests were built well inside the concrete gun-shelters. (c.f. Stevens (1950) who refers to a Herring Gull nest situated 18 inches from the entrance of a hole in the side of a disused clay pit.) Favourite nest sites were on open grassy ground, among rushes and small shrubs, on beaches and beach terraces, under over-hanging plants such as flax or toe-toe, or in sheltered nooks in the rocks. A few nests occurred under trees (Plate II c), e.g. at the base of clumps of *Olearia*. To reach these nests, the birds had to land outside the area of bush and walk under the trees on leaf-covered ground for many yards. No nests were found in trees, as has been described for the Common Gull *Larus canus* (Jourdain, 1935; and Bos, 1947). In the Antarctic, nests of moss have been built upon a foundation of snow (Murphy, 1936). Preferred nest sites have been determined from the marked areas and are presented in Fig. 4. The gulls make little or no attempt to seek a sheltered nest site for, out of 95 nests, only 8% were well sheltered. 24% had partial shelter for the sitting bird but 67% were in exposed positions. Some nests were built without any special construction in precarious places on slopes, or on the high tide mark, so that storms or spring tides destroyed them. When damaged some of these nests were strengthened by addition of more material, but this rarely prevented the eventual destruction of the nest. The following is a typical example of a nest built in an unsafe position. A marked nest containing one egg and built with insecure foundations on the uppermost slopes of the island collapsed after the pair had been sitting for 19 days. Twenty-two days later, with two new eggs, the nest collapsed again. A further two eggs were then laid but did not hatch.

2. *Nest Structure.* A typical nest is a rather loose collection of grass, feathers, sticks and oddments which are partly intertwined more by accident than intention, but which in many cases form a strong, well bound nest. The dimensions of 280 nests were determined by three measurements when the first egg appeared in each.

(a) Diameter of complete nest: This measurement of the greatest spread of nest material was made across the centre of the nest.

(b) Diameter of the bowl: This measured the width of the bowl from edge to edge.

(c) Depth: This measured the greatest depth of the bowl.

The results of these measurements are presented below in inches. Average values are based on the measurements of 115 nests.

	Diameter of Complete Nest	*Diameter of the Bowl*	*Depth*
Maximum	30.0	10.5	7.0
Minimum	10.0	7.0	2.5
Average	17.5	9.0	5.0

Nests in beach areas tended to be slightly larger, i.e. contain more material than those on the slopes; the diameter of complete beach nests (19.0 inches) averaged two and a half inches greater than the

diameter of complete nests on the slopes (16.5 inches). There was no difference between the average depth of beach and slope nests. It is seen that nests vary considerably in size, which is dictated in part by the site chosen and the material used, but in similar circumstances size is probably a measure of the nest-building drive of the birds concerned. After the eggs have been incubated for a week or so the nest material sometimes becomes slightly flattened and spread so that the diameter of the bowl may increase, and all nests flatten out after the chicks hatch.

3. *Double Nests.* Divided or double nests were occasionally found in late October, i.e. the early part of the breeding season. These were two almost full-sized nests placed side by side so that they seemed to be part of each other. Eventually one nest would be chosen by the birds and the eggs incubated in it, but the fate of the twin nest was variable. In some cases the unused nests were simply ignored and disintegrated, but later in the season others were found containing eggs or chicks, with a partly formed nest beside each one. It was thought likely that the partly formed nests were made from material brought by the non-sitting bird during nest-relief, and then moulded into a nest shape as a displacement activity if the incubating bird refused to be relieved. (When describing nest-relief in the Herring Gull, Tinbergen (1953) states that in cases of frustration, nest building appears as a displacement activity.) A double nest was under observation for varying lengths of time over a period of a week, but only one addition of material to the nest was seen. The male of the pair was sitting on three eggs while the female stood by the twin nest. A strange gull approached and kept walking close by the two nests, whereupon the resident female choked a little as a sign of aggression, picked up some grass, and patted it into the twin nest. Finally the male sprang from the nest and drove the strange bird away. In this case, however, addition of grass to the twin nest was prompted not by frustrated nest-relief but by the approach of a strange gull.

4. *Secondary Nests.* No mention has been found in the literature of what have been called "secondary nests" (Plate II D). These nests were found in the latter part of the season, associated with at least four of the marked nests, and it is considered they arose in the following way. Eggs sometimes fall out of nests and come to rest a few feet away, where they are usually ignored. However, it was found that, when the eggs in the original nest were broken or lost, the lone eggs would shortly after become the site of nest building, and new (secondary) nests would be constructed around and beneath them. A good illustration of this was provided by one of the marked nests which contained two eggs. The second egg disappeared 23 days after it had been laid and, 18 days after that, the now addled first egg was found outside, but near the nest. Four days later a nest was built around this egg, which was then looked after for about five days. In another secondary nest the egg was kept warm for 19 days before it was finally abandoned.

5. *Objects in Nests.* Nests with or without eggs were often found containing one or two small objects other than eggs. These objects ranged from rough or smooth stones of various sizes, to clods of earth, pellets of sheep dung and round shells of marine gastropods. It is clear that in most cases the objects had been placed in the nest by the pair concerned, but the reason for this was not apparent. In grass pulling

and aggressive choking birds have often been seen to pick up bits of earth or a pebble, hold them for a few seconds, then drop them. It seems likely that on some occasions these objects may then be carried to the nest and dropped in it. Davis (1942) states that gulls "commonly roll stones or sticks into the nest from nearby." Garden snails have also been found after very wet weather in some nests, where they have probably sought shelter under the sitting bird.

NESTING DENSITY

In Fig. 3b it is seen that nesting occurred practically all over the land outside the main farm and quarantine area. Only the activities of people and stock prevented the birds from nesting over the whole island. As previously mentioned the number of nests in an area increased as the season progressed, so that maximum density of nesting occurred after the middle of the season. Towards the end of breeding, when the number of birds in the colony had been maximum for some time, the nests in each area were plotted on maps and the nesting densities determined. These are shown in Table 1.

TABLE 1 — NESTING DENSITY IN THE SIX MARKED AREAS

Area	*Size of Area in Acres*	*Total No. Nests*	*Nests/ Acre*	*No. Square Yds./ Nesting Pair*
A (lower slope)	0.46	37	80	60
B (beach)	0.55	47	86	56
D (upper slope)	0.97	106	109	44
F (upper slope)	0.79	51	65	76
G (beach)	0.42	37	88	55
H (beach) Mainland	0.36 | 0.43	27 | 31	75	64
Islet	0.07 |	4 |	57	86
Averages	0.60	51	84	59

(Only the mainland portion of area H was considered in determining the averages of the two right-hand columns.) It will be noted that the average density of nests was 84 nests/acre. No significant difference was found between the nesting densities of slope and beach areas, nor between comparable areas with different aspects. The maximum density of nests was found in an upper slope area (area D) and so was the minimum (area F), apart from the off-shore islet in area H which had only four nests. The dispersal of nests in these two areas of extreme nesting density are shown in Fig. 5. Since both areas were on slopes, for comparison a beach area (area G) has been included in the figure.

The extreme nesting densities were:—

	Area	*Sample Region*	*No. of Nests*	*Nests/ Acre*	*No. Sq. Yds. /Nesting Pair*
Maximum Density	D	0.11 acres	29	264	18.6
Minimum Density	F	0.45 acres	22	49	99.0

In the area of maximum nesting density many nests were only a few feet from their neighbours, and the average number of square

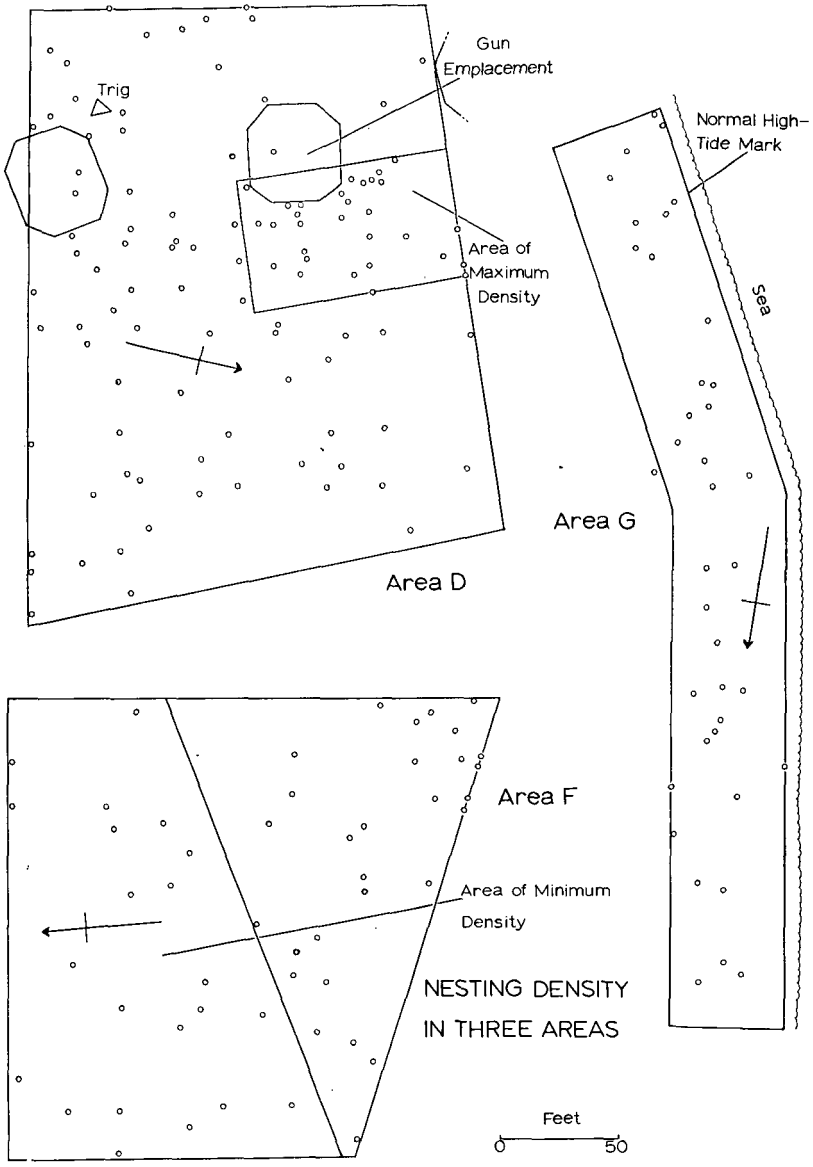


Fig. 5 — *Nesting density in three marked areas.* Area D — upper slopes. Area F — lower slopes. Area G — beach.

yards per nesting pair (18.6 sq. yds.) contrasts sharply with the size of territories claimed by Herring Gulls, where "each gull tends to claim a territory of about 30 - 50 yards in diameter" (Tinbergen, 1953).

The activity of the gulls around the densely nested region of area D early in the season was thought to correspond to the "headquarters" of the Lesser Black-backed Gull *(L. fuscus)* colony described by Darling (1938). Darling described a portion of the colony in which his intrusion caused more excitement amongst the birds than in other parts of the colony. Later on, however, it was found that all parts of the Somes Island colony behaved in the manner described by Darling and, because of the entirely different conditions, further comparison became impossible. In the area of minimum nesting density, the nests were on the whole evenly but widely spaced. The reason for this low density was probably that the area was largely one of cropped pasture, with little cover for the chicks.

EGG STAGE

Dates of Laying

The length of the egg-laying period is shown in Fig. 6. The first egg was found on 18th October, and by the end of November (i.e. after 44 days) the peak laying period was over. Occasional new nests continued to appear for a further 55 days (till 24th January) and the whole laying period therefore lasted 99 days. Although the last few nests were located in new sites it is probable that some were in fact repeat nests of pairs that had lost their first clutch. Stead (1932) mentions that "towards the end of January the old birds in many cases begin nest building again, but don't raise a second brood." A general pattern of a protracted laying season is common in New Zealand, which has a temperate climate. This type of pattern can be contrasted with the northern-hemisphere pattern of a compact or abrupt season. Paludan (1951) gives the length of the laying season for a Herring Gull and Lesser Black-back colony studied in Denmark:

Length of Laying Season in Denmark — 1943 & 1944

	Herring Gull	*Lesser Black-backed Gull*
1943	38 days	49 days
1944	42 days	50 days

Since Paludan's figures include all renesting occurrences, the laying season for the northern hemisphere gulls is about half the length of the laying season for the Somes Island gulls.

As mentioned previously the first egg was found on 18th October. An intensive search of the island was made the same day but no other eggs were found, although one or two other nests with eggs may have been in hidden or inaccessible places. The peak of laying was reached by 5th November (19th day of the season) and lasted for about eight days, during which time 122 new nests were marked. This number represented 39% of all nests in the marked areas. A second, lower peak of laying occurred about 20th November, after which time laying gradually decreased. The last new (?) nest with eggs was found on 24th January, but some birds were still incubating eggs far into February and newly built nests without eggs were found at the end of that month. In mid March 1963 three non-flying chicks were found; these chicks must have hatched some time in mid February of the 1962 - 63 season. Incubation of eggs in mid February on Somes Island has been

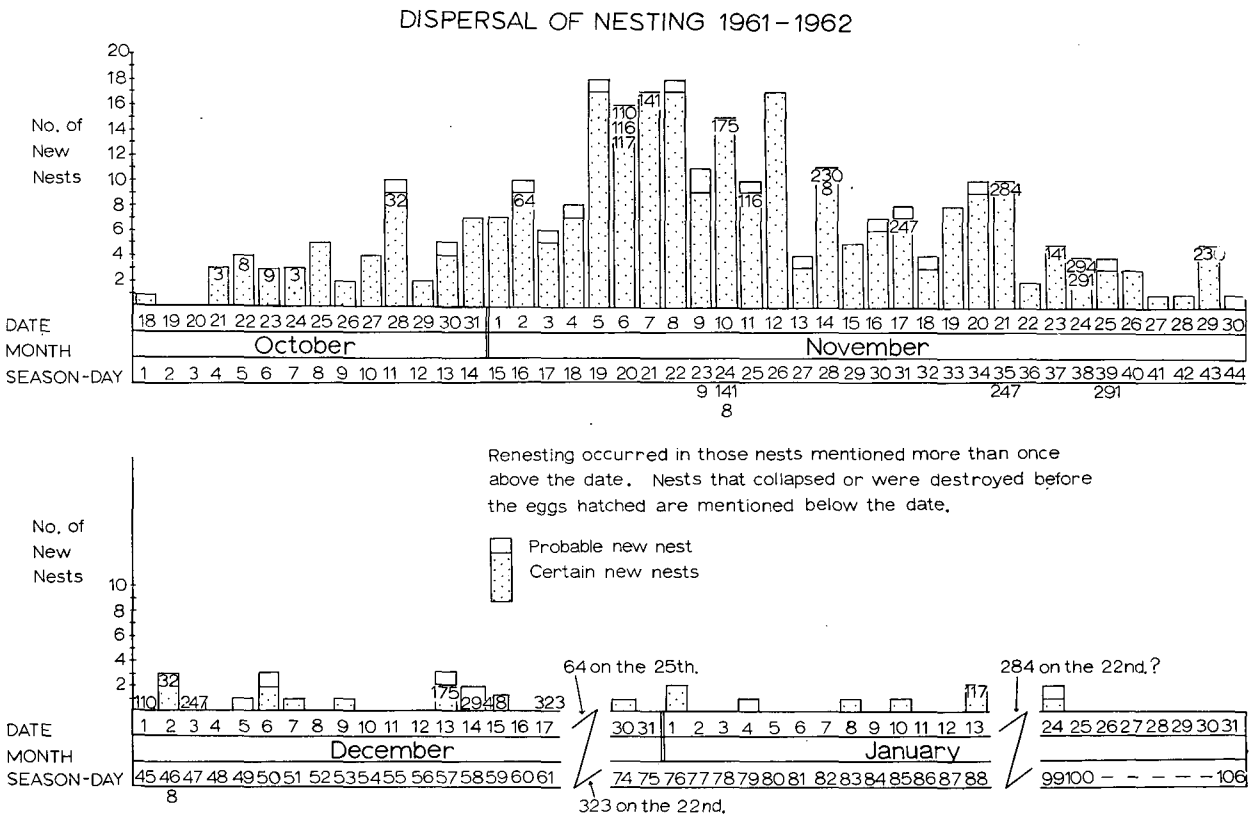


Fig. 6 — Dispersal of nesting, 1961-62

noted also by Kinsky (1962). Weather apparently had no effect on laying, as storms did not seem to hinder the building of new nests. However, destruction of established nests by storms did give rise to some renesting. In Fig. 6 "probable new nests" refer to those nests which were not discovered until the two or three egg stage. In nearly all of these nests it was possible, once the chicks hatched, to determine when the first egg had probably been laid. Laying in the Somes Island colony usually begins about mid October (Mr. F. C. Kinsky, pers. comm.) but there are only limited data available for colonies elsewhere in New Zealand and no pattern is discernible except that in most cases laying begins about mid October. In the 1961-62 season the Wellington colonies varied a little in the date of first laying. Mr. C. P. Gallop told the author that laying began at the Baring Head colony, east of Wellington Harbour mouth, about 20th October, while Mr. C. N. Challies supplied data (unpublished) showing that the first eggs in the Palliser Spit colony, Palliser Bay, must have been laid about 7th October. However in the 1950-51 season laying at Palliser Spit must have begun about 5th November, since the first chicks hatched on 1st December (*Notornis* IV, Class. summ. notes). Since on Ward Is. in Wellington Harbour, the first chicks hatched on 19th November, 1950, laying must have started about 23rd October (*Notornis* V, Class. summ, notes), and on Taieri Is., south of Dunedin, since two eggs had hatched by 14th November 1943, laying must have started about 18th October (*Notornis* I, Class. summ. notes).

If colonies south of New Zealand are taken as a whole, it is seen that they start laying later than those in New Zealand. This is explained by differences in latitude — birds in higher latitudes laying later than those in lower latitudes. Table 2 shows that in the southern colonies laying began three to six weeks later than at Somes Island. Falla (1937) records that the first egg in a Kerguelen colony of 1929 was laid on 16th November, and that nesting was almost over by the beginning of February when most of the young birds could fly. On Heard Island the first chick hatched on 1st December (1929), which means the first egg must have appeared about 4th November if an incubation period of 27 days is allowed.

TABLE 2 — START OF LAYING IN SOME COLONIES OUTSIDE NEW ZEALAND

Place	*Latitude*	*Start of Laying*	
(Somes Island, N.Z.	41°S	18th Oct. 1961	this study)
Kerguelen Island	48°S	16th Nov. 1929	Falla (1937)
Falkland Island*	52°S		Murphy (1936)
Heard Island	53°S	ca. 4th Nov. 1929	Falla
S. Georgia*	54°S		Murphy
Macquarie Island	55°S	9th Nov. 1912 & 1913	Falla
S. Orkney Island*	61°S	15th Nov. 1913	Murphy
S. Shetland Island*	63°S		Murphy
S. of Antarctic Circle	66°+S	20th Nov. 1914	Murphy

*The breeding season at the South Shetlands, South Georgia and the South Orkneys is somewhat earlier than at the Falklands, for which no date is supplied by Murphy (1936). The first pair of Southern Black-backs ever recorded nesting in Australia must, according to information supplied by Gwynne and Gray (1959), have laid sometime in early or mid December.

Time of Day Eggs are Laid

To find the time of day when eggs are laid, seventeen nests in one marked area were inspected up to five times a day. The area chosen permitted use of binoculars from an overlooking cliff-top, so two or three inspections during daylight were made without unduly disturbing the birds. Unfortunately the records are too slight to do more than indicate the possible results of more complete data, but it does seem that the times at which eggs are laid do not fall into any well defined pattern, and that they may be laid at any time of the day or night. Lesser Black-backs may also lay at any hour of the day or night, according to Paludan (1951), and Weidmann (1956) found no significant tendency for Black-headed Gulls *(L. ridibundus)* to lay eggs at one particular time of day. On the other hand detailed surveys by Skutch (1925) of 40 species of Central American land birds have shown that each species has its own time for laying, with generally well marked family trends. In addition birds which lay about sunrise show less variation in the hour of laying than those which lay later in the day. However, the laying habits of gulls in temperate regions are not strictly comparable with those of land birds in the tropics where there is a different relationship of day to night.

Spread of the Clutch

The time interval between the laying of individual eggs in a clutch can be called the spread of the clutch, or "laying pattern" (Paludan, 1951). There are two or three main laying patterns, and also a number of less frequent patterns which may be explained in part by errors in observation caused by only one daily visit to most of the nests. There was found to be no correlation between the time of season and the spread of the clutch, since clutches showing an uncommon laying pattern occurred at intervals throughout the season. The various laying patterns of 257 nests are shown in Tables 3 and 4.

TABLE 3 — SPREAD OF THREE-EGG CLUTCHES

Type	*Laying Period of the Clutch*									*Total Clutches*	*Percentage*
Days	1	2	3	4	5	6	7	8	9		
A1	1st	2nd		3rd						5	3.70
A2	1st	2nd			3rd					5	3.70
A3	1st	2nd					3rd			1	0.74
A4	1st		2nd		3rd					44	32.60
A5	1st		2nd			3rd				32	23.70
A6	1st		2nd				3rd			2	1.50
A7	1st			2nd		3rd				32	23.70
A8	1st			2nd			3rd			12	8.90
A9	1st			2nd					3rd	1	0.74
A10	1st				2nd			3rd		1	0.74
										135	100.0

For three-egg clutches the most common pattern was A4 where approximately 48 hours elapsed between the first and second, and the second and third eggs, so that laying was spread over five days. The next two most common patterns were A5 and A7 where there were respectively: 48 hours between the first and second, and 72 hours between the second and third eggs; and 72 hours between the first and second, and 48 hours between the second and third eggs, i.e. in both cases laying was spread over six days. Eighty-one (60%) of the 135 three-egg clutches took six to nine days to be completed, a tendency towards a prolonged laying period noted also in Lesser Black-backs by Paludan (1951). In both Herring and Lesser Black-backed Gulls, laying pattern A4 is also the most common; 70% of the Herring Gull, and 46% of the Lesser Black-back clutches being laid in this manner. The laying patterns outlined thus show resemblances to those of both the Herring and Lesser Black-backed Gulls.

TABLE 4 — SPREAD OF TWO-EGG CLUTCHES

Type	*Laying Period of the Clutch*								*Total Clutches*	*Percentage*
Days	1	2	3	4	5	6	7	8		
B1	1st	2nd							9	7.4
B2	1st		2nd						29	23.7
B3	1st			2nd					60	49.2
B4	1st				2nd				14	11.5
B5	1st					2nd			9	7.4
B6	1st							2nd	1	0.8
									122	100.0

In contrast to the three-egg clutches, the most commonly occurring time lapse between the first and second eggs to two-egg clutches was 72 hours (B3), i.e. laying was spread over four days. The next most frequent pattern was B2 with the usual time lapse of 48 hours, so that laying was spread over three days. It is possible that in B6 an egg was laid between the two recorded eggs, but disappeared out of the nest, thus escaping notice. The conclusion seems to be that the most common lapse of time between each egg is 48 hours in three-egg clutches and 72 hours in two-egg clutches.

Clutch Size

The number of eggs in 310 first, and 14 repeat clutches is given below:

	First Clutches		*Repeat Clutches*	
	Number of Nests	*Percentage*	*Number of Nests*	*Percentage*
3 eggs ---	149	48.1	4	29.0
2 eggs ---	133	42.9	10	71.0
1 egg ---	28	9.0	0	0.0
	310	100.0	14	100.0

The 310 first clutches studied had a total of 741 eggs. This gives an average clutch size for the whole season of 2.3 eggs per nest, a figure which is almost identical to the mean clutch size of Herring Gulls given by Paynter (1949). No four-egg clutches were found. Stead (1932) records that the clutch size is almost invariably three, though sometimes only two are laid. He found one nest of four eggs out of thousands of nests. Wilkinson (1952) states (rather surprisingly) that "the full clutch usually consists of two, three, or four eggs, but three is the most often seen." Further, one nest of five eggs was seen by Wilkinson but was considered "very unusual."

Data from colonies outside New Zealand are few. Falla (1937) mentions that in 1929, "three eggs was the usual full clutch" on Kerguelen, while at Heard Island "two-egg clutches were the rule . . . no three-egg clutches were found." No four-egg clutches were found on Kerguelen, Heard, or Macquarie Islands by Falla.

In Herring and Lesser Black-backed Gulls, the usual clutch size is three, but two, and rarely one and four may be found (Paludan, 1951). Further, the Lesser Black-back has more two-egg clutches than the Herring Gull, although Paludan doubts that this is a real difference since he considers that the Lesser Black-back is a poor nest builder, and loses eggs. But the Southern Black-backs also have a fairly high percentage of two-egg clutches (42.9%) all of which certainly cannot be attributed to the loss of eggs, or careless nest-building. In fact the numbers of two-egg and single-egg clutches rise as the laying season progresses, while the number of three-egg clutches drops. This progressive variation in clutch size is shown in Fig. 7, in which the number of new nests found each week is totalled, and separated into three groups, viz: those which subsequently became three, two, or one-egg clutches. As can be seen from Fig. 7, the average clutch size dropped as the laying season progressed.

Lack (1954) states that as a general principle older birds (i.e. those which have nested in previous seasons) nest earlier and have

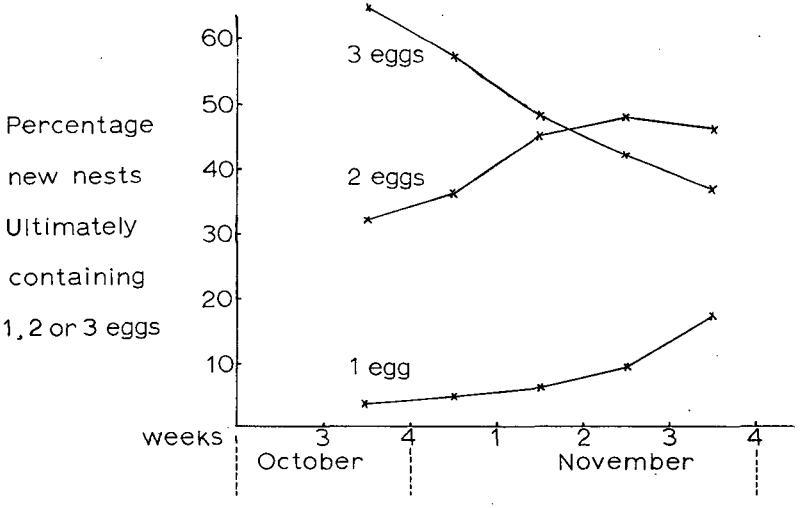


Fig. 7 — Seasonal change in clutch size

larger clutches than younger birds which are nesting for the first time. Drost *et al* (1961), and Dr. R. W. Balham (pers. comm.) state that in the Herring Gull and Canada Goose *(Branta canadensis)* respectively, older birds establish territories earlier than birds breeding for the first time. Another reason for the drop in average clutch size as the laying season progresses is that, in general, late nesting birds lay fewer eggs than earlier nesters (Lack, 1954). However, Paynter (1949) considers that there is no significant difference between the mean clutch sizes of early- and late-nesting Herring Gulls; but his findings depend on an arbitrary division, based on hatching dates, of the breeding birds into "early and late nesters." The date when half the total number of chicks had hatched was chosen by Paynter to divide early and late nesters. But since the peak hatching period naturally follows the peak laying period it is surely unreal to imply that chicks belonging to the second half of the peak hatching period come from late nesters. Birds participating in the peak laying period can hardly be called late nesters. Certainly at Somes Island, the results show that the mean clutch size does drop as the laying season progresses.

It is clear that the average clutch size must be calculated from the whole laying season, and not from one period of it, which will tend to give misleading results. Information supplied by Mr. C. N. Challies on the Palliser Spit Colony shows that on 5th November in both 1960 and 1961, the percentages of three, two and one-egg clutches agreed fairly closely with those for the same period in the Somes Island colony in 1961. The percentages obtained are comparable, even though discrepancies between the figures arise because some of the one- and two-egg clutches noted in the Palliser Spit colony would have subsequently been added to, and also because the Palliser colony may not start breeding at exactly the same time as the Somes colony. No doubt later visits to the Palliser Spit colony would have provided different percentages of three-, two-, and one-egg clutches. The percentage of two-egg repeat clutches (71%) is high, and is probably explained by the general rule that late nesting birds lay fewer eggs than earlier nesters.

(By removal from one nest of all eggs as soon as each was laid it was found that a total of nine eggs were laid before the nest was finally abandoned. The number of days between the removal of one egg and the laying of the next were 3, 3, 2, 7, 4, 2, 9 and 3 days. The nest material was usually disarranged for one to several days after each egg was removed. Paludan (1951) found nine to 13 eggs may be laid by Herring Gulls, and even as many as 16.)

The Eggs

1. *Weights.* Almost all the eggs laid in marked nests were weighed in a small bag attached to 100 gram spring scales, but in one or two instances scales reading to 200 grams had to be used. (To prevent inaccuracies the eggs should be weighed within at least one or two days of being laid, for they begin to lose weight fairly quickly; the loss of weight of eggs during incubation is described below.) There is wide variation between the weight of eggs of different clutches, and nearly always between the eggs of any particular clutch. The first egg laid is nearly always heavier than the second, which in turn is usually heavier than the third. Weights of 787 eggs from first clutches only are presented in Table 5. (The weights of 167 eggs from known first clutches in unmarked nests are included in this total).

TABLE 5 — WEIGHT OF EGGS IN GRAMS

	Number	*Maximum*	*Minimum*	*Average*
1st eggs	249	105	57	84.2
2nd eggs	232	93	65	79.7
3rd eggs	139	87	57	72.9
All eggs	787	105	57	80.1

The two smallest eggs encountered in the marked nests and included in the table weighed 57 grams each and both failed to hatch. In addition two abnormally small eggs were found; one was found broken near an unmarked nest, but the other, which was approximately the same size weighed 18 grams and represented the third egg of the clutch. Eggs of repeat clutches followed the general rule mentioned above of difference of weight between first and subsequent eggs in any particular clutch. In two thirds of the repeat clutches the first egg laid was lighter than the first egg of the original clutch, and in one third the first egg laid was heavier than the first egg of the original clutch. This difference in weight between the first eggs of original and repeat clutches is not related to the lengths of time that elapse between them, so that early or late repeat clutches may contain first eggs either lighter or heavier than those of the original clutch.

Eggs lose weight during incubation, principally by evaporation of moisture (Romanoff & Romanoff, 1949). To gain an indication of the weight loss with gull eggs, two eggs from one clutch were weighed daily until they hatched. The weight of both eggs remained fairly steady for four days after laying, except that the first egg had already lost one gram after one day. Loss of weight was gradual until the eggs pipped, but became rapid two days after pipping. The initial weights of the two eggs were 89 and 81 grams, and weight losses were 35 gm. (38.8%) and 29 gm. (35.8%) respectively. The first chick died the day it hatched, but the second one reached the original weight of its egg four days after hatching.

2. *Measurements.* The measurements of 798 eggs were recorded in millimetres with vernier calipers, no distinction being made between first and subsequent eggs in a clutch.

	Length	*Breadth*
Maximum	82.9	51.5
Minimum	59.7	41.0
Average	69.2	47.0

The abnormally small egg mentioned above measured 39 x 29 mm. and has not been included. These measurements cover a greater range than those given by Wilkinson (1952) from Kapiti Island, and are exceeded by Oliver (1955) in only the maximum breadth — recorded from the Chatham Islands (See Table 6). The measurements made in this study have a greater range than those of the (very small) South African and Australian samples, but much broader eggs come from South American regions, and the average dimensions of the Buenos Aires series are greater than those of the New Zealand sample. As far as these figures can be compared, it can be said that eggs from New Zealand may be longer, but not as broad as those from other sources.

TABLE 6 — EGG MEASUREMENTS FROM SOURCES OUTSIDE NEW ZEALAND

Locality	*Author*	*Sample*	*Length* *Max.*	*Min.*	*Breadth* *Max.*	*Min.*	*Average*
Chatham Island	Oliver	2 ?	75.5	67.0	52.0	47.0	
Buenos Aires	Murphy	large series					71.0 x 51.0
Other places in S. America	„	22	75.4	66.7	59.0	47.5	70.7 x 48.5
Peyron Island*	„	3	73.7	69.6	59.1	50.0	
East Island*	„	12	77.3	68.6	52.2	48.1	
Falklands							
South Africa	Roberts	3	80.7	75.0	51.0	48.0	
N.S.W., Australia	Gwynne & Gray	3 (one clutch)	72.0	68.0	51.0	50.0	

*These were non-random samples, the eggs being chosen for their "variation."

3. *Colours.* The colours and patterns of the eggs vary greatly, even within a single clutch. The method adopted for determining the colours of the eggs was as follows: superficial markings (spots, streaks, blotches, etc.) were broadly described as dark or light, depending on how heavily marked the shell was, and the ground colour was noted. Use of a colour standard in the field was not practicable, so that descriptions of the eggs had to be subjective, but samples of each type recognised were collected and later standardised as accurately as possible by the use of Ridgway's Color Standard (1912). Previous workers have described egg colours subjectively, without standardisation, and will not be referred to here. Plate numbers mentioned are to be found in Ridgway's Color Standard.

(a) *Superficial Markings:* These ranged from evenly to unevenly placed spots, streaks and other markings all of varying sizes. They were all of a brown shade, and the big majority of eggs carried dark superficial markings called, for simplicity, "brown."

"brown" — Plate 11 n 11 (between Auburn and Black)

(A large number of divisions of shades of the brown superficial markings could be made, but would be impractical.)

(b) *Ground Colours:* The greatest variation in egg colour was in the ground colours of the shell, and nine types were recognised. It is considered that this would be the minimum number recognisable.

"yellow-grey" — Plate XLVIa 21 '''' (between Grayish Olive and light Grayish Olive)
"grey-green" — Plate XLIf 29 ''' (Glaucous)
"green" — Plate XXXII f 35 '' (Pale Olivine)
"brown-green" — Plate XLb 21 ''' (Deep Olive Buff)
"green-blue" — Plate XXXIII f 39 '' (Pale Glaucous Green)
"blue" — Plate XXXXIII g 41 '' (between Pale-Niagara-Green and White)
"blue-grey" — Plate XLVIIf 29 '''' (Court Gray)
"grey" — Plate LId 23 ''''' (Light Olive-Gray)
"off-white" — Plate LIg 23 ''''' (between Pale Olive-Gray and White)

Colours of 818 eggs are presented below in Table 7 with percentages obtained for each type. It will be seen that grey, grey-green and green are the most common ground colours, and that superficial markings are almost universal, as witness the fact that only one pure blue egg and no pure grey, green or off-white eggs were found.

TABLE 7 — EGG COLOURS

Ground Colour	*No. of Eggs*	*Percentage*
yellow-grey	5	0.6
grey-green	297	36.3
green	99	12.1
brown-green	17	2.1
green-blue	13	1.6
blue	8	1.0
blue-grey	12	1.4
grey	362	44.3
off-white	5	0.6
	818	100.0

There is no apparent sequence in the colour variations of the eggs in a clutch, i.e. the ground-colour of the second or third eggs may or may not be generally lighter or darker than the first egg. Of a total of 280 clutches (including 13 repeat clutches) only 35 (12.7%) comprised eggs all of the same colour type. The rest were clutches in which the eggs were not all of the same type. One marked nest had eggs with ground colours ranging from brown-green, to blue-green, and finally blue-grey, all with dark superficial markings. In the B.A.N.Z.A.R.E. Reports of 1937, Falla records that on Kerguelen "there appeared to be more uniformity in the ground colouring of a large number (of eggs) than is usually the case . . . in New Zealand." Almost all eggs had shells of a smooth texture, only two (from the same nest) being found that were notably rough to the touch. One of these failed to hatch, and the chick from the other egg died two days after hatching. A few eggs showed ridges in the plane of the short axis.

RENESTING

Fourteen cases of renesting were recorded in the 310 marked nests. The appearances of these repeat nests are shown chronologically in Fig. 6, and the fates of the original clutches or nests are given in Table 8.

TABLE 8 — CAUSES OF RENESTING

Fate of the Clutch or Nest	*No. of Cases*
Eggs disappeared, or destroyed by parents or predators	6
Small chicks died or disappeared	2
Nest destroyed, or abandoned by parents	2
Unstable nest that collapsed twice	2
Nest blown to pieces during gale	1
First egg broken by author — nest abandoned	1
	14

One other marked nest was found with a single egg in it when the chicks of the original clutch were about four days old, but this egg was probably laid by another bird. Renesting is retarded as the breeding season progresses, and as the gonads of individual birds continue to regress following completion of the first clutch. Two naturally caused repeat clutches were recorded in only one of the marked nests (see nest 8, Table 9). The shortest length of time that elapsed between the disappearance or destruction of eggs, chicks, or nest, and the appearance of a new egg in the same, or new adjacent nest, was one day in the third nest of the season. The longest time between the loss of a clutch and the laying of a new clutch was 30 days, which occurred in nest 284 after the peak laying period. In this case, the laying of a repeat clutch actually followed the loss of small chicks. Renesting occurrences are presented in Table 9.

TABLE 9 — RENESTING OCCURRENCES

Nest No.	*First Egg*	*Nest or Clutch Destroyed*	*Fate*	*First Egg of Repeat Clutch*	*No. of Days Before Renesting*
3	21 Oct.	23 Oct.	Abandoned	24 Oct.	1
8	22 Oct.	10 Nov. + 2 Dec.	Nest collapsed twice	28 Nov. + 15 Dec.	18 & 13
32	28 Oct.	18 Nov.	Eggs destroyed	2 Dec.	14
64	2 Nov.	7 Dec.	Egg disappeared	25 Dec.	18
110	6 Nov.	11 Dec.	Egg + small chick disappeared	1 Jan.	21
116	6 Nov.	7 Nov.	1st egg disappeared	11 Nov.	4
117	6 Nov.	18 Dec.	Eggs disappeared	13 Jan.	26
141	7 Nov.	23 Nov.	Nest blown to pieces	23 Nov.	13
175	10 Nov.	1 Dec.	Eggs destroyed	13 Dec.	12
230	14 Nov.	15 Nov.	1st egg destroyed	29 Nov.	14
247	17 Nov.	18 Nov.	Nest destroyed by parents ?	3 Dec.	15
284	21 Nov.	25 Dec.	Small chicks died	24 Jan.	30
294	24 Nov.	14 Dec.	1st egg broken by author	14 Dec.	20
				Average	15

An illustration of how renesting was retarded as the laying season progressed is given by five of the nests mentioned in Table 9. In these five nests the first egg was lost or abandoned soon after it was laid. In two nests (3 and 116), built nearer to the beginning of the season, renesting occurred after only one and four days respectively, whereas in nests 230, 247 and 294, built later in the season, renesting took, 14, 15 and 20 days respectively. The "breeding" condition of the birds concerned (i.e. stage of gonad regression) has also to be

considered when renesting is discussed. It may be seen in Table 9 that in nests 3 and 116, where the first egg was lost soon after it was laid, renesting took only one and four days respectively, but in nests 110 and 284 where small chicks were lost, renesting took 21 and 30 days respectively. Gonad regression would have been far more advanced in the case of the latter two nests, than in the former two.

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