BREEDING DATA ON THE SPUR-WINGED PLOVER IN SOUTHLAND, NEW ZEALAND

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ABSTRACT

A population of Spur-winged Plover *(Lobibyx novaehollandiae)* in Southland was studied from 1965 to 1969. Nest areas and nest building are described and breeding territories discussed. Average clutch size was 3.74. Clutch size was not affected by rainfall. Incubation was shared between male and female by day. Laying began in June and ended in November, with peak laying occurring in August. Re-nesting occurred after nest or brood loss. There was one record of double brood. Incubation period was 30 to 31 days. Excessive incubation, laying pattern and hatching pattern are discussed. Hatch success in fully incubated nests was 73.99%; 50% of unhatched eggs contained early dead embryos; 49.83% of nests produced live chicks. Causes of nest loss are discussed. Chick mortality in the first fourteen days was high. 17.45% of chicks were known to fledge, but the true survival rate was probably of the order of 25%. Mean hatch weight was 20.5 grams. Chick growth rate is demonstrated. Fledging age was 7 to 8 weeks. Post-fledging dependence is discussed. Fledged juveniles remained with parents until 7 to 8 months old. The breeding cycle occupied the successful breeders for 11 months. Females could breed when one year old; males could breed in their second year, and may have done so when one year old. There was evidence that some pairs did not effectively part until the death of one of the pair. One bird was still breeding at 9 years 11 months, another at 8 years.

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1. INTRODUCTION

The establishment of the Spur-winged Plover *Lobibyx novaehollandiae* as a wind-blown migrant from Australia has been described by Barlow (1972). In 1964 a group of Southland members of the Ornithological Society of New Zealand decided that a concentrated study of the species would make the best use of the limited number of active field workers in the area. The study began in the 1965 breeding season and continued through to 1969 with some follow-up observations in 1970 and 1971. In 1968 there was an opportunity to co-operate with the National Film Unit in providing suitable material for a film of the species (Fig. 1). Recently some sequences were shown in the feature "The New Settlers," one of the new series of natural history television films produced by the National Film Unit, making its debut on Central Television on 2 July 1972.

The topic was to be looked at from three aspects:

1. Population study: distribution and movement.
2. Breeding data.
3. Behaviour study.

This paper collates the data gathered under section 2.

The plan called for an intensive study of the 8000-acre (3237.49 hectares) area shown in Fig. 2, one-third of the area to be covered by each of the three field workers. We had hoped to produce population and nesting density figures for each area and so fix the rate of increase of the species in it, but because we could not be certain that we had found every nest we had to abandon this part of the plan. Nevertheless some deductions on the rate of increase are possible from the statistics which follow.

A wary bird, the Spur-winged Plover cannot be approached successfully on foot except on the rare occasions on which it nests or feeds near cover. Thus we were limited to working from vehicles. Since most of the area was too wet to be negotiated with ordinary vehicles during the breeding season, we were confined to nests within sight of roads. As a result of this limitation, even though the study block was reasonably well roaded, observations were gradually extended beyond the initial study area in order to enlarge the sample, but most observations were made in the original area or in the areas immediately adjacent to it. A few nests in other areas which could be visited regularly were included in some of the statistics.

FIGURE 1: In 1968 the study team co-operated with the National Film Unit in obtaining material for a film of the species. (Left to right: Peter Muller, Lionel Lobb, Grant Foster (Film Unit), Roger Sutton, Dr R. A. Falla, Maida Barlow, Dale Pomeroy (Film Unit)).

Photo: National Film Unit

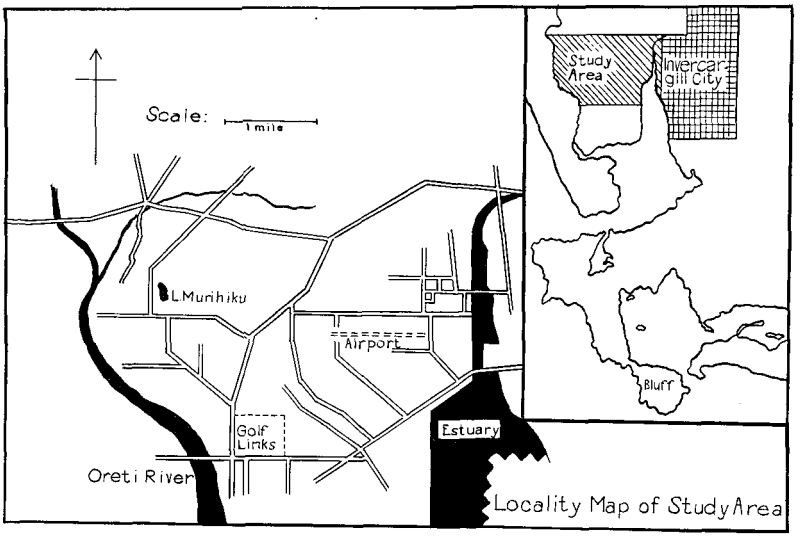

FIGURE 2: Locality map of study area.

2. MATERIAL AND METHODS

2.1 *Nest Records:*

Breeding data were recorded on nest record sheets under the following headings: Nest number; locality, description of breeding territory; distance from wet area; date found; number of eggs; date hatched; clutch size; number of eggs hatched; data on unhatched eggs; notes on chick mortality; number of chicks reared to fledging; weather during rearing period; notes (stock movement, etc.).

2.2 *Banding:*

Individual colour banding was used. After five years' wear some bands were largely devoid of colour but others stood up well and a few looked, from a distance, as good as when they were first applied. Because the monel bands soon darkened in colour and became difficult to see on a muddy leg, we had our remaining stocks electroplated and this overcame the problem. Some colours were more successful than others. We used black bands but had to discard them (the mud problem again) and we found green difficult to pick up at a distance. White, yellow, orange and blue were the most successful colours. Chicks younger than fourteen days were usually too small to retain the E band. Two weeks was therefore the minimum age adopted for chick banding. Two-week-old chicks retained the bands and did not appear to be handicapped. One band was monel,

the others being aluminium and lighter than the monel band. Many one- to three-day-old chicks were handled and weighed. Various methods of temporarily marking these young chicks — essential if we were to obtain data on chick growth — were considered and discarded. Most carried a risk of maiming the chick if it was not recovered, of modifying its activities or of increasing its vulnerability to predators. In 1967 a satisfactory method of marking young chicks was evolved. It consisted simply of making up small bands in a variety of colours from thin strips of rubber. These were easily applied to the chick's leg, with the use of expanding circlip pliers. Even if the chick was not subsequently re-caught there was no danger of restriction or injury to the bird. A different colour was used for each chick in a brood and the colour recorded with the chick's weight and age. When the brood was picked up again later each chick was identifiable, the rubber band was removed, the chicks weighed and the permanent metal bands applied. The occasion did not arise when there was confusion between broods. Broods did not mingle until many weeks, usually months, after fledging. Chick finding was usually preceded by adult finding and these adults were usually colour banded and therefore identifiable.

FIGURE 3: Individual colour combinations were a key factor in the study. This two-week-old chick has the combinations White over Aluminium (left), White (right).

Photo: R. R. Sutton

2.3 *Trapping methods:*

Lionel Lobb provided the tools for bird-catching. He first constructed drop-traps which were used to trap adults at their nests, and later a form of clap-trap for catching adults after the chicks had hatched. No one who has seen these traps can doubt the ingenuity and painstaking workmanship of the designer and builder. The bait for the clap-trap was the clutch of chicks in a small wire cage. As long as the chicks were only a few days old one or both adults would return to them, perhaps settling down by the cage in an attempt to brood them. The trap could then be tripped and one or both birds caught. Adult birds would rarely return to chicks older than a week, and the likelihood of their return dropped markedly after the first few days. In all trapping operations we tried to put the bird's welfare before our own interest, and to cause as little disturbance as possible.

Frequent discussions were necessary during the course of the study, both to report results and to modify plans in the light of experience. These get-togethers also were valuable in boosting flagging morale, for if one member of the team had just about given up in despair another had invariably had an encouraging success. None of us acting alone could have obtained the results we were able to achieve as a team. Each member made regular observations on his or her section of the block, but could also call for assistance from the others if daily (and sometimes thrice daily) visits were needed to a nest site, or if a day-long nest vigil was to be attempted.

2.4 *Rainfall data:*

Rainfall information was examined, particularly in attempting to make correlations with clutch size (see Section 3.6). Table 1 (compiled from Meteorological Service records — see "Literature Cited") shows rainfall for the five years of the study. It will be seen that during the peak breeding months of July to October there were three seasons of near average rainfall, one which was wetter than average, and one which was extremely dry.

2.5 *Sex determination:*

No reliable guide to sex difference, either in the field or in the hand, was discovered. Sex determination in the field was by observation of previously banded birds in copulation.

Laven (1940), as quoted by Little (1967), records that in a population of Ringed Plovers *(Charadrius hiaticula)* studied, he never observed reversed positions in copulation by male and female. Little (1967) records similar findings in a population of Wattled Plovers *(Afribyx senegallus)*. In many of the banded pairs of Spur-winged Plovers copulation was seen a number of times. With each pair it was always the same bird which mounted the other. It is assumed that with the Spur-winged Plover reversed positions in copulation occur rarely, if at all.

TABLE 1

TOTAL RAINFALL IN INCHES
INVERCARGILL AIRPORT : 1ft A.S.L.
(N.Z. Meteorological Service)

	1965	1966	1967	1968	1969	Mean
Jan	4.27	3.19	1.90	3.47	4.46	3.56
Feb	5.41	3.46	2.33	3.69	1.47	3.81
Mar	2.05	1.26	2.36	4.72	5.00	4.26
Apr	4.24	5.29	5.88	4.61	4.37	3.76
May	4.39	2.81	4.99	3.17	3.12	3.70
Jun	7.93	5.28	1.98	3.22	4.67	3.85
Jul	2.98	2.42	1.98	3.78	2.01	2.76
Aug	1.88	1.19	4.03	1.18	2.57	3.04
Sep	3.00	1.05	2.22	5.17	2.32	3.26
Oct	4.88	1.65	3.55	4.27	5.40	3.37
Nov	2.70	3.90	4.46	3.75	1.45	3.57
Dec	5.01	2.96	4.48	1.98	5.23	3.62
Totals	48.74	34.46	40.18	42.99	42.34	42.56

Average annual rainfall : 42.56

TOTAL RAINFALL

	1965	1966	1967	1968	1969	Mean
Jul/Oct	12.74	6.31	11.78	14.40	12.30	12.43

Both sexes have spurs protruding from the carpometacarpus, close to the carpal joint (see Fig. 7). Length and shape of spurs varied and consideration was given to the possibility that this variation could be related to sex difference. The spurs of twenty-two breeding adults were measured. Of these eight were known fmales and five

were known males. Six other birds were from three breeding pairs and therefore of opposite sex, and the remaining three were birds of unknown sex. The age of the birds was not considered. Length, width and thickness of each spur were measured, using vernier calipers. Two birds (males) were measured on two different occasions, and showed variations in measurements, as could be expected considering the deciduous nature of the keratinised epithelium of the spur. These measurements were:

Bird	Date	Left Spur	Right Spur
No. 224	7/9/68	18.7 x 5.7 x 3.4	17.5 x 5.8 x 2.9 mm
	30/9/70	17.7 x 5.5 x 2.9	18.1 x 5.5 x 2.8 mm
No. 265	5/10/68	15.4 x 5.4 x 3.1	15.3 x 5.6 x 2.9 mm
	1/11/70	15.2 x 5.7 x 3.2	14.5 x 5.9 x 2.9 mm

TABLE 2

SPUR MEASUREMENTS

Size of sample	Length	Width	Thickness
16			
FEMALES			
Minimum	13.4	4.9	2.9
Maximum	19.3	6.2	3.4
Mean	15.9	5.3	2.9
Median	15.0	5.3	2.9
14			
MALES			
Minimum	13.7	4.4	2.0
Maximum	18.9	5.7	3.4
Mean	15.8	5.5	2.9
Median	15.4	5.6	2.9

In two of the three pairs of unknown sex there was a marked difference in spur lengths and first indications were that this may be a reliable method of determining sex. However, in another pair the lengths (14.8 mm and 15.3 mm in one bird and 14.2 mm and 14.2 mm in the other) were very similar.

While the male measurements were usually the larger, there were two examples where the females' spurs were considerably longer than the males (19.3 mm and 19.1 mm compared with the male's 13.7 mm and 13.7 mm; and 19.1 mm and 18.1 mm compared with the male's 15.4 mm and 15.3 mm). In the small sample measured, these two females have influenced the mean figures. For this reason the median figures in Table 2 demonstrate the findings rather better than do the mean. The results were inconclusive.

3. RESULTS

3.1 *Nest areas:*

Farm animals (sheep, cattle, horses and pigs) and regular human movement influenced the choice of nesting area. Nest records strongly indicated that the birds preferred a nesting area wheree there were no animals. In only 31 of 222 nests where the full early history of the nest was known did nesting start in an area accessible to farm animals. On 29 of these 31 occasions only a very few animals (maximum 13, minimum 1) were on or had access to the chosen nesting area. A sample of 126 paddocks in the study block had a total acreage of 2110 acres (853.9 hectares). Maximum paddock size was 47 acres (19 ha), minimum 2½ acres (1.01 ha), and average paddock size 16.7 acres (6.7 ha). No nests were recorded on the Otatara Golf Links which are contained in the study area. Suitable nest sites were available here but human movement was considerable. No nests were recorded on the Invercargill airfield during the study period, but there was one earlier report of a nest on the uneven edge of the sealed runway. Pedestrian movement on the airfield is small but regular movement by vehicles, especially aircraft, is considerable. Regular vehicle movement did not appear to be a limiting factor in nest site selection in other parts of the study area. Closely mown grass with no surface irregularities was the probable reason for no nesting on the airfield.

The type of land used for nesting is shown in Table 3 (see also Fig. 4).

With one exception nests were in an open position which provided the incubating bird with an uninterrupted view in all directions. The exception was placed between two small tussocks *(Poa triodioides)*. Nests were usually placed where some roughness of ground or vegetation provided camouflage. Patches of dead *Carex cominata,* dead thistles and tufts of dead pasture grasses were favourite nest sites. Nests were frequently placed on small raised mounds,

TABLE 3

TYPE OF NEST AREA

Type	Total	%
Good pasture	78	25.32
Rough pasture	129	41.88
Old turnip and choumoellier	44	14.29
Old grain stubble	12	3.90
Gravel pits	5	1.62
Young grain crop	6	1.95
Reclaimed land	2	.65
Rough cultivated land	32	10.39
Total	308	100.00

NOTE : The total of 308 includes 15 nests which were of value for nest area selection purposes only and from which no other data were obtained.

especially in areas where the ground was generally wet. Nests in good pasture were more conspicuous but here too full use was made of any surface irregularities. The practice of mowing rushes *(Juncus polyanthemos)* which often grow in damp pasture in the area helped to create additional suitable nesting areas. The birds quickly occupied such areas soon after rush mowing, using the cut off rush crown as a nest site.

The distance of nests from wet areas is recorded in Table 4. A wet area near the nest site provided newly hatched chicks with a suitable feeding area. Nevertheless it is not considered to be an essential factor. Even very young chicks showed considerable mobility. A single chick from nest M/2/67 travelled half a mile from the nest within three days of hatching. Three nest sites on dry stony ground in Central Otago in 1969 were at least quarter of a mile from the nearest water, which was an irrigation race.

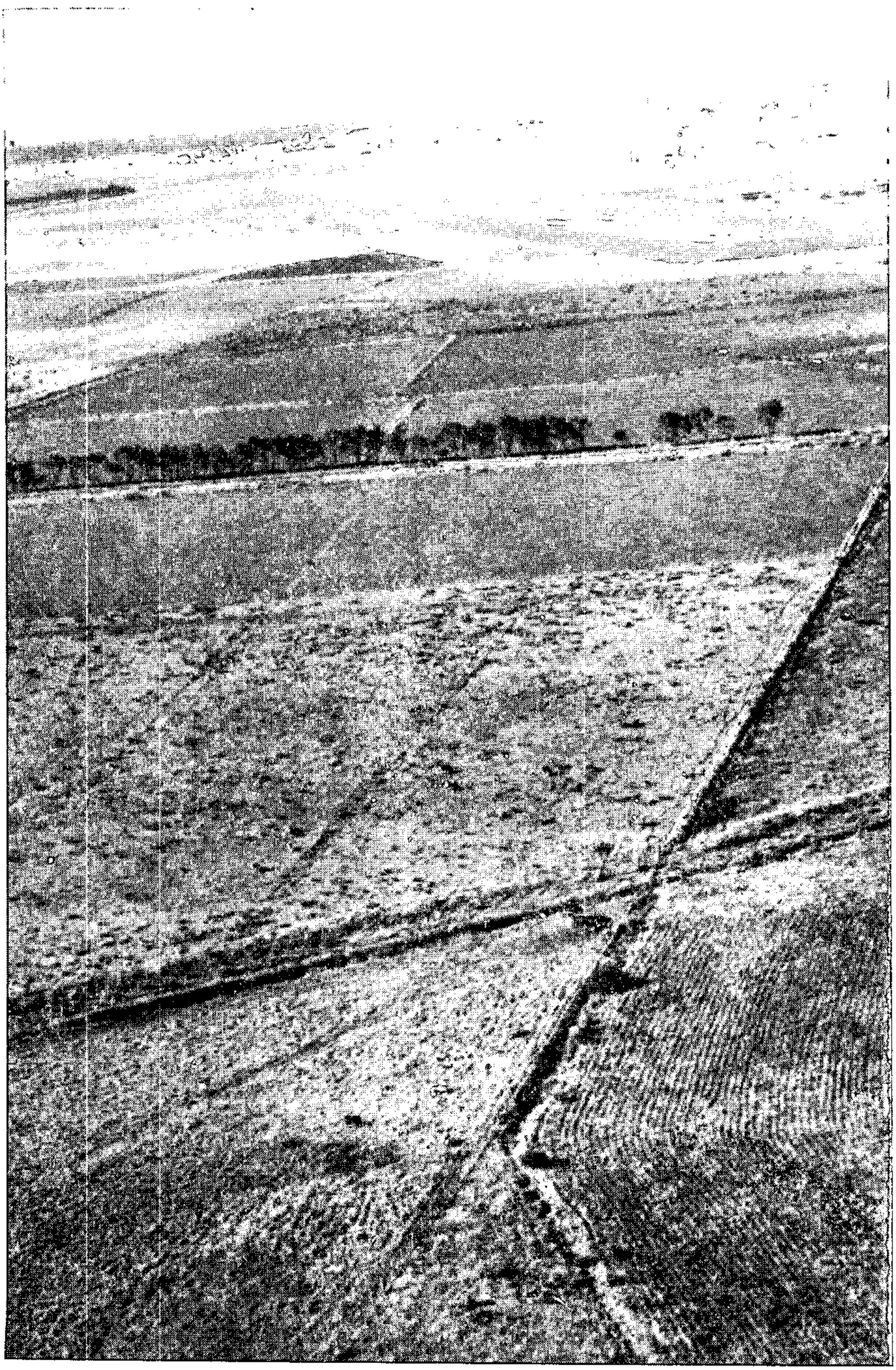

FIGURE 4: Typical Spur-winged Plover habitat. Rough pasture and old crop ground in the foreground and developed pasture beyond. In the right background are the buildings of the Invercargill Airport and beyond them the city.

TABLE 4

NEST DISTANCE FROM WET AREA

Yards	1965	1966	1967	1968	1969	All Years	%
0 - 10	20	19	28	31	27	127	40.58
11 - 20	3	3	5	8	2	21	6.82
21 - 50	13	11	16	12	11	63	20.46
Over 50	14	9	10	20	8	61	19.80
Not wet	5	9	18	2	4	38	12.34
Totals	55	51	77	73	52	308	100.00

3.2 *Copulation-egglaying time relationship:*

Copulation was observed in different pairs as follows:

14, 13 and 9 days before first egg laid
8 and 7 „ „ „ „ „
8 „ „ „ „ „
7 „ „ „ „ „
4 „ „ „ „ „
2 „ „ „ „ „
1 day after first egg laid, but before incubation started. (The only record of copulation after egg-laying, except following a lost nest.)

3.3 *Nestbuilding-egglaying time relationship:*

Nestbuilding was observed in different pairs as follows:

12 days before first egg laid
9 „ „ „ „ „
7 „ „ „ „ „
5 „ „ „ „ „

3.4 *Nest building:*

The birds adopted a typical attitude when shaping the nest. They leaned forward on bent legs with tail tilted well upwards and breast pressed into the nest cup. This was done with a shuffling circular movement. Both male and female shared nest building. Most nests were lined with dead grass, thistle stalks, dead carex leaves, carex roots or some other similar naterial found near the nest site. Nests on sites such as old turnip ground where no such material was available remained unlined throughout incubation. Two exceptions were nests S/40/68 and B/6/69, which were lined with

material not available near the nest site, the first with pieces of bark and other residue from a pine plantation some 250 yards (220 m) away, and the second with small twigs and pine needles which were unlikely to have been collected closer than 25 yards (22 m) from the nest. Birds were never seen carrying nesting material but it is apparent that this probably happened in these instances. The usual procedure was that both birds would toss nesting material towards the nest from any direction within about a six foot (1.8 m) radius of the nest. This material was then gathered and placed in the nest by either of the pair while sitting or standing on the nest site. Nest building continued in some cases during the first week of the incubation period. Trial nests, in which eggs were never laid, were sometimes found. These were usually close to the final nest site.

Nest sanitation was of a high order. Droppings in or near the nest were found only at the few nests which the birds themselves had destroyed. Eggshells were removed in sequence as each egg hatched, and were frequently found jettisonned in water at varying distances from the nest.

3.5 *Breeding territories:*

The size of apparent breeding territories was considered, but this matter appears to be extremely complex and is not fully understood. Distances between nests were usually considerable, but exceptions were recorded, the best examples being nests S/13/66 and S/14/66 which were only 22 yards (20 m) apart and were both being incubated at the same time. Fig. 5 shows the areas within

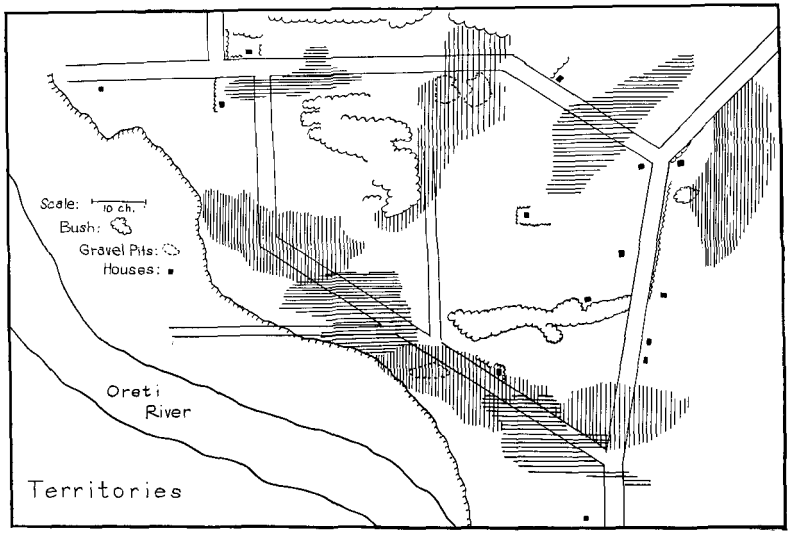

FIGURE 5: Areas, pairs and territory of Spur-winged Plovers.

which nine marked pairs of birds were always found, and outside which they were never found, during the months from June to November. Areas varied from 21 to 48 acres (8.4 to 19.4 ha). The average size was 36 acres (14.5 ha). Some territories appeared to overlap slightly. There were gaps of 100 acres (40.47 ha) or more between some territories, but this was largely due to other factors involved in nest area selection. Aggressive behaviour between birds of neighbouring territories was never observed.

3.6 *Clutch size:*

The 206 clutches listed in Table 5 were certainly complete because they were watched regularly during the laying period or they contained four eggs which, with two exceptions, was the maximum number recorded for any clutch. The only five-egg clutch had one abnormally small egg (42.1 x 31.1 mm) which did not hatch. A nest found in 1967 was unusual in containing six eggs and in having three adult birds in attendance; these eggs, perhaps laid by more than one female, are excluded from Table 5.

TABLE 5

CLUTCH SIZE

Year	1 egg	2 eggs	3 eggs	4 eggs	5 eggs	Mean
1965	(2)	(7)	13 (7)	24		3.65
1966	(1)	1 (4)	5 (15)	32		3.81
1967	1 (2)	2 (13)	8 (23)	34		3.66
1968	(5)	1 (11)	5 (14)	37		3.83
1969	1 (2)	1 (6)	5 (6)	35	1	3.79
All years	2 (12)	5 (41)	36 (65)	162	1	3.74

NOTE : Figures in brackets represent clutches discarded because? incomplete (see text).

Some other clutches, with less than four eggs, are shown in brackets in Table 5. They were found after laying had finished and an egg or two could have been lost before the nest was found. It is unlikely, however, that eggs were lost from all these clutches so the figures in Table 5 for the mean number of eggs per clutch are probably a little too high.

In Tasmania, Thomas (1969) found mean clutch sizes of 3.57, 3.47 and 3.62 over three years, and stated that these values " slightly underestimate true clutch size because eggs may have been lost before some nests were found." No importance can be attached

to the small differences between the New Zealand and Tasmanian figures because different criteria were used in defining a full clutch.

The nests in Table 5 are not all first clutches. Some are known to be re-layings, and others may be re-layings. Size difference between first and subsequent clutches is not considered significant, see Table 6.

TABLE 6 CLUTCH SIZES

1ST AND 2ND LAYING

Size of Sample : 10

1st Clutch	2nd Clutch
2	3
3	3
3	2
2	2
4	4
3	3
2	4
4	4
4	4
4	4

In Southland the clutch size seemed unaffected by rainfall during the breeding season. Although 1966 was a very dry season with only 6.31 inches (160.27 mm) of rain between July and October (see Table 1) and 1968 a wet one (14.40 in; 365.76 mm) the mean clutch size was almost identical in the two years, 3.81 and 3.83 (see Table 5).

3.7 *Behaviour of incubating birds:*

The behaviour of incubating birds was studied by occasional day-long observation of a few well placed nests. These nests, belonging to banded birds of known sex, were in places free from disturbance by passers by, and they could be watched from a parked vehicle distant enough for changeover of vehicle to have no effect on the birds. The results are shown in Fig. 6.

Vigils 1 and 2 show the same nest at different stages of incubation. In Vigil 3 the near monopoly of incubation by the female seems unusual. With many other pairs, observed less intensively, the female seemed to be the off duty bird as frequently as the male (Fig. 7).

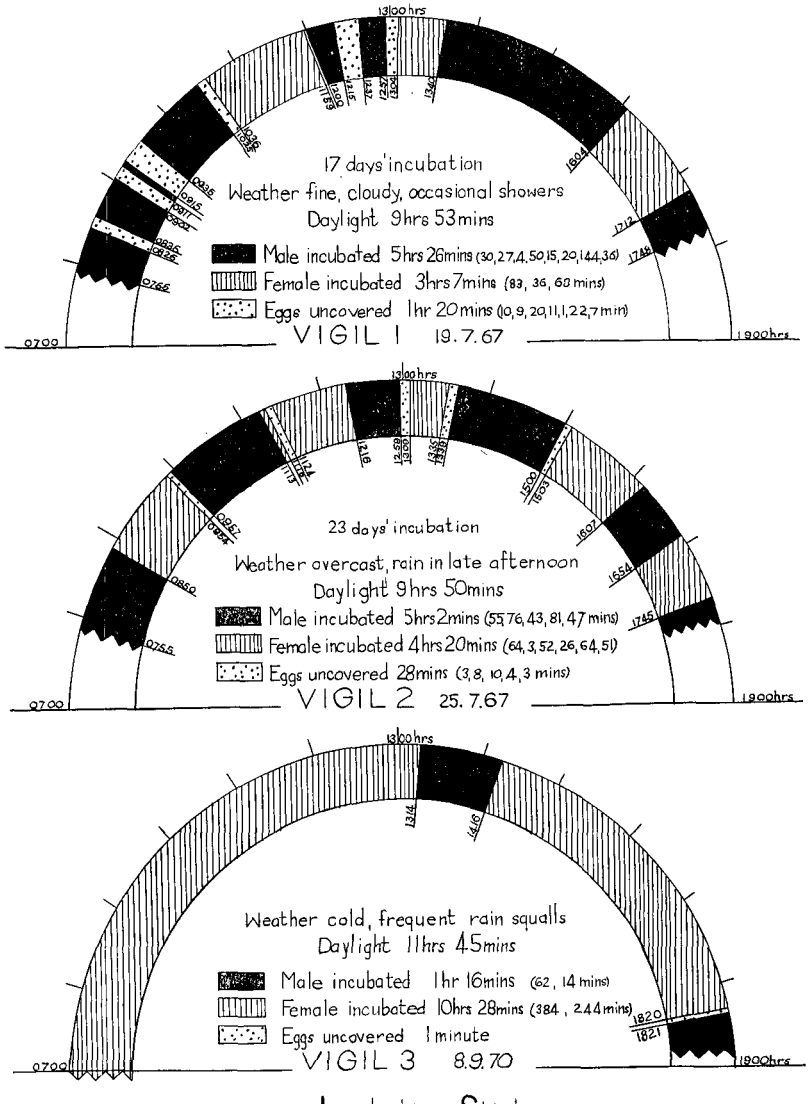

FIGURE 6: Incubation stints.

Nests were watched before nightfall on nine occasions, and each time the male took over just before dark. Moreover, early on frosty mornings incubating birds had frost on their backs indicating that they had been sitting for some considerable time (cf. also Fig. 14).

On the few occasions when the sex of the bird was known, it was always the male. These observations suggest that although incubation is shared between the sexes by day the male may incubate all night.

On several occasions birds were seen using the bill to turn their eggs, and sometimes the toes may have been used too. Numbered eggs changed position from one visit to another and the small egg in the five-egg clutch was in a different position in the nest on three out of four visits. These observations conflict with those of Thomas (1969) who wrote " the eggs normally assume a fixed position in the nest."

The problem of shading eggs from excessive heat observed in African Plovers by Hall (1964) and Little (1967) does not arise in Southland.

FIGURE 7: Adult Spur-winged Plover about to settle on nest. Note how the spurs protrude when the bird is in this attitude.
Photo: R. R. Sutton

3.8 *Egg dimensions:*

Sixty eggs were measured in millimetres with vernier calipers:

	Length (mm)	*Width* (mm)
Maximum	54.8	37.6
Minimum	45.7	33.0
Mean	49.4 ± 2.0	35.3 ± 1.0

The abnormally small egg mentioned above measured 42.1 mm x 31.1 mm and was not included in the calculations.

3.9 *Dates of laying:*

The number of clutches started each week in the five years 1965-69 is shown in Fig. 8. In all cases laying date was known either by field observation or by back-calculating from hatching date. Lack of observer efficiency in nest-finding in 1965 is a variable which may be reflected in the figures.

Peak laying occurs in August.

Some nests in Fig. 6 are known to be re-layings, and others may be re-layings. These undoubtedly cause the second surge of laying in most years.

3.10 *Re-nesting:*

Re-nesting following nest or brood loss often occurred. Proof was obtained on 24 occasions. Of these cases, 5 are excluded from the sample as the time lapses between sightings were such that interim nesting attempts may have been made. Of the remaining 19, 3 were cases of re-nesting after brood loss and the other 16 after nest loss. All time-lapses quoted are absolute maximum periods.

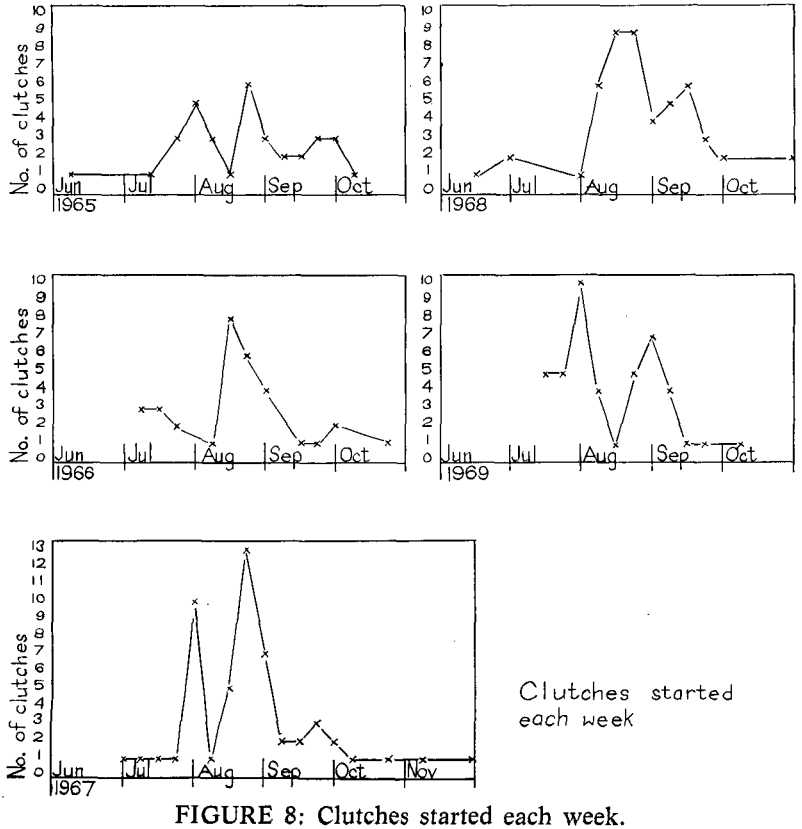

FIGURE 8: Clutches started each week.

After nest loss: In 16 cases, time lapse between loss of nest and start of second clutch ranged from 6 days to 28 days, mean period being 16 days, median 13, and mode 10 days. The mode occurred 4 times out of the 16.

After brood loss: Time lapses until start of second clutch were 19, 21 and 21 days.

In two cases at least three nesting attempts were made. The first of these produced a nest in which close interest was maintained for seven weeks but no eggs laid, a second nest with a 3-egg clutch (deserted), and a third nest with a 3-egg clutch (ploughed in). The second example produced three 3-egg clutches, the first predated, the second deserted, and with the third the eggs disappeared.

Location of subsequent nests in relation to the first varied from 20 yards to 800 yards.

Loose eggs lying about the study area were found once only, in association with a 4-egg nest which eventually hatched.

3.11 *Discussion of " breeding condition ":*

Consideration must be given to the " breeding " condition of the birds. The longer time lapse in cases of re-nesting after brood loss supports the supposition that gonad regression would be more advanced in these birds than in birds re-nesting after nest loss at an early stage of incubation. Evidence on this point is scanty, again because of the difficulty in finding nests before the clutch was complete. In the cases of lost first nests there could of course be no back-checking from hatch date. Factors other than gonad regression undoubtedly influenced the time lapse; e.g. in one instance there was a time lapse of 19 days when the first nest had been under incubation for only 4 days (i.e. 4 days since clutch completion). The male was a 2-year-old bird, banded as a chick, constantly seen since then, known to be in its first breeding season, and never a very " tolerant " bird. Inexperience could have been a factor here. In cases of nest loss due to farming activity the finding of a suitable new nesting area was probably an important factor.

3.12 *Incubation period:*

It has been impossible to determine exactly when incubation begins. Some birds would sit on the nest from the time of the laying of the second egg in a 4-egg clutch, but whether the bird was actually incubating was not known. Some birds with an incomplete clutch would leave the nest unattended throughout the day, except for an occasional visit to " look at " the egg(s). The laying time of the last egg in the clutch has been regarded as the starting time of incubation.

From 1967 attempts were made to number eggs in order of laying, using a felt-tipped pen. The aim was to assess incubation period, and to compare laying order with hatching order. Finding nests before incubation had started was difficult, but with increased

TABLE 7 INCUBATION PERIOD

Nest No.	Found	Number of eggs	Notes	Hatched	Incubation period
M.4/65	14/8/65	4			30-31 days
B.5/65	19/8/65	4			31-32 days
S.26/65	18/9/65	3	4th egg laid say 18/9/65	completed evening 19/10/65	Not less than 31 days
B.4/68	7/8/66	1	2 eggs hatched on 8/9/66		
	10/8/66	3rd egg laid between 0830 -1315 hr	1 egg hatched between 1600 hr 9/9/66 and 1100 hr 10/9/66		31 days from laying of 3rd egg
B.10/66	23/8/66	1			
	26/8/66	1645 hr 3			
	27/8/66	0730 hr 4	Frosty, cold; bird in adjoining paddock; did not go to nest.		
		0930 hr	Sunny, cold; bird not on nest.		
			28/8/66 0830 hr) 1050 hr) 1530 hr) bird incubating		
			26/9/66 1130 hr 2 hatched	1815 hr 3 hatched	
			27/9/66 0800 hr 3 hatched	1315 hr 4 hatched	29-30 days
B.9/67	Latest time laid:		Earliest time hatched:		
	Egg No 1 : 0800 hr 19/8/67		0800 hr 19/9/67 = Minimum 31 d after laying		
	Egg No 2 : 0800 hr 19/8/67		1500 hr 19/9/67 = " 31 d 7 hr " "		
	But a further egg was laid after these two, therefore incubation may not have begun until say, 20/8/67, which would reduce incubation time approximately 30 days				
B.11/67	Egg 1 laid before 1000 hr 19/8/67		Hatched between 1800 22/9 - 0925 23/9		
	" 2 " " 1430 hr 21/8/67		" " 0800 - 1215 22/9/67		
	" 3 " after 1430 hr 21/8/67		" " 0800 - 1215 22/9/67		
	No 1 hatched 34 + days after laying				
	No 2 " 32 + " " "				
	No 3 " 30½ " " "				30½ days
B.14/67	Egg 1 laid before 20/8/67		Hatched before 1800 hr 19/9/67) At least		
	" 2 " " 20/8/67		" 0800-1530 hr 19/9/67) 30 days		
	" 3 Earliest		Latest		
	Laid 1200 hr 20/8/67		1500 hr 21/8/67		
	Hatch 0600 hr 20/9/67		0700 hr 20/9/67		
	Therefore maximum incubation period Egg 3 - 30 days 19 hours				
	minimum " " " 3 - 29 days 15 hours				
S.1/69	Egg 4 Laid before 1430 hrs 12/7/69				
	Hatched and chick just dry 1145 hrs 12/8/69				
	Incubation period 30 days 21¾ hrs.				

SUMMARY : Minimum proved incubation period was 29 days 15 hrs.
Usual incubation period 30/31 days.

understanding of the birds' behaviour some results were obtained. Disturbance of the birds in the egg-laying or early incubation period would often be followed by desertion of the nest. On two occasions disturbed birds were seen trampling nests with their feet and using both feet and bill in breaking (and eating) the eggs. Eggs were marked only up to the end of August, so that any pair which " lost "

its nest as a result of this interference would have time to renest successfully in the same season. Egg-marking was carried out with circumspection, when the birds were well away from the nest. This could mean a long vigil, as often as three times per day over a period of several days. This section of the study could not have been accomplished without close team-work. The sample is small, but definite data were obtained.

Using criteria as detailed, the incubation period for the species in Southland is thirty to thirty-one days.

There were two instances of excessive incubation of 50 days, and one each of 55, 56, 57, 59 and 62 days. All eggs contained early dead embryos. This evidence suggests that the fact that eggs are not viable is not a reason for desertion.

Renesting following excessive incubation was not observed.

3.13 *Laying pattern compared with hatching pattern:*

Variable hatch weights and size of chicks was a noticeable feature. Most broods would contain at least one weakling. Spread of the clutch was known to extend over several days. Start of incubation was unproven. There was variation in the time birds began to cover the eggs.

The hatching process was variable. In some cases a 4-clutch would hatch in a few hours from first to fourth chick (minimum recorded six hours); in others hatching would extend over a longer period (maximum recorded thirty-six hours — actual interval between emergence of first and last chick).

An attempt was made to determine whether laying order and possible incubation time had an effect on hatching order and hatch weights. Results were difficult to obtain for several reasons: the difficulty of nest-finding at the pre-egg stage; interference at egg-laying stage appeared to promote desertion and possibly increased the chance of predation; interference at hatching time had to be minimal, as more than one visit to a hatching brood could result in the adults moving off with the chicks and deserting the unhatched or partially hatched eggs.

The following results were obtained:

Nest B.11/67: 3-egg: Nos. 2 & 3 hatched before No. 1.
No. 1 hatched 34+ days after laying.
2 hatched 32+ days after laying.
3 hatched 30½ days after laying.
No. 1 chick (first egg laid, last to hatch) was the weakling.

Nest B.14/67: 3-egg: 1st and 2nd laid eggs hatched first.
3rd egg hatched last.
3rd chick (last to hatch, last egg laid) was the weakling.

Nest S.3/67: 4th egg only marked in each case, and in each case
Nest S.36/67: this was the last to hatch.

Results are inconclusive.

Although the actual hatching may be near to simultaneous, the progress of the hatch can vary.

Nest B.16/68: A 4-egg nest, discovered incubating 1 September 1968. Hatch details:

Oct. 1 3 p.m. 1 pipped; 1 starred; 2 entire.
2 2 p.m. No progress.
3 4.30 p.m. 1 pipped+++; 2 pipped++; 1 entire.
4 1.30 p.m. 1 chick 1 foot from nest
1 chick dry in nest
1 chick damp in nest
1 egg entire.

The fourth egg contained an early dead embryo.

3.14 *Double brood:*

In 1967 a banded pair produced two broods. The second clutch was laid at the time when the single surviving chick of the first brood fledged. This juvenile remained under the protection of the non-incubating adult until the second clutch hatched, when the first juvenile (then aged 11 weeks) disappeared. One juvenile was reared to fledging stage from the second brood.

In 1966 this pair had two nests, a 4- and a probable 3-clutch, both of which were lost, presumably to predators. The female was not banded at this time, and it can only be assumed that she was the same bird (see later notes on Pair-bond in Section 3.22).

In 1968 the pair bred again, a single brood from which one juvenile was reared to fledging age at least.

3.15 *Hatching:*

Earliest known hatch-date in each year
2/7/65 2/8/66 26/7/67 12/7/68 9/8/69.
Latest known hatch-date in each year
7/11/65 29/10/66 24/12/67 28/11/68 1/11/69.
Hatch success is shown in Table 8.

TABLE 8

HATCH SUCCESS

Year	Total fully incubated nests	Total eggs	Eggs hatched	% hatch
1965	28	94	71	75.53
1966	21	75	60	80.00
1967	34	109	83	76.15
1968	42	143	94	65.73
1969	33	121	93	76.86
All years	158	542	401	73.99

Where possible eggs which failed to hatch were examined. Criteria used were those adopted by the Imperical Chemical Industries Game Research Station (see " Literature Cited ").

Of 141 eggs which failed to hatch, 15 (10.64%) were infertile. When the total number of eggs (542) is considered, the infertility figure is 2.76%.

3.16 *Nest success and causes of nest loss:*

A successful nest is defined as one which, after the full incubation period, produced live chicks.

TABLE 9

UNMATCHED EGGS

	1965	1966	1967	1968	1969	All years	%
Infertile	2	3	4	1	5	15	10.64
Early dead embryo	11	8	10	27	15	71	50.35
Dead in shell	3	1	4	8	0	16	11.35
Cracked	4	3	1	3	3	14	9.93
Missing or unknown	3	0	7	10	5	25	17 73
Totals	23	15	26	49	28	141	100 00

TABLE 10

NEST SUCCESS

Year	Total nests	Successful	% success
1965	55	25	45.45
1966	45	20	44.44
1967	73	33	45.21
1968	70	35	50.00
1969	50	33	66.00
All years	293	146	49.83

Uniformity: When considering the figures shown in Table 10, the question of uniformity of observer efficiency must also be examined. The amount of observer time expended in each of the five years is considered to have been uniform with the exception of 1969, when less time was spent in the field. The possibility of failure to find

unsuccessful nests could be reflected in the higher than usual nest success percentage shown for 1969. This is unlikely, as the lesser amount of observer time is compensated for by the fact that experience gained in the previous years made it possible to obtain a similar result with less expenditure of observation time. Any unevenness in data collection is more likely to have occurred in 1965 when observation techniques were being developed.

The causes of loss in the 30 cases recorded as "Unknown" in Table 11 will be covered by one of the other causes listed in that table, and probably in a similar ratio to the figures shown.

TABLE 11

CAUSES OF NEST LOSS

Cause	Number lost	%
Land usage	25	17.01
Farm animals	27	18.37
Predation	12	8.16
Poor hatchability	12	8.16
Egg disappearance	20	13.61
Human interference	9	6.12
Bird interference	9	6.12
Flooding	3	2.04
Unknown	30	20.41
Total	147	100.00

Land usage and farm animals: These are major factors in nest loss (35.38% of total). "Land usage" includes such activities as cultivation, fertilizer spreading, bulldozing and ditch excavation. Where farm animals were moved into a nesting area the nest and eggs were frequently trampled and destroyed. Animals responsible were sheep (25 times), cattle (once) and horses (once). Concentrations of non-breeding sheep in particular had a habit of congregating around the incubating bird and eventually trampling the nest. Only 2 nests were known to survive in the presence of a concentration of sheep. Cattle appeared equally inquisitive but were much less prone to trampling the nest. This was well demonstrated with Nest S/25/67, where dairy cows spent considerable time nosing the incubating bird but did not trample the nest. A cow calved within 20 yards of the ultimately successful Nest S/10/68.

In the presence of farm animals 22 nests were successful: sheep 9, cattle 9, horses 3 and pigs 1. These figures indicate a higher rate of nest success in the presence of farm animals than is really the case. In all but 6 of the 22 cases animals were present in very small numbers. In 4 of these 6 cases the stocking rate was low in relation to paddock size, with stock numbers ranging from 188 to 120 in paddocks ranging from 47 acres (19 ha) to 33 acres (13.3 ha) in area. The other two held 36 and 22 animals on 9 acres (3.6 ha) and 5½ acres (2.2 ha) respectively. Further, nests were frequently situated in a rough semi-grazeable part of the area which animals were less inclined to frequent.

In the presence of farm animals (sheep 15, cattle 11 and horses 5), 31 nests were built. These figures would indicate that the birds preferred the company of sheep, cattle and horses in that order, but in fact this was not the case. Sheep were the predominant animal in the area, cattle were present in moderate numbers and horses were few. The chances of birds nesting in the presence of sheep were therefore much greater.

Cultivation and the movement of farm animals suited the species' breeding habits, and influenced both the choice of nesting area and the overall breeding success. In the study area it was normal farm management to have almost all the sheep and cattle concentrated in a small area, being fed on turnips, hay and choumoellier during the winter period from mid-May to mid-August. Most the paddocks were unoccupied by farm animals during this period, thus providing early nesting birds with a wide choice of nesting areas. In mid-August, sheep were moved from winter feeding quarters on to kept pasture in the unoccupied paddocks. Grazed-off turnip and choumoellier ground was then left vacant until mid-October when drier weather permitted cultivation of this ground. As can be seen from Fig. 8, this mid-August animal movement clashed to some extent with peak nesting. The vacant turnip and choumoellier ground was used to some extent for re-nesting, and sufficient time was usually available for full incubation to be completed before cultivation began. By comparison, South Island Pied Oystercatchers *(Haematopus ostralegus finschi)*, which also nest on farm land in Southland, are generally less successful. This species, which starts egg-laying in early September, commonly nests on old turnip and choumoellier ground. Although little information is available, observations suggest that the rate of nest loss with Pied Oystercatchers is much greater than with Spur-winged Plovers, because the generally later nesting period clashes with cultivation.

Predation: The 12 losses are likely to be conservative and can probably be supplemented by a number of the 20 cases listed under "Egg disappearance." Predators were not definitely identified. The main suspects were Pukeko *(Porphyrio melanotus)*, rats *(Rattus norvegicus)* and stoats *(Mustela erminea)*. The predatory habits of the last-named are consistent with egg disappearance. Hedgehogs *(Erinaceus*

europaeus) were present in the area but were disregarded as predators for two reasons: (a) the complete disappearance of eggs from the nest is inconsistent with the hedgehog's method of attack. It usually eats eggs on the spot and makes a mess of the nest in the process. This was not observed. (b) Hedgehogs do not come out of hibernation in Southland until late August, by which time the nesting season is well advanced.

Poor Hatchability: These 12 nests were the subject of excessive incubation. The reasons for poor hatchability are unknown.

Interference: Destruction of nest and eggs by the birds themselves is covered under "Bird interference." The 9 cases of "Human interference" were largely inadvertent. Nest trapping was responsible for some, and other activities such as fence construction near the nest site for the remainder.

Flooding: The 3 instances occurred in July 1968, when unusually high rainfall was recorded (3.78 inches; 96 mm) (see Table 1). Average July rainfall is 2.76 inches (70 mm). Because of the uniform monthly rainfall damaging fluctuations in water levels were rare. Many nests were situated in very wet areas.

Unknown: Each year some nests were deserted early in the incubation period for causes which this study has not uncovered. The eggs in many such nests were found to contain early dead embryos. It is tempting to hypothesize that the birds were by some means aware that the eggs were not viable, and that this could have been a reason for desertion, but this is disproved by the evidence of excessive incubation previously documented.

3.17 *Chick survival:*

Despite the genuine and regular attempts made to follow the fortunes of all broods hatched, the "No data" figures in Table 12 show that many chicks were not found. The figures show the high mortality rate within the first fourteen days (90 from a total of 401 = 22.44%). In addition many, and probably most, of the 169 chicks in the "No data" column must have died. The true mortality rate in the first fourteen days is probably nearer 55%.

Of the 142 known to have survived the first fourteen days it will be seen that 70 are known to have fledged. This represents 17.45% of the chicks hatched, and 49.3% of the chicks known to have survived the first fourteen days. The "No further data" figure of 64 will include a large number of birds which did fledge. The true survival rate is probably nearer 25% of chicks hatched.

While the chicks were under a week old the adults spent a considerable time brooding them, particularly if temperatures were low. Chicks would still be brooded at times when they were two weeks old. During this early period the adults were assiduous and vociferous in driving off predators, particularly Harriers *(Circus approximans)*. These two activities of brooding and Harrier-chasing

were of great assistance to us in locating young broods. As chicks grew behaviour patterns changed. The adults would often be hundreds of yards apart, and sometimes one would fly off altogether for a time. Adult behaviour would become more secretive, the birds tending to skulk low in the rushes and sedges. The chicks would crouch flat and immobile without the constant warning calls uttered by the adults when the chicks were younger. Harrier-chasing was less apparent. Chicks older than four or five weeks would often run before crouching. The combination of all these factors meant that finding of chicks older than fourteen days was not simple (Fig. 9). It is our belief that many of the birds which survived to fourteen days, but were not subsequently found, did in fact survive to fledging stage. This belief is supported by the fact that many of the 70 birds known to fledge were not seen from the time of banding until many weeks, sometimes months, and in two cases years later.

Broods from nests where the number hatched was known are listed in Table 12. It does not include all chicks banded.

3.18 *Hatch weights and chick growth rate:*

While some birds were more tolerant of approach and interference than others, the general pattern was that adults and young would move from the brooding area after interference and would be difficult to re-locate. Even without interference it often happened

FIGURE 9: Camouflage of unfledged chicks in relatively sparse escape cover was a factor in chick survival.

Photo: R. R. Sutton

TABLE 12

CHICK SURVIVAL

Year	No. hatched	Succumbed at less than 14 days	Survived to 14 days	No data	Of those surviving to 14 days: Known to fledge	Known to succumb	further data
1965	71	7	43	21	13	3	37
1966	60	8	18	34	8	2	8
1967	83	31	19	33	11	0	8
1968	94	25	31	38	18	1	12
1969	93	19	31	43	20	2	9
All years	401	90	142	169	70	8	64

that the birds moved from the original nesting/brooding area when the chicks were about two weeks old. There was frequently a further move when the young were about five to six weeks old. These moves were probaly dictated by the need for more cover as the chicks grew, although food needs may have been a factor. Thus, a brood would soon be moved from a nesting area with little more cover than cattle hoof-marks and one-inch high growth. But a similar area with an adjacent patch of *Carex sp.* and some patches of rushes may have been adequate habitat for a brood right through to fledging at eight weeks. Unsuitability of surrounding terrain was not a hindrance to movement. Broods were known to cross roads, ditches, gravel pits, heavily stocked paddocks, sizeable streams of running water, and even a fair-sized river (Waihopai River). (On 18/10/64 H. W. M. Hogg (1964) saw a 2-4 day old chick swim forty feet across the strongly flowing Taieri River and struggle up a sloping rock retaining wall six feet high.)

The following factors appeared to influence a move to a different area:

1. Stock movement.
2. Land usage.
3. Disturbance after a certain age — often two to three weeks, sometimes earlier; but some birds were more tolerant of disturbance than others.
4. When chicks five to six weeks old; better protective cover; more, possibly different, food.
5. Weather: the drying up of wet areas could cause the birds to move to the nearest suitable wet area.

TABLE 13

CHICK GROWTH RATE

Hatch wt (g)	1 day	2	14	15	16	17	18	19	21	24	34	35	44	52
20)			72											
22)			44											
20)												195		
20)											150			
20)		17†												
18)		16†												
18)	13†													
20)	19	20†												
20)	20	20†												
18)	19	†												
24)		24												
24)														
20)						56								
18)						†<								
22)						78								
22)						†<								
18)			52											
22)			56											
20)			60											
20)				49										
21)				59										
?)				45										
19)			64											
23)			77											
24)					65									
22)					58									
24)					64									
18)								73						
20)								80						
22							83							
22)					80									
24)					†<									
23)			51											
21)			49											
20									74					
20													218	
20)				48										225
20)			†<											
18			62											
?)					34					58				
?)										45				
?)										55				

KEY : † Died < Before

Hatch weights: 75 new-hatched chicks were weighed. " New-hatched " means chicks known to be less than twenty-four hours old.

Size of sample:	75
Minimum weight:	14 grams
Maximum weight:	26 grams
Mean weight:	20.5 grams.

Growth rate: While attempts were made to recapture rubber-banded chicks at fourteen days and thus standardise results, this was in fact achieved with only 10 birds. Other birds were recovered when older. The results are set out in Table 13 and Fig. 10.

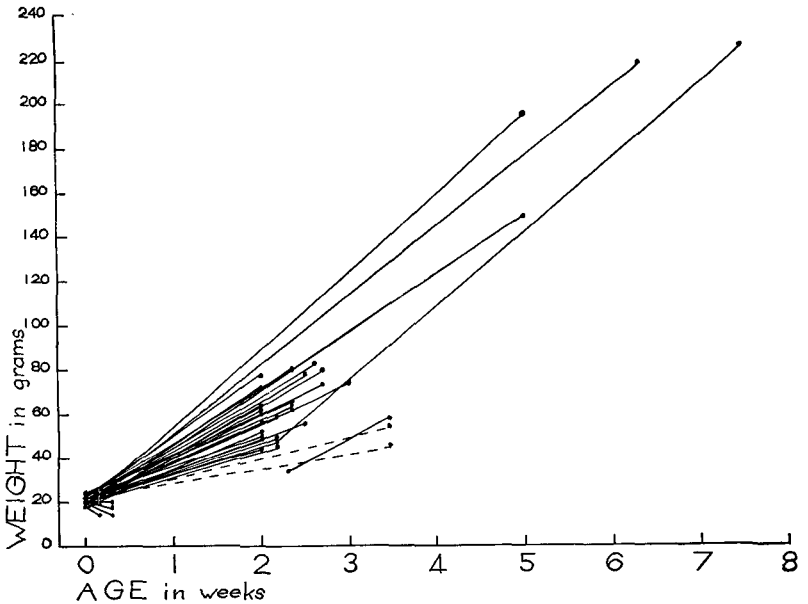

FIGURE 10: Chick growth rates.

The sample is too small to allow any firm conclusions to be drawn, but several points are raised by the figures. They reflect the variability in growth rate, which was observed in many more instances than those in which weights were obtained. Extremes of growth rate were not found to be caused by difference in habitat or apparent food supply. The usual pattern was to find variation within the brood. This is demonstrated in Table 13 where birds of the same brood are bracketed. It will be seen that while it was usual for chicks with the higher hatch-weight to make the greater growth-rate, this did not invariably happen.

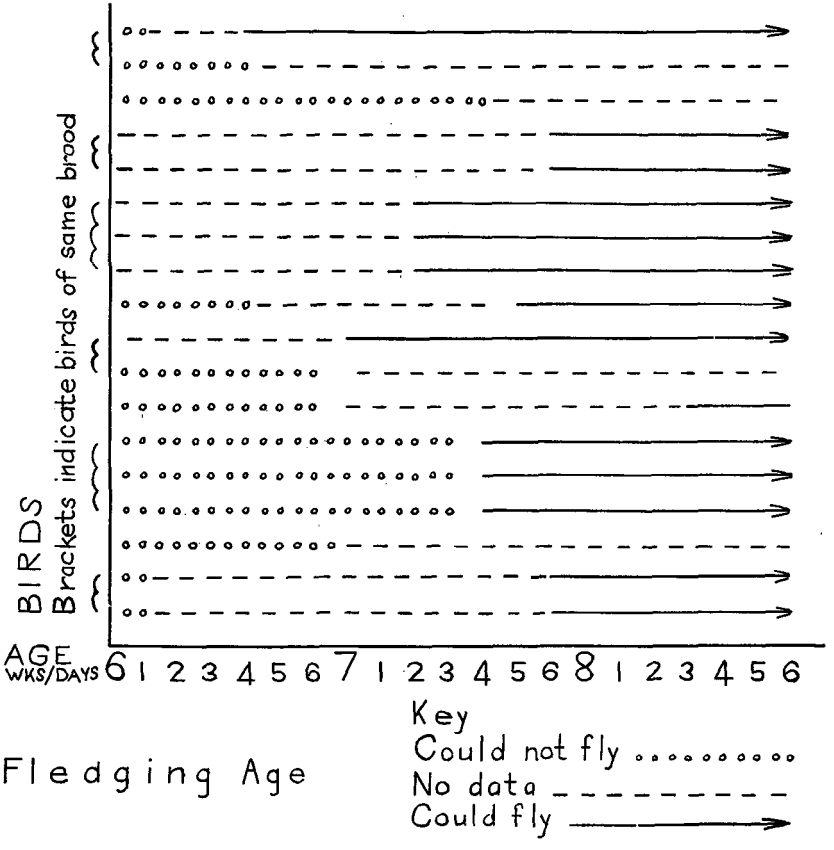

FIGURE 11: Fledging age.

Adult weights: Only 4 adult birds have been weighed. Two breeding males weighed 375 g and 400 g. A breeding pair (sex unknown) weighed 375 g and 390 g.

3.19 *Fledging age:*

Most birds could fly by the eighth week (Fig. 11). A field note on early flight reads: " Low floating flight, most gliding, with some wing-beats. One bird, when walking and feeding, flew a few feet over an obstructing log; when disturbed flew about 25 yards, rising to about 12 feet." No birds were seen in obvious practice flights, wing-beating or wing-exercise. Young birds would stretch a wing almost horizontally when preening, but so would adults.

3.20 *Post-fledging dependence:*

The species is nidifugous and the young often moved from the nest within an hour of hatching. Chicks less than 24 hours old were seen feeding, and when picked up had mud adhering to their bills.

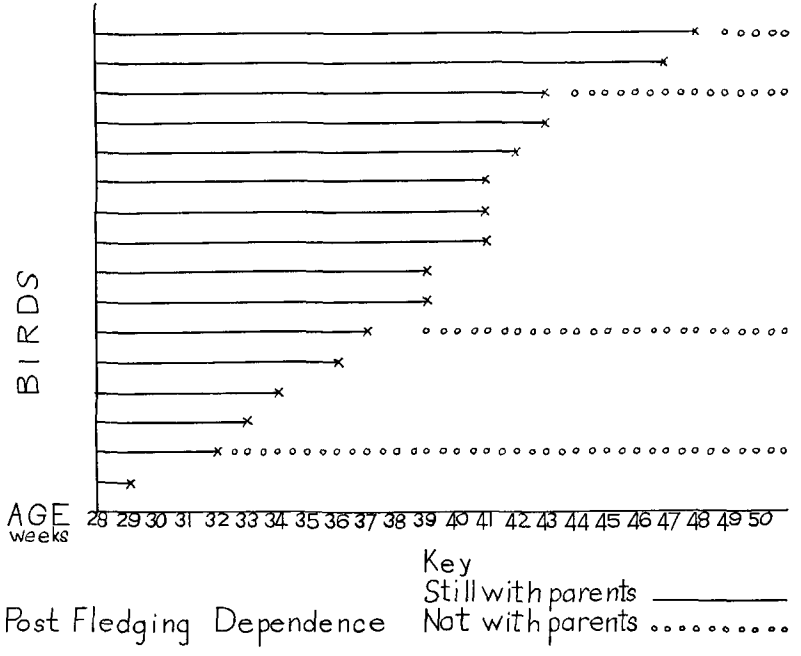

FIGURE 12: Post-fledging dependence.

Nevertheless they appeared to be closely dependent upon the parents for many months (Fig. 12). It was not until the fledglings were seven to eight months old that they began to mingle with other birds. Even at that age they were usually found with one or both parents. The parental behaviour was still protective with at least one adult on guard and alert and warning calls by the parent eliciting response from the young. The following extracts from field notes describe the position:

" 19/5/69; Family groups still mostly together, but juveniles briefly moving off and back again. Some communal flocking, but adults tending to remain on, or soon return to, usual territories."

" 9/6/69: Much haphazard group-forming and breaking-up, although many family groups still firmly together."

"2/7/70: Families together part of the time, juveniles moving away at times; parties of restless juveniles together. They settle and relax when with adults. Some adults copulating."

In Fig. 12, " Not with parents " means that the juvenile was never again seen with the parents, although the parents were seen frequently thereafter.

In summary, it is seen that the breeding cycle occupied the successful breeders for the greater part of the year. With some closely observed pairs the new season's breeding began within a week or two of the departure of the previous season's young.

3.2 *Breeding age:*

Breeding age is established by the following evidence from the field notes:

1. E23457 banded as chick approximately two weeks old 31 October 1964. Nest-trapped 18 October 1966 at its second nest for the season; first nest found 28 August 1966 and subsequently deserted. Rebanded with combination A.O/R (E61331). A female as seen in copulation (4 observations).
   Therefore a female can breed in its second year.
2. E61405 (O.A.) banded as a chick approximately two weeks old on 8 August 1965.
   1966: 12 sightings; twice with small flock, 3 times alone, 7 times with unbanded bird. Behaviour as pair, but copulation not seen, and frequency and intervals of sightings satisfied observer that these birds did not breed successfully in 1966. However the possibility of an unsuccessful nest for a short time cannot be dismissed.
   1967: Many sightings, same area, with unbanded bird.
   25 June 1967, seen in copulation; this bird the male; seen similarly several times 1967 and 1968. 27 July 1967, with nest, 3 eggs.
   Therefore a male can breed in its second year.
3. E61436 (-.W/A) banded as a two-week-old chick 24 October 1965.
   1 November 1966: One of a breeding pair, with two chicks; clap-trapped and bands examined; incubation of its eggs must have started at least 1 October 1966.
   7 June 1971: A female as seen in copulation.
   Therefore it is possible for a female to breed at the end of its first year.
4. E61561 (A/B.R/B) hatched c. 7 September 1966, banded 22 September 1966. Seen (a male) copulating with unbanded bird on 30 July 1967 at age of approximately 10 months. Copulation preceded by nest-building activities, but no nest eventuated at this site.
   Therefore a male will attempt copulation at approximately 10 months.

3.22 *Pair bond:*

By the end of 1966 seven breeding pairs had been banded, in 1967 twelve further pairs, and in 1968 eight more pairs. No further data were obtained from 9 of these 27 pairs. The subsequent history of the remaining 18 pairs is indicated in Fig. 13.

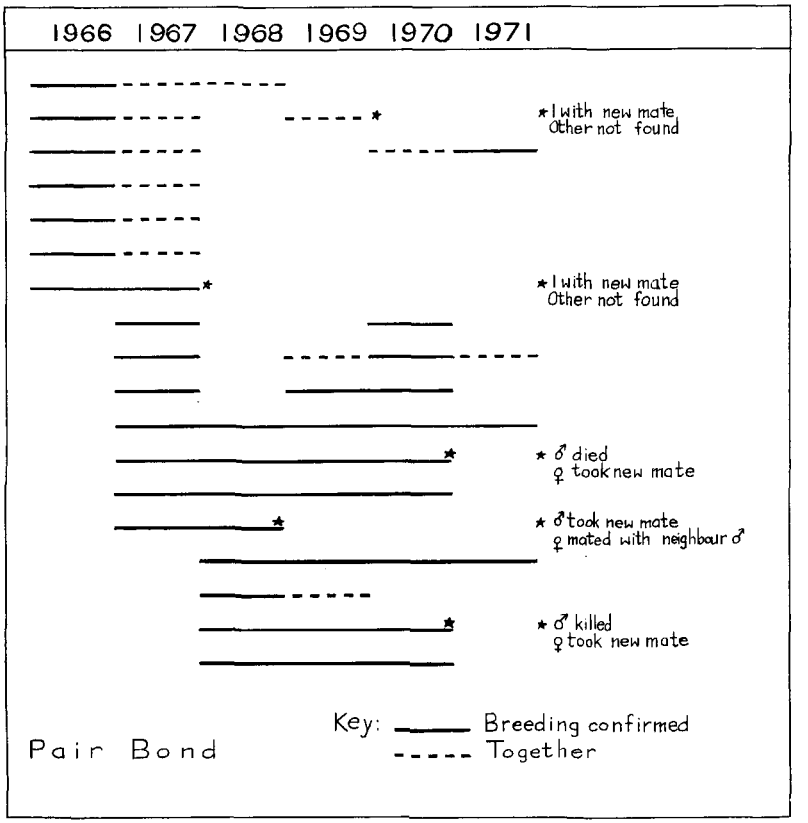

FIGURE 13: Pair bond.

Of the five cases of change of mate, only one was the result of a known "divorce." In this case the female mated with a neighbouring male for a season, the male taking a new (unbanded) mate. The female bred successfully with the neighbour male for the season then disappeared. This (neighbour) male bred with an unbanded bird in 1967 and again in 1969 and 1970. It is not known if this was a frank exchange of mates for a season.

In three other cases of change of mate, the "old" mate was not seen again. It must be assumed that some if not all of these birds died, and the change of mate was due to death of the previous mate.

The two remaining cases occurred in 1970, and we were able to discover the circumstances.

The first of these pairs had been together for at least four years (this was in fact the pair concerned with the double-brood). They bred in 1970, but when the chicks were two days old it was noted that the male looked bunched and unwell. He was not seen again alive, and the dessicated corpse was found after a close search of the area a month later. In the meantime the chicks disappeared (apparently died), and the female took a new mate. 15 days after she was last sighted with the original mate and the chicks, she was seen in a "new" (to her) area adjoining her usual territory, with a new mate; 6 days later their nest with a single egg was found.

The second pair had been together for at least three years. In 1970 they nested in rough ground across a road from the wet area where they usually raised their brood. After hatching, they were apparently shepherding the brood across the road when the male was hit by a car and killed. By simple good luck, one of the study team was driving along the same road shortly afterwards and found the dead but still warm bird, with the agitated female and brood in the grass on the road verge. Two days later the female was seen with the brood in the wet paddock. Twelve days later again (14 days after the death of the male) there was no sign of the brood, and the female was seen near the boundary of her usual territory copulating with a " new " male. (We cannot resist commenting on the promptness with which these two females acquired new mates, after their known long and continual association with the previous mates. They did not " sweat and whine about their condition," but got on with the business of living; perhaps just another example of the adaptability of the species !) It is also interesting that both these episodes occurred at the height of the breeding season, in a part of the study block where most birds were banded and breeding areas closely adhered to. " Strange " birds were seldom seen in this area over the years. The question of where the new mates came from can only be speculated upon. One, certainly, was a stiff, unusual-looking bird, recognisable by his peculiar stance, and had not been seen in the area before.

3.23 *Longevity:*

Between 1959 and 1965 113 chicks were banded with single aluminium bands (Kinsky 1960-62) (C. J. R. Robertson pers. comm.). The 1959 birds were the first of the species to be banded in New Zealand. All were banded in Southland. Between 1966 and 1968 14 other unfledged birds were banded in Otago and Southland. In the course of the present study 388 birds have been banded. Of these 269 were unfledged chicks and 119 were adults.

Some of the unfledged chicks were of known hatch-date and therefore of known age. As fledging age is approximately eight weeks, age of all birds banded as chicks is known to within eight weeks.

Of 119 adults banded, three were birds which had previously been banded as chicks.

Therefore, 396 birds of known age to within eight weeks have been banded to date. Two birds give particular information on longevity: *1.* No. 5813 banded as a chick on 9 November 1961 by R. R. Sutton; nest-trapped 13 September 1967 as a breeding adult, and was found to be a male as seen in copulation 27 June 1971. The latest sighting was as a breeding bird on 10 October 1971, aged 9 years 11 months; and, *2.* No. 4101 banded as a chick on 16 October 1960 by Mrs Olga Sansom, nest-trapped 19 October 1968 as a breeding adult, sex unknown, aged eight years old.

The passage of time should provide more conclusive evidence of the longevity of the species.

4. SUMMARY OF RESULTS

Nest areas were generally where there were no farm animals or human interference; nests were in open positions, with some roughness of ground or vegetation for camouflage, where the incubating birds had an uninterrupted view in all directions.

Copulation and egglaying times varied from 14 days to 2 days before and one day after the first egg. Nest building was noted up to 12 days before the first egg. Average clutch size was 3.74. The clutch size was not affected by rainfall.

FIGURE 14: Rigorous weather was no barrier to successful breeding. Snow falls and frosts up to 11 degrees Celsius did not disrupt nesting.

Photo: R. R. Sutton

Incubation was shared between the male and the female by day. Laying was from June to November with the peak in August. Re-nesting occurred after nest or brood loss. One record of double brood was made. Incubation period was from 30 to 31 days.

Hatching success was 73.9%. In unhatched eggs 50% contained embryos. Live chicks were produced from 49.8% of the nests. Chick mortality in the first 14 days was high, the true survival rate probably being about 25%. The mean hatch weight was 20.5 g. The fledging age was 7 to 8 weeks. Fledged juveniles remained with their parents until 7 or 8 months old.

The breeding cycle occupied the birds for 11 months of the year. Females can breed at one year old and males in their second year. Some evidence was found of pair bonds lasting until death of one partner. Longevity reached to nearly 10 years.

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