of Robertson Bay. It seems, that except possibly at Cape Adare, none of the rookeries in the Ross Sea region occupy all the bare-rock space available for colonisation.

Balleny Islands: Commander Price Lewis, Jnr., captain of the U.S.S. *Staten Island,* has informed me verbally that he spent some days cruising in the vicinity of the Balleny Islands in January, 1959, while *en route* to Wilkes Station, and that a large number of Adelie Penguin rookeries were discovered there during helicopter reconnaissance flights in company with Dr. W. Sladen. Chin-strap Penguins *(Pygoscelis antarctica)* were observed, this being the first record of their occurrence in the Ross Sea sector of the Antarctic.

ACKNOWLEDGEMENTS

Most of the field work was made possible by sea and air transport generously provided by the U.S. Navy and the United States Antarctic Program scientists in the best spirit of international co-operation and assistance. Captain E. S. McDonald, Captain J. Cadwalader and Commander Price Lewis took a special interest in the geological and surveying work from which these notes on penguins are a by-product. Thanks are also extended to many Antarctic biologists for discussions about wild-life matters, and for a free exchange of views and information, particularly Drs. W. Sladen and R. Goldsmith, and Messrs. G. Caughley, J. Dearborn, H. Dewitt and R. Penney.

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KEAS AT ARTHURS PASS

By J. R. JACKSON

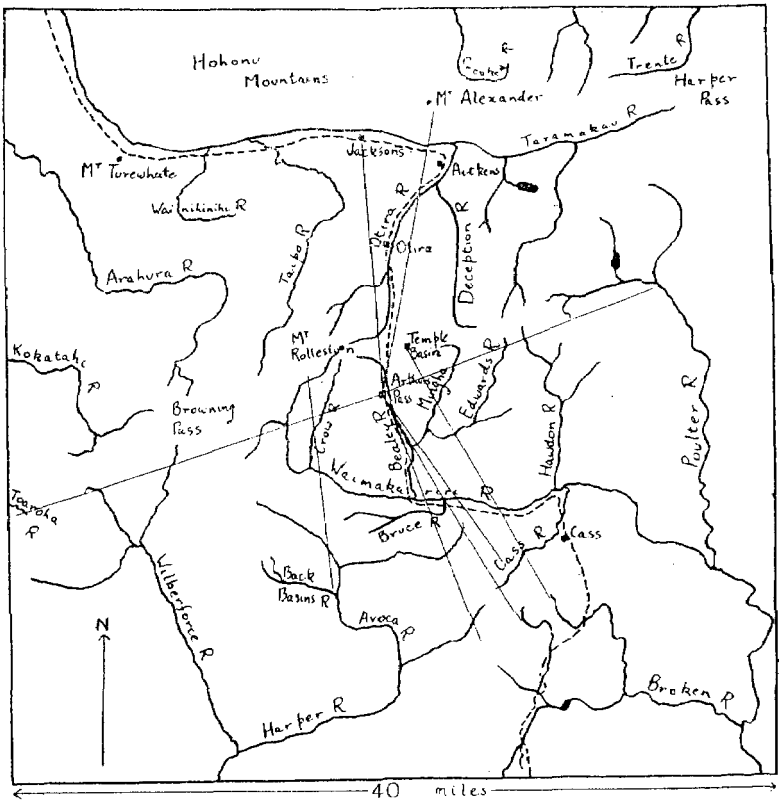
INTRODUCTION

In the years 1956 and 1957, 213 Keas *(Nestor notabilis)* were banded in Arthurs Pass National Park. There were 224 recoveries of 115 different birds, 94 recaptured and 130 by sight. For a sight record the band number was read either with the naked eye or through binoculars*. Where relevant I have included observations made in 1958, 1959 and 1960. The field work was done during 5 days in 1956 and 53 in 1957 well distributed through the year as the first line Table 3 shows.

The area studied is east of the alpine divide in Canterbury (see map). Up to 4500ft. is a forest of mountain beech *(Nothofagus cliffortioides)* and above is alpine tussock grassland and rock to the permanent snowfields above 6500ft. The highest peak is Mt. Rolleston (7453ft.) and all the dividing ridges rise to about 6000ft.

Previously I spent 7 years on the West Coast, where the Keas' range is in a different environment, in the Westland forest, a mixed forest with totara *(Podocarpus hallii),* miro *(Podocarpus ferrugineus),* rata *(Metrosideros lucida)* and *Dracophyllum traversii,* important trees for the kea. The Westland forest is found over Arthurs Pass in the Otira Valley.

* Below "seen" indicates a sight record.



Distant Recoveries _____ Main West Coast Road — — — —

This account describes territory, food and an estimate of population. Mating and nesting behaviour, productivity and mortality, and sheep killing will be dealt with elsewhere.

METHODS

Most of the Keas have been caught and banded at Arthurs Pass township (2420ft.) or three miles away at Temple Basin (4500ft.) in winter time when they are hungry and easily attracted with butter as bait; indeed the refuse in the rubbish dumps has already attracted them as scavengers to these places. I have also made several trips further afield especially to the Crow Valley and the Edwards Valley, where some idea of their dispersal from the Arthurs Pass-Temple Basin area has been obtained.

The Keas were caught both by hand and with a snare. To snare them a semicircle of stones, like a fireplace, is made and the snare and the main bait laid on the floor. This prevents the Keas from taking the main bait except by walking over the snare. Outer baits

are put on the semicircle, prominent stones nearby and about me to keep a large group of interested Keas about, for then they are more bold.

A Kea soon learns that if it takes the main bait it may be snared but that the outer baits can be taken with impunity. This introduces a bias, compensated by the many sight records of Keas taking outer baits. A more serious failure has been the missing of many adult females as they seldom wander far from their nests.

For example, the pair 26967 ♂ and 35007 ♀ have their nest half-a-mile horizontally and 2000ft. above Arthurs Pass. 26967 was banded in 1956 and has since (until 31/12/59) been seen on 29 days at Arthurs Pass. 35007 has been seen at Arthurs Pass on the occasion when she was banded in 1957 and once later the same winter.

In summer it is necessary to search a wide area until a flock of young Keas is found. A deer carcase is a good magnet. In a few days Keas will have found it and at daybreak and nightfall the flock will return to feast.

TERRITORY

In 1957 I established the territory or location of seven pairs of Keas. This territory is centred about the nest and the nearby roost. They feed within one or two miles of their nest, except that occasionally in winter, and in summer if they fail to nest, they may forage further afield. In the early afternoon on most days throughout the year the hen will be in the tree-tops close to the nest, sunning herself. The cock will be further away but within earshot.

A pair of Keas will join a flock while it is in their territory or that of neighbouring pairs, but the pair will return to its own roost each night. When I have camped by a nest I always see the hen. So on each of eleven occasions in 1957 when I camped by the nest at the head of the Crow Valley I saw the hen 34254 and usually a second bird was about, sometimes identified as 34259, her mate. On three brief visits of an hour or so I failed to see them by the nest. On one of these occasions, 12/7/57, they joined a flock in a neighbouring territory, 3 miles away. I did not see them on both 26/10/57 and 15/11/57, a season when adults are timid and usually seen flying at 4 a.m. about daybreak and not later in the day.

A pair does not mind other Keas within 25 yards of their nest. If there are chicks in the nest, visiting Keas are intensely interested in the chicks' calls.

Yet a frequent call is the territorial call, also used as a threat to a man walking along the road, or even a railcar passing by. A pair perched in the tree-tops high on the valley walls will see another family flying along the valley below them, or the neighbouring hen flying into her nest across the valley, when they will give the "Kua-ua-ua-ua" call.

A similar call, "kuer" is used by a Kea flying in search of its mate in the tree-tops, to elicit a response. Or as a Kea settles to roost "kuer" draws replies from its neighbours and shows all is well.

On one occasion I saw an aerial chase. The pair, 34259 ♂ and 34254 ♀, and a third Kea, 35040 ♀, were in the open near the nest. 34254 flew into the forest to the nest. 35040 sidled up and chickened to 34259. 34254 immediately flew out and the three birds took flight

to a perch 200 yards away. Floating down the valley out of the mist came a fourth Kea, presumably 35040's mate, and when close to the perched Keas they all took flight. A hectic aerial chase of the two cock birds followed for two or three minutes. All the birds settled together for several minutes, flew away quietly and were lost.

FOOD

Young leaves and buds of forest trees form the main food of Keas. At all seasons they spend much time in the tree-tops (at Arthurs Pass in mountain beech) steadily and slowly picking buds; or they may strip a twig of leaves, rest and preen, vary their activity by walking along the branches instead of over the leaves, and sample bark, moss and the lichen *(Usnea)*. Or they may turn their attention to soft rotten twigs in which they find grubs and beetles. Only once, possibly a displacement activity, have I seen them ripping up slightly decayed wood. Several Keas were lined along a log while I was below it, ready to catch any Kea which jumped down and took a bait. The Kea opposite me would take possession of the log a yard on either side of the bait and eye the bait and me. Some, fearful of jumping down close to me as I waited to catch them by hand, would turn their attention to the log, rip it up as a Kaka *(Nestor meridionalis)* does solid timber and after a minute or so run back and jump down.

After examining the crown of a tree a Kea glides silently two or three feet above the tree-tops to another tree. After some hours in the trees the flock, or pair, of Keas rises with the "kea" flight call and may fly to an alpine meadow, or a grassy bank by a stream. There they will eat the leaves of the herbs and grasses, roll the moss off stones or roll stones over looking for grubs or succulent roots. In autum and spring they root out the large Celmisias (as *C. coriacea* and *C. spectabilis*) and eat the roots.

For a few short weeks in January nectar flows and the Keas feast. At daybreak they fly to a favourite patch of mountain flax *(Phormium colensoi)* or to a rata tree and feed for several hours. Both of these important blossoms are unreliable. Not infrequently the flax over large areas fails to flower, and rata is notorious for its blossom being ruined by heavy rain. If so the Keas turn to smaller flowers as *Celmisia discolor*. They pick the whole flower, chew it and spit it out.

Then the berries ripen. Snow totara *(Podocarpus nivalis)* is the most important fruit. In a good year it is the main food from January until it is buried in snow. During the winter the plants alongside a stream are often uncovered, when they are searched again. Next September or October in the thaw, a few shrivelled berries remain and are again an important food. However, totara fails in wet seasons, for it is wind-pollinated. In the alpine meadows are several other fruits as *Leucopogon fraseri* which is always taken, *Pentachondra pumila* which is sampled but usually not eaten extensively, and *Coprosma repens*. The snowberry *(Gaultheria antipoda)* is eaten when the others fail. It is perhaps significant that the favoured berries are large (to

½ inch diameter) and red (*Leucopogon* is orange) and the less favoured snowberry white and the Kea is the only animal which takes these fruits*.

I have not seen Keas feeding on seeds, though Potts (1882) records them as feeding on kowhai *(Sophora tetraptera)* seeds. In captivity they are adept at removing the seed coat from peas, or apple pips, or the stone from the kernels of plums and eating the cotyledons. This skill would seem to have little importance in the wild as there are few large seeds.

In winter, green droppings of bile indicate that many juvenile Keas are starving. At this season Keas feed at a lower altitude and often on the forest floor. They take such unattractive berries as *Coprosma pseudocuneata,* neglected by Blackbirds *(Turdus merula).* When snow falls to low levels they find some food as the mosses around shelter boulders and plants in any small trickle of water. Keas are not seen above the bushline now, except around the ski-huts where they congregate.

At Temple Basin (4500 ft.) and 1500 ft. above the low bushline of Arthurs Pass (the pass) table 4 shows a rapid turnover of Keas, almost complete from one three-week period to the next, indicating that at this altitude the climate is too hard. This can be seen by the small fraction of Keas recovered and by comparing the numbers released with the numbers entered in first horizontal row of diamonds, comparing those released with those seen next time, i.e. on 31/8/57 twenty were released; five had been seen a week earlier on 25/8/57 and two were seen a fortnight later on 13/9/57. One of these two Keas had been seen on 25/8/57. Now the week 25/8/57 - 31/8/57 was fine and many people were at a ski school, so less turnover than usual might be expected. At the beginning of winter the Keas take a month or so to find the well-supplied dumps at Temple Basin so very few will be seen there during April, May and early June.

On a fine day the Keas enjoy the snow. One will take a puddle from the Black-backed Gulls *(Larus dominicanus),* others will join it and tread the mud but soon tire. The Keas may then fly on to the snow and wrestle, rolling over and getting well covered in snow. In the different conditions of a thaw they will wash in the puddles like Blackbirds. When feeding among snow Keas frequently eat snow though flowing water is close at hand.

In early spring Keas spend much time high on the alpine grasslands 1000 ft. or more above the bushline and feed on the smaller grasses and herbs.

In all its feeding the beak is used carefully and slowly. The upper mandible is a lever and the lower a gouge. The lower scrapes forward, if necessary with the tongue a little ahead pushing the food into the hollow of the upper mandible, where it is tested, if liked rolled into the cup of the mouth and consumed.

* The Paradise Duck (Tadorna variegata) feeds on Leucopogon growing on the river flats at lower altitudes.

TABLE 1

A Kea's Year

January	A plentiful supply of nectar and berries. Last eggs being laid. The main fledging period. First year birds in flocks c. 20.
February	Feeding on berries. Last eggs hatching.
March	Much time spent on steep faces. Adults moulting, so feathers about the roost.
April	Celmisia being rooted out. Flocks descending in the forest.
May	Last chicks being fledged. Larger flocks breaking up into parties of c. 6 Keas.
June	First year birds becoming hungry and flocks constantly moving. Feeding on *Coprosma pseudocuneata* berries.
July	Heavy falls of snow cover much ground and Keas feed in the forest and on the forest floor. First eggs laid (corresponds to Marriner, 1908).
August	In fine weather Keas high in the alps feeding on grasses. Gathering into larger flocks.
September	Weather less settled. During the frequent spells of bad weather most Keas of the winter scavenging. First year Keas beginning to moult.
October	Peak of laying. Adults very shy and quiet. Flocks dispersing. Some first-year birds wander 15 miles.
November	Mature second and third-year birds may leave the location where they spent the winter and move several miles to a permanent territory.
December	Earliest fledglings I have noticed. Most adult females are either with a clutch or building a nest.

MOVEMENTS

Keas are essentially forest birds and their conspicuousness gives a deceptive impression of the extent to which they are found above the bushline. Once I saw a pair rolling stones on a steep face at 6000 ft. and the adult Keas from the Mingha Valley have crossed the 6000 ft. ridge to the ski-huts at Temple Basin on several occasions. However, this is not normal as shown by the fact that all the totara berries may have been stripped from the bushes at the bushline, but 500 ft. up they will be untouched and remain until next spring. Again, the nest by the Crow hut is less than two miles from Arthurs Pass, but separated by a 6000 ft. ridge. The pair of this nest has not been seen at Arthurs Pass but was seen on the Bealey face of Mt. Rolleston (Arthurs Pass is 3 miles down the Bealey Valley) on 1/2/58, a season when they failed to nest. Confirmation of this avoidance of altitudes above 5000 ft. is found in the dispersal from the Bealey Valley. Few banded Keas have crossed the ridge from the Bealey into the Crow Valley, and to my knowledge none over Mt. Rolleston into

the Rolleston Valley or beyond to the Taipo Valley. They have flown down the Bealey Valley into the main Waimakariri Valley and wandered up and down the Waimakariri Valley and over its Ice Age distributary channels into other valley systems. These facts have to be kept in mind in considering movements in terms of straight-line mileages.

The first-year Keas at Arthurs Pass in winter have been drawn certainly from eight miles, and perhaps from fifteen miles. The surrounding countryside is stripped almost completely of first-year Keas; I have frequently failed to find them; for they are almost all around the ski-huts or in the townships. Later when they disperse from Arthurs Pass they may fly out 15 miles in any direction, giving a possible movement of 30 miles.

In winter, away from Arthurs Pass-Temple Basin only adults can be found still on their territory, though occasionally they may wander, certainly five miles, possibly fifteen miles and be away all day.

TABLE 2

Records of Distant Recoveries

(assumed to be from Arthur Pass when a banded bird has been seen but the number not read)

From	*To*	*Distance*
34251 Waimakariri Falls, 2/2/57	Back Basins Hut, 24/6/57	13½ miles
— Arthurs Pass, /9/56	Black Stream, /7/57	16 ,,
26785 Arthurs Pass, 4/8/57	Jacksons, 10/8/57	14 ,,
— Arthurs Pass —	Poulter Hut, /10/57	16 ,,
— Arthurs Pass, /10/57	Cass, /10/57	12 ,,
26957 Temple Basin, /8/56	Craigieburn Ski Field 16/3/58	16 ,,
— Arthurs Pass —	Head of Toaroha Valley /10/59	20 ,,
At least 2 among 6 Arthurs Pass —	Aickens Face, Mt. Alexander 22/11/59	15 ,,
26934 Arthurs Pass, 22/9/56	Craigieburn Range, Mt. Algidus Station 16/12/59	16 ,,
35088 Arthurs Pass, 28/9/58	Zit Saddle, Toaroha Valley /2/60	20 ,,
— Arthurs Pass —	Pinnacle Creek, Kokatahi Valley /2/60	20 ,,
— Arthurs Pass —	Brian O'Lynn, Haupiri Valley 14/5/60	23 ,,

26926 ♂ and 269__ ♀ (the Edwards roche moutonne pair) were seen at Arthurs Pass, five miles from their nest, on the morning of 26/10/57, and later that afternoon at Temple Basin.

26785 ♀ adult, was banded at Arthurs Pass 4/8/57 and shot at Jacksons, 14 miles away 10/8/57. Probably her nest was near Jacksons and she flew this fourteen miles up the Taramakau Valley and the Otira Valley, over Arthurs Pass and down the Bealey Valley to Arthurs Pass township and back in one day. This 28-mile flight would be little further than that of the pair from the Edwards roche moutonne.

Many Keas have been seen at both Arthurs Pass and three miles away at Temple Basin in one day. 34251 was seen three miles up Back Basins Creek on 26/6/57 and that evening at Back Basins hut where the creek joins the Avoca River.

On 11/10/58 a pair of Keas flew from by the Bruce hut across the Waimakariri Valley, two and a half thousand feet above the river to Mt. Bealey, a distance of three miles in one flight.

All the above are voluntary flights. Rather different are movements of birds caught in storms as a Kea I saw at Greymouth on the morning of 17/4/55 after a night of strong north-east winds and rain. This bird may have been blown eight miles from the Paparoa Mountains, but more probably sixteen miles from the Hohonu Mountains. The bird was lost in the clouds over Boddytown, when flying in the direction of the Hohonu Mountains.

Such loss of direction by Keas must be infrequent as they are adapted to live in a region of high winds and storms. A family enjoys playing on the gusts which precede a storm two or three minutes away, and only takes shelter from the rain. Young Keas soon become highly experienced in using the winds to best advantage.

The population estimates of table 3 contain evidence that in late winter Keas are coming into Arthurs Pass from one and a half times the distance of early winter. For instance on 23/6/57 89 was the population and on 3/8/57, 156. If these populations are for similar areas it is necessary to take the square root of the ratio to obtain the ratio of distances

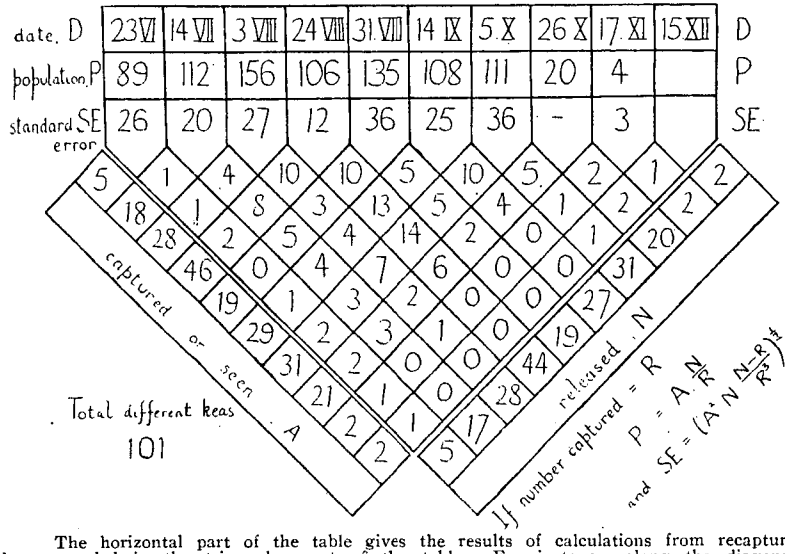
and $$\sqrt{\frac{156}{89}} = 1.3$$

or more accurately 1.32 ± 0.23

or if, as below the area is regarded as a valley of constant width 1.75 ± 0.61

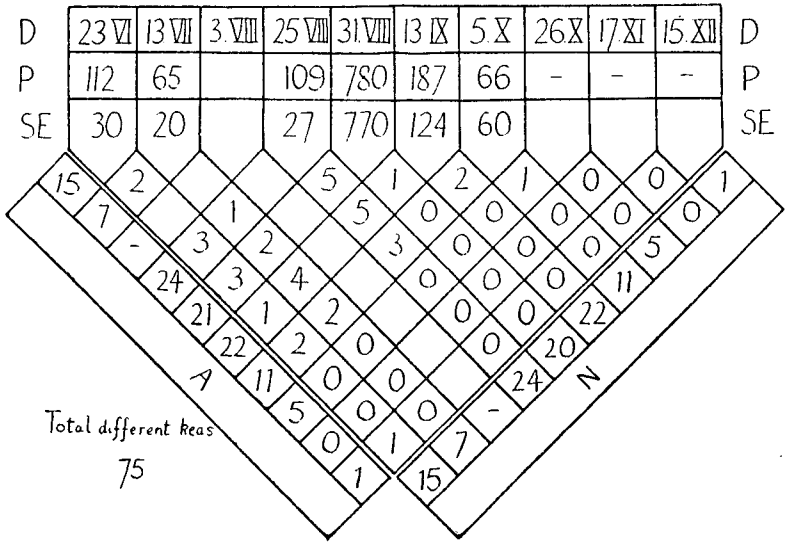
One and a half is included in these estimates.

TABLE 3
Recaptures at Arthur's Pass, 1957



The horizontal part of the table gives the results of calculations from recapture data recorded in the triangular part of the table. For instance, along the diagonal vertically below 31/8/ and running from NE to SW we read for the week-end 31/8/, 19 different birds were captured or seen; there were no recaptures of 23/6/ birds, 5 of 14/7/, 3 of 3/8/, and 10 of 24/8/. Along the NW - SE diagonal we read that 5 31/8/ birds were seen on 14/9/, 5 on 5/10/, 2 on 26/10/ and none later and also that 19 were released.

TABLE 4
Recaptures at Temple Basin, 1957



POPULATION

I have estimated the number of Keas which are attracted to the settled areas of Arthurs Pass-Temple Basin in a winter

1. by internal analysis of 1957 results

and 2. by comparison of 1956 and 1957 results
both calculated from the Lincoln index after Dowdeswell, Fisher and Ford (1940) and with standard errors calculated with the formula given by Bailey (1951) (see tables 3-6). Unfortunately, one premise of the method is not obeyed, namely that there be no migration into or out of the area, so the results may be too large but alternative methods of estimation show that this error is small.

By internal analysis for Arthurs Pass-Temple Basin the largest monthly total is 201 with a standard error of 33 and by the comparison 327 with an error of 60. The latter is for a longer period of time and requires correction for births and deaths. If my estimate of the annual survival rate, 2/3 is used

$$\text{then } 1956 \text{ population} = 2/3 \quad (327 \pm 60)$$
$$= \quad 218 \pm 40.$$

Independent evidence for this rate will be presented elsewhere. A comparison of 201 and 218 suggests that few Keas move far, so far that they do not return to feed in winter.

If this population is thought of as part of that within a 15-mile radius of the centre, Arthurs Pass-Temple Basin (the approximate distance of the furthest recoveries) it can be checked by a third method. If the facts are simplified by assuming that all Keas at the centre are banded and none at the circumference, and that the proportion of banded Keas decreases linearly with distance from the centre, then doubling the number banded will give the population as approximately 450 Keas. Actually comparison of the population estimates with the total number of birds identified shows that nearly all are banded at the centre (see tables 3 - 5) and table 2 shows the small number banded at the circumference. The results I have show a more rapid decrease of proportion than linear, so 450 is a low estimate.

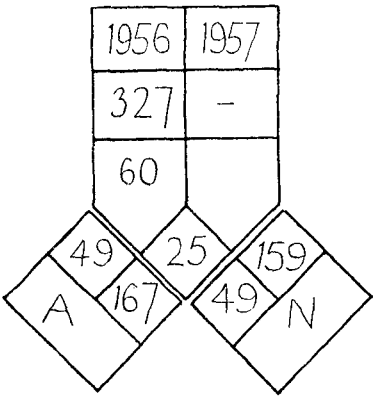
TABLE 5

Recaptures at Arthur's Pass and Temple Basin, 1957
Total Different Keas 161

D	23.VI	14.VII	3.VIII	24.VIII	31.VIII	14.IX	5.X	26.X	17.XI	15.XII	D
P	131	140	201	161	181	152	104	24	4	-	P
SE	19	19	33	16	34	27	27	-	3		SE

TABLE 6

Recaptures at Arthur's Pass and Temple Basin, 1956 and 1957



Now taking 450 Keas as the population for a circle of 15-mile radius gives a density of 2/3 Kea per square mile (approximately 1 Kea per square mile); if for a circle of 10-mile radius $1\frac{1}{2}$ Kea per square mile. Confirmation can be obtained from the density of nests which I have found to be about 1 nest per 4 square miles.

(a) In the Crow Valley where there were in 1957 two pairs, 2 miles apart. The width of the valley is two miles so the territory is 4 square miles, and in this territory live the adult pair and juvenile birds.

and (b) In the Edwards Valley (excluding the East Edwards Valley which I have not investigated) there were nests at the bottom gorge, at the forks, at the roche moutonne, and by the hut. Besides, I found two other adult hens, not definitely located. So there were four (perhaps six) nests in 14 square miles.

In the Bealey Valley my impression is of a greater density, caused no doubt by the large winter-carrying capacity.

Now from the theory advanced so far the results for Arthurs Pass and Temple Basin; and Arthurs Pass-Temple Basin and the adjusted result from 1956 and 1957 might be expected to be the same, not merely that, but each monthly estimate the same. Actually the tables show a small and fairly static population early in the winter and a larger population in early August when there is more movement. Several of the estimates for early winter both for Arthurs Pass and for Temple Basin are approximately 100. The hundred at Arthurs Pass can be thought of as the population within the rectangle 3 miles up and 3 miles down the Bealey Valley (the distance of single flights and the distance adult pairs have frequently been found away from their nests when in flocks in neighbouring territories) or 6 miles in length and 2 miles across the valley. This is a population of 100 Keas in 12 square miles or a density of 8 Keas per square mile. When Temple Basin is combined with Arthurs Pass the rectangle is 9 miles long so the number of Keas might be expected to be one and one half times as many. Actually Table 5 shows 131 on 23/6/57 which is to

be compared with 89. When further similar comparisons are made it is found that the population for the combined area is rather less (average value 1.37) than one and a half times the population for Arthurs Pass, so 8 Keas per square mile is an overestimate.

Certainly the results show that in a good year between 100 and 200 Keas can be seen at Arthurs Pass and Temple Basin, and further that the density of Keas is between one and eight per square mile. The weight of evidence suggests the true value is nearer the lesser value and indeed the greater value is for the Bealey Valley where my impression is of a great density.

THANKS

I wish to thank the Arthurs Pass National Park Board for permission to band Keas and continued interest in the project; Mr. R. Cleland for continually watching the Keas at Arthurs Pass; Mr. L. Angus for showing me how to snare Keas; Dr. B. I. Hayman for help with the statistics; Mr. E. G. Turbott for several discussions about the paper; and many friends for reports and observations.

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A MIXED SHAG ROOST AT CLEVEDON

By W. L. MOISLEY

On 28/3/60 I noticed that an evening shag roost near my home, known for some years, but not studied, contained four species of shags. The roost is in a small plantation of exotic pine trees on a short steep face above a tidal creek lined with tall mangrove. Flat grassland stretches back from the trees. The birds fly in from the sea about 1½ to 3 miles distant and from the nearby river and maze of mangrove-bordered creeks. This roost shows no sign of ever having been used for nesting.

After it had been noted that the birds came in to roost from late afternoon to dusk, counts were made and notes taken for the six days March 30 to April 4 and on April 14, 18 and 19. In this I was assisted several times by H. R. McKenzie and on separate occasions also by Messrs. A. Blackburn, F. M. Brookfield and W. W. Renouf. Some of my observations were made from in the top of a totara tree, where I could command the bend in the creek and the face of the crescent of pine trees. The birds could see me but did not mind. Perhaps they thought I was another kind of shag with an odd choice of roosting tree. Most of the watching was done from a large hide I made in the mangroves, while I did some close study from a rough hide of branches right under the birds. Notes of the weather and tides were kept but the roosting was not affected by them.

The counting was exciting as dusk approached. Fifteen to twenty birds of perhaps three or four species would come in at once,