Bittern. The ventral area behind breast collar was buff, striped with light brown. Its "baggy pants" were light with very distinct wavy dark lengthwise lines about an eighth of an inch wide. Tail: straggly. Legs: bright green. Bill: horn coloured, with dark culmen; noticeably small.

It is thought that sufficient change of plumage and leg and bill colour from mid-June to Sept. 17 has been observed to merit the assumption that this bird, if the same one, may well be a young female changing into full feather. It must also be noted that every change of position causes a change of plumage pattern and that even the bill and legs can look different according to the light, so that a sighting at any one time may not necessarily appear quite the same as given in text-books. Dr. W. R. B. Oliver, "New Zealand Birds," p. 398, makes generous allowance for its difference from the species or sub-species in other countries.

[The Little Bittern is one of the most unknown birds on the New Zealand list. According to the Checklist (1953) and Oliver (1955), there is only one acceptable record for the North Island, viz. Tauranga 1836; and there seem to be no twentieth century records at all for the whole country.

The big swamps of the lower Waikato, now partly a forest of willow and alder, would seem to be an ideal habitat, seldom penetrated by man. It is of some interest therefore that Mr. R. T. Adams, an assistant game-officer, made the following report, dated 2/11/60, from which we quote with permission, to the Controller of Wildlife. "On 28/10/62 at about 9 a.m. I saw at Steed's Swamp, Kopuku, what I believe was a Little Bittern. . . . It was standing on some exposed mud. I had time for a quick look before the bird turned and stalked into a stand of spiked rush *(Eleocharis).* It appeared to be a little bigger than half the size of the common Brown Bittern; and the only difference I could distinguish was that the top of the head and the back of its neck were a darker colour. Many Brown Bitterns frequent this swamp and it may be that what I saw was an unusually small specimen. However the turning and stalking into the stand of spiked rush are not in my experience in keeping with the ordinary Bittern's habit."

Meremere is only a few miles from Kopuku, and swamps extend all the way. — Ed.]

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THE NESTING OF KEAS

By J. R. JACKSON

The nesting of Keas *(Nestor notabilis)* has been described by Potts (1882), Marriner (1908) and more recently McCaskill (1954). McCaskill indicates some of the earlier confusion by his remark that "until recently it has also been assumed that the nest always occurred in rocky country usually well above the bushline." This confusion has arisen through careless reading of the earlier work which exaggerated the difficulty of reaching the nests. In this paper I describe the nesting of Keas about Arthurs Pass as I have found it. During the last seven years I have found 36 Kea nests, have observed a Kaka *(Nestor meridionalis)* nest, Jackson (1936), and have also found a second Kaka nest.

THE NEST LOCATION

Keas nest on the ground under a boulder, in a crevice, in a hollow log or among the roots of a tree. Most often the boulder is part of a Pleistocene moraine, now hidden within the forest; it may be an avalanche boulder carried down by the larger avalanches of the past; or a boulder at the top of an avalanche gully whose head has been captured by another stream. Crevices by rocky outcrops breaking the forest canopy, and especially crevices in the forest around a slip are used. Often around an active slip there is evidence of a larger slip, now clothed in forest: in crevices near the top of these slips Keas nest. Also at the very top of a slip there is sometimes an undermined earthen lip from whose end a tunnel often continues into the hillside. Keas use these tunnels.

One hen built her first nest on a ledge behind a tree on a cliff-face, but a month later found and built in a crevice 50 feet away. 3/12/61 I found a second-year cock "playing" at building a nest in a hollow tree. He entered on the underside of the trunk 4 feet up, where a branch had broken out, walked along a foot and dropped to the nest in the heart of the tree, a site similar to that of a Kaka nest.

As mentioned a slip nest is near the top of the slip, perhaps for good drainage or to obtain a wide view. Also a moraine nest is often under an odd erratic boulder, 10 or 20 feet above the general level of the moraine. The site may also be selected where the larger avalanches have left their trace in boulders on the hillside above the vertex of an avalanche fan.

At the entrance of a nest is a characteristic well-worn runway leading through a narrow entrance to a wider chamber 3 to 20 feet back, where the nest is built of the epiphytic lichens, *Usnea barbata* and *Anzea*, moss and ferns, twigs, leaves and small rotten pieces of wood. When nesting in a log Keas use wood chips picked off the log, like Kakas in a hollow tree.

The cock uses a small stone around the side of the nest boulder as a roost while the hen is incubating, and when chicks are in the nest. Later, when the chicks are two months old the hen roosts here; she also roosts here before nesting. Often there is a large accumulation of droppings, 4 or 5 inches deep and in quantity about a cubic foot, around the stone — an accumulation of several years and perhaps of several successive birds.

By the nest boulder there is generally a rocky promontory breaking the forest canopy or less often a prominent dead tree. The hen when impatient for the return of the cock runs out on to the promontory, and looks and calls. Some hens, if the observer sits on their promontory while they are nesting, get very excited. They fly in a zig-zag flight close over or around under the promontory, swing out 100 yards on either side and call loudly all the time, perhaps a quarter of an hour. The cock during this display remains further back.

The nest is usually near an edge of the forest, by a slip, by an alpine meadow or a pakihi. Many of the feeding ceremonies, for preference, occur in this open ground rather than in the forest.

I have found nests between 2000 and 4000 feet above sea level; thirty-two nests were in mountain beech forest, one in Westland rain-forest and three in subalpine scrub. In the head of a Canterbury valley the beech-forest is perpendicular to the valley so it is often 1000 feet higher on the valley walls than on the floor. Upstream of

the beech forest sub-alpine scrub grows on the valley walls below 4000 to 4500 feet and tussock clothes the floor. The beech forest, *Nothofagus cliffortioides,* has not invaded the very head of the valley which is occupied by subalpine scrub, (Phyllocladus, Coprosma, Dracophyllum, Hebe and Olearia species). Keas nest in the beech forest and more sparsely in the sub-alpine scrub. In Westland Keas usually nest well down in the rata *(Metrosideros lucida)* forest and less commonly in the *Dracophyllum traversii - Libocedrus bidwilli* forest above.

They avoid cold localities as down near the stream in a narrow gorge, or a steep southerly face. Only two nests of the thirty-six have had a southerly aspect (actually both south-easterly). This preference for warm faces is confirmed by the many Kea hens which I have located but whose nest I have not found.

In two instances an old hen disappeared and was replaced by a new hen who selected her new nest within 25 yards of the old nest. Another nest I found by watching two young birds building. The next year a third-year hen built in the nest. This hen disappeared in the following spring and the nest has been used by another young hen during the last two years.

NESTING STATISTICS

Laying occurs between July and January (Table 1):

Table 1

Month laid	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Number of nests	4	4	3	1	2	3	3

The laying of Keas in different months. The number has been deduced from the hatching of eggs or the age of chicks and partially confirmed by Table 2.

Table 2

Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.
Number banded	4	5	17	16	5	31	27	6	4	1	1

The banding of recently fledged Keas. The entries in this table are 4, 5 or 6 months behind those of Table 1. Unfortunately the classing of a Kea as "recently fledged" is not as definite as the aging of nestlings so deductions from Table 2 must be made with caution.

Both tables show a protracted laying period, certainly from July to January inclusive and perhaps occasionally February and March. Keas do not seem to lay in late autumn. Both tables show an early peak of laying in July-August: Table 1 shows a gradual decrease of laying whereas Table 2 suggests that there is a constant rate of laying until the end of December and then a sharp decrease.

The clutch is between two and four eggs, with an average of 2.5 eggs per clutch. (Table 3).

Table 3

						Total
Clutch deduced	2	3	4			50
Number of nests	11	8	1			20

The clutch. The clutch has been deduced from chicks and eggs in the nests so may actually be larger if chicks had already been lost, or addled eggs disappeared.

One complete clutch had not hatched 3 weeks later but had hatched in four weeks. The incubation period is thus more than 3 weeks. The nestling period is 13 weeks. The cock feeds the female fledglings for at least 6 weeks more, after they have left the nest. Young male Keas probably become independent about 4 weeks after fledging when they may have wandered two or three miles.

Table 4

	Number	Average	Rate %
Eggs	50	2.5	100
Chicks	38	1.9	76
Chicks fledged	32	1.6	64

The Success of 20 Kea Nests

The nesting success is shown in Table 4. If only the results from the 8 nests found with eggs are used the averages are 2.4, 0.9, and 0.8 respectively. The near equality of the clutch average and the difference in success may be explained either by the birds being disturbed when the nest is found early or because Keas may sit for a long time on infertile eggs, so there is a greater chance of their being found. Four of the 8 nests were failures. In two cases the eggs were eaten after the nests had been found. Other evidence suggests the Keas had been incubating these eggs for a long time. In the second two cases when the nest was found the eaten remains of the eggs were already there.

I have four instances of a hen nesting in successive years. Generally she adds to her nest, destroys it by scratching it out, perhaps urged by the many fleas, and builds again. One hen built for four years and nested in the fifth year.

A few of the older hens feed their husbands. The cocks are polygamous and feed their nesting wives and the chicks. They also feed the wives who are busy building. The activity of the hens at 36 nests is shown in Table 5.

Table 5

	Nesting	Building	Feeding the Cock
Hens per season	24	49	2
Fraction %	32	65	3

The Activity of Adult Hens

Young hens, at the end of their second year and the beginning of their third year, begin at least one year of building. This is the nest which they normally use for the remainder of their lives. Hens whose husbands have died — a quite common occurrence — spend the season building and other hens, who get little attention from their husbands may also.

If the fledging success and the activity of hens are compared the productivity per adult hen can be calculated:

$$\text{Productivity} = \text{average fledging success} \times \text{fraction of hens nesting}$$

$$= 1.6 \times \frac{32}{100} \text{ fledglings per adult hen per season}$$

$$= 0.5 \text{ fledglings per adult hen per season}$$

In a static population two average parents are replaced by two adult offspring. To produce two adult offspring the hen must fledge at least two chicks and this would require four or more seasons. When the two juvenile years are added the life of the average adult Kea hen must be at least six years.

The Development of Chick Behaviour into Adult Mating Behaviour:

As with many animals the behaviour is foreshadowed in the activity and play of juvenile Keas.

When hatched a chick is helpless, thrown against its brothers and sisters for warmth. If it hears its mother approach it can stand, supported by the other chicks but not yet raise its head. Its mother bends down and gently picks up its beak from one side and feeds it. When three weeks old the chicks still keep together in the nest but now when about to be fed a chick is more vigorous, standing and climbing with its wings as it begs for food. It is still reluctant to raise its head. And so is an adult hen when begging (Jackson, 1963). The wing pose is identical.

Fledgling Keas, just out of the nest, are fed by the cock. They fossick in the underscrub while their parents guard in the tree tops. After a week the hen loses interest; the cock goes further afield to forage; and the chicks play as they await their father's return. On the forest floor they look under boulders at possible nest sites. They select one and climb the trees to gather material for the nest. In the tree tops sunning they steal titbits from each other. Soon they begin flirting. They stand alongside and mutually preen. The sister begs and the brother crosses beaks as he pretends to feed her.

I have seen year-old birds attempt to copulate. Usually it occurs at the whip-end top of a beech tree. The young hen climbs up and stands alongside the cock. She edges up and pushes him further out on the arched-over whip-end. Eventually the cock flies a few yards to the next whip-end. She walks across the foliage to the twig underneath him. She pushes up with her crown against his belly, grasps his leg and bites lightly. He pulls away an inch or two. She follows along her twig under him, sings a nasal subsong and bites again. She straightens up, attempting to throw him on to her back.

On another occasion I saw a young hen fly from the ground to the cock perched on the whip-end. She landed on his back and stood straight-legged, like a circus performer standing on horseback. The cock struggled to keep his balance. She bent forward as if to catch his nape but the cock's movement prevented her. He overbalanced and swung around under the whip-end while she landed on the upper side. He climbed up and jumped into a similar position standing on her back. They separated but came together to preen mutually.

A pair of adult Keas before the laying of the eggs spend much time together in trees by the nest. And here copulation probably occurs.

The play and flirtation of young Keas does not result in the formation of adult pairs. At the end of her second year a hen usually begins following closely a high caste cock. The cock's older wives attempt to drive the young hen away. Together the cock and young

hen spend much time on the forest floor and look for a nest. Sometimes the hen's first choice of nest is poor and she soon moves to a better nest nearby, though occasionally a mile away. When the nest has been chosen and for the next year or two the young hen builds and the cock feeds her.

Other hens mate with a cock of their own age. In December a young hen who has spent two years and moved only five or six miles suddenly begins to wander. Within one or two days she may move ten miles; a storm may drive her back to familiar ground but she does not stay. She will meet a second or third-year cock and they will become mates. The same searching together and building takes place. But the young cock is more elated. When not with his mate he spends much time across the valley opposite her nest, watching. He will call frequently and excitedly as she builds. Sometimes she comes across to him and now the boss Kea of the neighbourhood will join them. The boss stands aside and looks disapproving at the young cock. His hackles are slightly raised. Many of the young cocks do not remain mated to their wives. He moves on but the hen remains, using the nest for her life.

Other less successful hens fail to mate in their second year. Such a hen often spends much time with a hen busy building. It is possible that the young hen learns much from watching the older hen closely.

THE NESTING

After several years building her nest a Kea lays and immediately begins incubating. Indeed for a week or more before laying she spends much time on the nest. The cock may enter the nest to feed her or to shelter but the hen does all the incubation. She leaves the nest for an hour at daybreak and again at nightfall to feed and to be fed by her cock. He may get impatient and attempt to drive her back to the nest away from rich feeding. While she is incubating the cock will attend to his other wives. Or if the cock has only one wife he may feed her about mid-day also.

When the chicks hatch he is nearby and is greatly thrilled at their calls. He coos quietly in reply. For the first month he feeds the hen and she feeds the chicks. Gradually he feeds the chicks directly but he feeds the hen still. She also feeds the chicks. When they are fledged he does all the feeding and the hen soon ceases.

While the chicks are in the nest the hen feeds within twenty-five yards or straight across the valley near her tryst. When the chicks are about to be fledged she spends most of the day in the nest and he stands guard at the mouth. Then a chick escapes and flies a few yards on to a nearby rock gendarme. The hen follows, the chick climbs down into the scrub, while the hen guards. That night and next morning the parents and the fledged chick call and seek to entice the remaining chicks out of the nest, now less closely guarded. And there is necessity to guard the nest and fledglings. At least three of my seventeen nests with chicks have been discovered by falcons *(Falco novae-zealandiae)*. The parents chase the falcons away. Also visiting Keas are very interested in the nestlings and the parents drive them away from the last five yards by the nests with much noise. I suspect that visiting Keas destroyed the young chicks two or three weeks old in one nest.

When two or three weeks fledged, the male chicks follow their

father and meet his other wives. Now a wife who has been building will guard the chick and be his stepmother. The chick begs from her though I have not seen her feed him. They, chick and stepmother, play in flight. She leads him away from danger, calling meanwhile and once in the air they play. The chick dives at her like a falcon. She rolls over and parries the blow. Then the tables are turned. They play in the gusts of a storm, swing around a spur, plunge down into the shelter of a gully and back into the wind on the turbulent air. Several times a day the father returns and feeds the chick.

While the first wife is incubating the cock pays more attention to his other wives. One cock certainly had two wives, both nesting at the same time, the second being four weeks behind the first. Another cock, the boss along three miles of the Bealey Valley, had seven wives. He would roost in the trees near an incubating hen. At daybreak he would feed for two or three hours nearby. During the next five hours he would spend half an hour with each hen, look at her nest to see the progress and feed her. For three or four hours he would rest in the early afternoon and then return to the incubating hen.

This life is very hard and he will be noticed losing condition. In January and February he will still be in old worn plumage, while his wives have new bright green feathers.

HISTORY

Comparing the Kea with the congeneric Kaka there are many differences. And the evidence points to these birds becoming separate species in the Pleistocene, perhaps during the last Glaciation. As Cook Strait did not exist in the Pliocene there was no barrier to prevent interbreeding so separate species could not develop. In the Pleistocene the Kea evolved its specific habits among the glaciers of the South Island.

In the South Island during the Pleistocene Willett (1950) considered "the bushline reached sea level"; Fleming (1962) noted that sub-alpine daisy scrub managed to survive and Wardle (1963) advances reasons for believing a varied forest existed in Otago. This forest was necessary for the Keas' survival. Probably it was on the moraine headlands in small forest remnants that the Kea learnt to come down out of the trees on to the forest floor to feed and also to come out of the forest on to the alpine grasslands. The stunted trees were too small to nest in, but holes among the glacial erratic boulders were a good substitute. It was necessary to carry leaves and other material to build a nest so the Kea remembered an ancestral habit, a habit of *Calyptorhynchus viridis* and some *C. funereus* (North 1912).

At this time the Kea got its flea, *Parapsyllus n.* sp. This genus is a circumpolar genus of marine bird-fleas. In New Zealand these fleas have been found on penguins *(Eudyptula albosignata),* Spotted and Black Shags *(Phalacrocorax punctatus* and *P. carbo),* prions *(Prion turtur)* and muttonbirds *(Puffinus griseus)* besides Keas. It would be interesting to check Blue Ducks *(Hymenolaimus malacorhynchus)* and Kakapos *(Strigops habroptilus).* Among negative results it has been found that neither Kakas nor gulls have these fleas. How did Keas get their flea? Perhaps Black Shags carried it into the mountains but only coastal shags have been found with fleas. Also Mr. F. G. A. M. Smit of the Zoological Museum who identified these fleas, considers the Kea flea a very distinctive member of the genus, related to the muttonbird fleas. During the Ice Age the Kea and muttonbird were brought together

when both nested under erratic boulders in the forest remnants of the headlands. Then the Kea got its flea. And already the Kea was a separate species from the Kaka, which has no flea.

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EXTERNAL FEATURES OF THE TONGUES OF NEW ZEALAND PSITTACIFORMES

By CHARLES McCANN

INTRODUCTION

The structure of the tongue of birds frequently gives some clue to the principal diet and manner of feeding of the species. Its character has a bearing on evolutionary trends and relationships. Salvadori (1891) placed *Nestor* in a separate family, Nestoridae; *Strigops* he also placed in a separate family, Strigopidae, and *Cyanoramphus* in the family Psittacidae, subfamily, Platycercinae. Mudge (1902) classified the order Psittaciformes on the lingual myology and osteology. In his classification Mudge (1902) followed Salvadori (1891) in placing *Nestor* in a separate family, Nestoridae, but, *Strigops* and *Cyanoramphus* he placed in the family Psittacidae, subfamily, Cacatuinae. The *Check-list of New Zealand Birds* (1953) included all the New Zealand Psittaciformes in the one family, Psittacidae. Oliver (1955) placed *Nestor* and *Strigops* in separate families, Nestoridae and Strigopidae, respectively, and *Cyanoramphus* he retained in the family Psittacidae.

In view of the marked anatomical and biotic differences between the three groups of indigenous Psittaciformes of New Zealand, the retention of the three separate families, Nestoridae, Strigopidae and Psittacidae is, perhaps, desirable and a more meaningful classification.

As the main theme of this paper is based on the external morphology of the tongue, it necessarily hinges largely on the food of these birds and the means of obtaining it, the bill. In most authoritative works the food of the various species is described in fairly general terms. They are said to be phytophagous, frugivorous or melivorous, for lack of specific observations in the field and the laboratory. One of the great difficulties of analysing the crop or stomach contents of parrot-like birds is that the food is generally reduced to fine particles before it is swallowed or in the case of fibrous foods, it is masticated and the fibrous material rejected, the juice alone being swallowed. Under such circumstances the determination of the food sources is often next to impossible. Nevertheless, the great differences in the

[S. Muff

XXXVIII — Female Kea at nest in hollow log, at noon on 14/1/62.

[S. Muff

IXL — She is joined by the male at 7 p.m. It had been raining hard and his plumage is wet.

[J. R. Jackson

XL — Young Kea **(Nestor notabilis)** about five weeks old on 2/3/57.

[J. R. Jackson

XLI — Young Kea about 66 days old on 23/3/60.