

SHORT NOTE

Food and nest sites of koki (*Prosopiea tabuensis*, Psittacidae) on 'Eua Island, Tonga

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The koki or red shining parrot (*Prosopiea tabuensis*, Psittacidae; Platycercinae) is about 45 cm tall with long tail, bright green back and rump, broad blue collar, and red/maroon head and underparts (Forshaw & Cooper 1973; Watling 1982; Juniper & Parr 1998; Higgins 1999). Koki were introduced to Tonga from Fiji in the 18th century (Watling 1982; Low 1994). They were once widespread on Tongatapu and 'Eua islands, but are now restricted to 'Eua Island. In 1988 the 'Eua koki population was estimated to be 700-1000 birds, many fewer than previously (Juniper & Parr 1998), and Rinke (1995) considered it endangered. The main agents of decline appear to be: human collection of chicks or adults for food, pets or feathers; forest clearance for agriculture; and egg predation by Polynesian rats (*Rattus exulans*) and barn owls (*Tyto alba*) (Watling 1982; Rinke 1989; Low 1994).

Very little has been published on koki ecology apart from Rinke (1989, 1995) who described aspects of reproduction. Koki nest in cavities, mainly found in mature trees in remnant native forest (Rinke 1989). Saafi (2002) measured koki density and habitat use on 'Eua Island in 1999-2000. In this note we provide information on the foods of wild koki and their nest sites.

'Eua Island, third largest of the Tongan archipelago, lies at 21°20'S, 174°55'W and is 20 km south-east of the main island Tongatapu. It is c. 88 km², rising from low west terraces to eastern coastal cliffs reaching 312m a.s.l. Topography, climate, and plant cover are described by Hoffmeister (1932), Wilde & Hewitt (1983), Rinke (1987, 1989), Drake *et al.* (1996) and Bellingham & Fitzgerald (1997). Remaining native forest is mainly found on steep east coast slopes in 'Eua National Park, c. 449 ha (Bellingham & Fitzgerald 1997).

Watling (1982) and Juniper & Parr (1998) state that koki feed on fruits and seeds of a wide range of forest trees. On 'Eua Island, Rinke (1995) found locals mainly fed captive koki root crops like taro and sweet potatoes, but he maintained captives on soaked wheat and mungbeans, sunflower seeds, unripe coconut, paw paw, mango, guava and mineral and vitamin supplements. In Fiji, wild koki also ate maize and banana as well as pine seeds (Rinke 1995). Of 76 wild koki we saw feeding in 1999 and 2000, 56 (74%) were eating introduced pine (*Pinus caribaea*) cones; seven (9%) beach almond (*Terminalia catappa*); seven (9%) weeping fig (*Ficus benjamina*); and four (5%) guava (*Psidium guajava*). Two birds were seen pecking at lemon (*Citrus lemon*), firewood fruit (*C. grandis*) and wild nutmeg (*Myristica hypargraea*). Pines exist in plantations on 'Eua Island but other plants are scattered.

Separately we monitored koki feeding signs on paw paw (*Carica papaya*) trees (absent in the forest) growing alongside bush tracks between May and October 2000, and kept partial or continuous records of fruit on 29 trees. Koki fed only on green paw paw, preferring the flesh, but seeds were also eaten. Koki pecked at 1-4 of the fruits on each tree, but generally ate less than 5% of the fruits they opened. Feeding bouts on each fruit were brief because local people travelling to and from their plantations often disturbed the birds, which appeared not to return to a paw paw once it had been pecked open. Consumption exceeded 5% in only two of 15 fruits examined. About 47% of damaged fruit were in the top third of the trees, but not significantly so ($\chi^2_i = 1.2$).

Pine cones appear to be a significant source of food for koki on 'Eua Island because they are available all year in large forest blocks. Koki sat high in the pine canopy holding dry ripe (not green) cones in one foot while removing bracts and seeds with their beak, leaving distinctive scars on the cones. We examined the cones dropped by koki and assessed the amount of feeding as: none; slight (some pecking); moderate (about half eaten); and

extensive (> 50% eaten). The length of each cone was measured. Of 254 fallen, measured pine cones, 76.4% showed some signs of koki feeding (Table 1), with 43.7% showing only slight signs. The degree of feeding was related to cone length (Table 1), with significantly more moderate or extensive damage on shorter cones ($F_{3,246} = 3.24$, $P < 0.05$). We did not measure the frequency of cone sizes on the trees, so cannot determine if koki actively selected shorter cones. On 'Eua Island, koki appears to be the only species of bird that feeds significantly on pine cones, paw paw, and some of the other wild fruits.

Koki breed in the dry season between about May and December (Rinke 1989; this study). No nests were found on 'Eua Island between September and November 1999 and all field evidence suggested little or no breeding occurred that year. Similarly, no koki bred in the Tonga Wildlife Centre, Tongatapu in 1999 (C. Matavalea pers. comm.). Between June and October 2000 on 'Eua Island, eight nests were found in the Mo'unga Te'emoa area by watching nest cavity entrances and koki movements. The presence of chicks was determined using a method employed by locals. A long, thin, flexible branch with terminal leaves was gently inserted in the cavity for five minutes. Peck marks on the leaves confirmed chicks in the nest. Rinke (1987) did not mention using this method. In 2000, three of the eight nests had chicks, however, all three were hacked open by locals who removed the chicks, and two other nests had already been opened when located by P. S. The remaining three nests were checked repeatedly but no breeding occurred (Table 2).

Our observations, with those of Rinke (1989) who found 19 nests, show that koki nest in at least five species of native trees: ngatata (*Elastostachys falcata*), tavahi (*Rhus taitensis*), salato (*Laportea harveyi*), mamea (*Litsea mellifera*), and pua-tonga (*Fagraea berteriana*). Koki appear not to excavate new cavities but are secondary cavity nesters (Newton 1994), enlarging existing holes produced by branch loss or decay. On average nest cavities were relatively high above ground and the height of the entrance low in mamea (Table 2), but entrances were relatively wide in ngatata.

All eight nests were in patches or strips of native forest bordered by crop plantations or cliffs. One nest was at the bottom of a 30 m deep gully with a stream 3 m away. Minimum distance between adjacent nests was 85 m, Rinke (1989) found it to be 120 m. All nests were in forest with a closed canopy, in trees generally larger than their close neighbours. The three nearest trees to each of the eight nest trees included 11 species, the most frequent being feto'omaka (*Garcinia myrtifolia*) (6/24), ngatata (5/24), and pua-tonga (3/24). The mean distance (\pm *sd*) to the three nearest trees

Table 1 Extent of koki feeding signs on 254 ripe pine (*Pinus caribaea*) cones, 'Eua Island, Tonga, 2000.

Feeding Sign	No. of cones (%)	Cone length (cm) mean (\pm <i>se</i>)
None	60 (23.6)	11.2 (0.27)
Slight	111 (43.7)	11.2 (0.18)
Moderate	49 (19.3)	10.6 (0.23)
Extensive	34 (13.4)	10.4 (0.24)

ranged from 2.00 ± 0.92 to 5.78 ± 2.13 m, and overall the mean was 3.00 ± 1.66 m ($n = 24$).

The three nests with chicks were observed for a total of 64 hours. Three visits by koki to one of these nests lasted 4, 16, and 57 minutes. The bird flew into the nest area calling and then rested silently before flying silently into, and later out of, the nest. The bird then flew to a perch c. 20 m away, before calling and flying off. Raided nests were opened by locals with axe or machete and the chicks removed. The holes cut in four trees were (mean \pm *sd*) 1.28 ± 0.34 m (range 0.89-1.67 m) above ground, 0.23 ± 0.08 m high and 0.2 ± 0.08 m wide.

Koki breeding was, therefore, unsuccessful with five nests vandalised and three unproductive. Rinke (1989) also had no successful nests in 1983-1984 because locals removed all 27 young before they fledged. Availability of suitable nest cavities may increasingly limit the birds and, although hunting and trading koki is illegal in Tonga, nests near tracks and roads are easily detected by people and robbed of chicks for pets or feathers. This study and Rinke's (1987) indicate the pressure on koki is serious and probably unsustainable.

Bellingham & Fitzgerald (1997) found local women on 'Eua Island use feathers for ta'ovala (waist mats) at the average rate of 1-2 koki/woman/year. Harvesting koki chicks has two effects: a nesting pair loses its young for the year and, because the tree is damaged, the nest site is permanently lost to the koki population. Koki nesting high in mamea trees with relatively small entrance holes may stand the best chance of avoiding detection and destruction by locals. However, it appears that reduction or cessation of koki chick harvesting by local people, and rigorous preservation of native forest with large mature trees in 'Eua National Park are both needed if koki are to survive on 'Eua Island. Modifying cultural practices and conserving original forest cover may, however, be hard to achieve.

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Table 2 Koki 'nests on 'Eua Island, Tonga, June - October, 2000. Abbreviations: Y - yes; N - no; D1 - damaged when located; D2 - damaged after located; I - intact but no production.

Tree	Above ground (m)	Cavity height (m)	Cavity width (m)	Koki present	Chick present	Nest outcome
Ngatata	3.40	0.22	0.13	Y	Y	D2
Ngatata	4.37	0.57	0.47	Y	Y	D2
Mamea	10.15	0.32	0.17	N	N	D1
Mamea	4.17	0.27	0.21	N	N	D1
Mamea	9.91	0.29	0.14	Y	Y	D2
Pua-tonga	1.07	0.38	0.16	N	N	I
Pua-tonga	0.82	0.54	0.19	N	N	I
Pua-tonga	4.30	0.26	0.14	N	N	I
Mean (\pm sd)	4.8 \pm 3.5	0.36 \pm 0.13	0.20 \pm 0.11			

on 'Eua: Jonathan Austin (N.Z. High Commission); Taisy Tangi (Prime Minister's Office); Savae Latu, Netatua Prescott, Paula Taufu (Land & Survey & Natural Resources); Lucy Lopeti (Ministry of Agriculture); Tevita Faka'osi, Sione Kaufusi, Hirofumi Ishizaka (Forestry Division); Claudia Matavalea. Vika Taliai and Pisila Kaumataili gave generous field assistance, and Kelepi Vailea and Paula Hafoka helped locate nests. We thank Isabel Castro, Alastair Robertson, and an anonymous reviewer for commenting helpfully on drafts of this note.

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