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SHORT NOTE

Female North Island brown kiwi (*Apteryx mantelli*) involved in incubation and chick care

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Parental care in many bird species varies across their range but for many there is a large gap in understanding the drivers of sex differentiation in providing parental care (Cockburn 2006). Male-only care is suggested as relatively uncommon in birds and is found predominantly in Gondwanan taxa that lack female only care (Cockburn 2006). Some kiwi have male only incubation, but biparental incubation becomes more prevalent in populations from colder, southern sites and the extremely southerly populations are cooperative breeders where the dominant male may not incubate at all (Colbourne 2002).

New Zealand bird guides (e.g. Scofield & Stephenson 2013; Robertson & Heather 2015) indicate that incubation by North Island brown kiwi (*Apteryx mantelli*) is male only. This is considered

similar in the little spotted kiwi (*A. owenii*), whereas all other kiwi have both male and female incubating (Oliver 1955; Robertson 2013; Scofield & Stephenson 2013; Heather & Robertson 2015; Jahn *et al.* 2022). Colbourne (2002) records that rarely a female North Island brown kiwi may incubate egg(s) for up to a week before being replaced by the male. Oliver (1955) records that the male makes the nest although the female may assist where this involves digging a burrow. The female is seen as a major contributor through the production of a large egg or eggs which is assumed to partly preclude her from other nesting assistance.

The outcome of this understanding is that researchers focus on males, since more immediate management information can be gained by having transmitters on males than on females. Modern transmitters record a range of information including whether the bird is alive, incubating, or dead, how long it has been incubating, and how long it was active over each of the past two

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nights and averaged over the last four days (NIB Chick Timer V3.4; wildtech.co.nz/kiwi). The logical outcome of only putting transmitters on males is that information on the role of females is inferred. Assuming behaviours are the same in all habitats, all populations, all climates and all seasons assumes a rigidity of behaviour that would be unusual for birds (Cockburn 2006).

Pataua North Landcare (35°42'S, 174°29'E), Whangarei, received a permit in 2017 to reintroduce 40 kiwi over three years to approximately 1,000 ha of regenerating native broadleaf/kauri/podocarp forest (McKelvey & Nicholls 1959) under intensive pest control. Wildtech V3.4 "chick timers" transmitters were fitted to one leg and broadcast information at ten-minute intervals. Transmitters were attached to 31 of the 38 birds eventually released, to confirm the establishment of a breeding population. Transmitters were removed from most birds after six months. To reduce further workload and focus on breeding, transmitters were retained on the male and female of four pairs. All nesting attempts and chick care was then followed by monitoring their transmitters, augmented by the use of five trail cameras (Bushnell Trophy Cam and Multrie S-Series Game Camera) at some nests and some roost sites. The greatest focus was on two pairs that were most easily accessible.

Taking the historical average rainfall over the past ten years (2011–2020) for the kiwi breeding season of June to February; www.metservice.com/whangarei), most pairs attempted only one or two nests. In contrast during a recent higher rainfall breeding season (2022–2023), up to three nesting attempts per pair were made (Table 1). Clutch size was one or two although one nest of three eggs was found. Most eggs were fertile and a few (3) nests produced two chicks. Annual production per pair varied from one to five. As a consequence of more nesting attempts in the seasons with higher rainfall, more chicks were produced.

Males incubated for the majority of the time at all nests, and time away from the nest was lowest immediately before and at hatching. Chicks could hatch up to a week apart (nests were not checked other than by cameras in order to minimise disturbance). On three occasions, the male moved to incubate at a newly prepared nest containing eggs the day of leaving the previous nest. This was recorded in both the pairs for which we have detailed information, and are presented as detailed examples.

Example 1: Alick was sitting on one egg in an earth burrow but the following day he was on an egg in a wooden nest box. The following day he returned to his first nest but subsequently abandoned that nest and incubated the egg in the nest box. His chick hatched in the nest box 58 days later suggesting that his partner, Renai, had incubated the egg for up to 12 days before Alick started incubation.

Example 2: Jo was on a nest with two eggs and as hatching approached, his partner Kiri became site attached under a puriri (*Vitex lucens*) tree which had been used for nesting in previous years. She reduced her night foraging time away from the nest site from 8–9 hours to 6 hours for 13 days (incubating birds markedly reduced their time foraging at night and remain incubating instead). When the chicks hatched at the first nest, Kiri moved to that area of the first nest and Jo moved to the new nest under the puriri tree 200 m away. His transmitter continued to broadcast at incubation frequency. Kiri remained in the area of the previous nest where the chicks were last seen for three days.

Example 3: Six weeks later, Kiri focussed her activity 300 m up the same valley and became site attached in a shallow burrow. Within days her transmitter changed to incubation mode and her nightly time away from the nest dropped to four hours. The camera on Jo's nest had previously pictured Kiri visiting and the pair copulated outside the nest. Twenty days after Kiri had switched to

Table 1. Breeding statistics for North Island brown kiwi (*Apteryx mantelli*) at Pataua North, Whangarei, New Zealand, in five seasons of average rainfall compared with a season of high rainfall (2021–2022). Average rainfall is taken from mean for the last ten years (2011–2020). *these only include multiple nests of two pairs followed in detail. Values are means.

	Average rainfall	Higher rainfall
Mean rainfall (mm, June–February)	999	2,278
Number of kiwi pairs	4	4
Mean number of nesting attempts	1.3 (n = 9)	2.0
Mean clutch size	1.5 (n = 13)	1.4 (n = 5)
Number of chicks produced per pair per season	1.2 (n = 11)	2.3 (n = 8)
Proportion of male incubation time*	95% (n = 4)	84% (n = 4)
Number of pairs with evidence of female incubation	2 of 2	2 of 2
Number of pairs with evidence of female chick care	Unknown and not followed	Unknown but suggestive at two nests

incubation mode, Jo hatched a chick at their second nest. He remained with the chick for three days and then moved to the burrow where Kiri was incubating. He then began incubating their third nest and his transmitter remained in incubation mode. Kiri moved back to the area of the previous nest as expected if looking after the chick

In total Jo incubated for 173 continuous days for the three nests. He eventually abandoned incubation at the third nest after 36 days. His total time on nest two was only 62 days so Kiri had incubated that nest for at least 13 days but possibly as high as 20 days. Assuming the minimum incubation plus chick care time of 75 days, she appeared to have incubated on the third nest for up to 22 days.

On both occasions when the male, Jo, took over incubation from Kiri, she moved to the previous nest presumably to be with their chicks. Trail camera footage at four nests, showed Kiri visiting the nest after the first chick had hatched and walking away from the nest area with the chick. In contrast, Alick had abandoned an unhatched egg and Renai did not have a chick to care for. Camera footage at nests where a follow-on nest was not prepared, showed chicks departing the nest with either of their parents. After nests were no longer used for roosting, we had no information on how long the female or male stayed in the same vicinity as their chicks as none of the chicks' carried transmitters.

We challenge the current widespread assumption that male North Island brown kiwi construct the nest (Oliver 1955). This would seem unlikely for the two pairs we observed where the females began using a new nest while the males (Alick and Jo) were incubating and had few active hours away from the nest. Furthermore, the females produced an egg and began incubating so it was ready for the male as soon as he finished the current nest. More information on the scale and prevalence of this type of female investment is required for North Island brown kiwi.

Despite the widely recorded observation that only the male incubates, our observations suggest that while this is usual, in areas and seasons when multiple nests are possible, the female can initiate the nest and incubate for up to the first three weeks. Moreover, she can incubate simultaneously with her mate but on a different nest. Other cases of female investment in nesting have also been observed; the most extreme example known was a female-female pair in Motatau (35°30'58S, 174°02'11E) who took turns at incubating eggs which were infertile (Paul Cornille *pers. comm.*). Further research is needed over multiple seasons to determine how common and for what duration female incubation occurs.

Regarding parental care, our numerous observations of the female visiting a nest with newly hatched young, and leaving with one of them,

in addition to the observation that the female changed her range to where chicks were last seen are all strongly suggestive of female parental care. Where the male does not move immediately to a new nest, he participates in chick care. How long parental care continues is unknown but we have found pairs roosting together with a third, smaller bird when we have been catching birds for transmitter change. This is suggestive that some parental care may continue for at least six months.

Our observation of considerable involvement of females in incubation and possibly chick care were in a season of high rainfall, soft ground, and multiple nests. This meant the male was less available to assist. We have no data to show this also occurs in seasons when pairs only have one nest. Closing this information gap relies on females with transmitters rather than the current standard practice of only tracking males.

The practice of removing eggs or newly hatched chicks, as occurs under Operation Nest Egg (ONE), would deprive those birds of parental care. It is interesting that Jahn *et al.* (2022) records a significantly shorter life span of ONE birds compared with wild reared birds. They record that ONE birds lived about half as long as wild or captive reared birds (Jahn *et al.* 2022). This should not be seen as a reason to condemn ONE since the program has led to the establishment of many new populations including that at Pataua North. It does, however, further demonstrate a large gap in understanding parental care in kiwi.

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