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SHORT NOTE

Changes in behaviour of great spotted kiwi (*Apteryx haastii*) following handling

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All five kiwi species (*Apteryx* spp.) in New Zealand are classified as nationally threatened or at risk (Robertson *et al*. 2017) and considerable effort is invested in their conservation (Germano *et al.* 2018). Many kiwi are caught and fitted with VHF transmitters, for research and monitoring, as part of translocations, or to enable removal of eggs from the wild for captive rearing (Operation Nest Egg, ONE). The Kiwi Best Practice Manual (Robertson & Colbourne 2017) sets out the mandatory and recommended procedures for interacting with kiwi. It recognises that catching kiwi is stressful for birds and requires that all catching is undertaken by trained and accredited kiwi handlers. The manual identifies stress indicators as panting, open bill, and head lolling; blowing bubbles is a sign of minor stress.

Little evidence is available for, either short-term or long-term, kiwi behavioural responses to handling. Kiwi learn very quickly not to respond to playback calls following attempted night-time capture and this wariness may last several years (Robertson & Colbourne 2017). In a survey of kiwi practitioners engaged in ONE, which involves annual handling of adult kiwi, several respondees reported they suspected a greater level of flightiness of monitored pairs over time and a movement away from monitored locations (Gillies & McClellan 2013). Roroa (great spotted kiwi, *Apteryx haastii*) are a shy, nocturnal species and may desert their nest if approached (McLennan & McCann 1991). Jahn *et al.* (2013) report that in the days following handling for transmitter change, a female roroa moved 1.6 km from her usual daytime roosting area for a period of two weeks. In two other instances, a roroa that had been disturbed by humans but not handled, was found more than 1 km from its normal home range, although one of these coincided with a period of unseasonal snow. One of these returned within a week, but the other had not returned by the end of the study, an unspecified period. Gasson (2005) reports two instances of roroa moving several hundred metres when their daytime roosts were approached by people.

Intensive monitoring of 44 roroa in the Flora Stream area to the north of Tu Ao Wharepapa (Mt Arthur) in Kahurangi National Park (172°41’E, 41°10’S) provided an opportunity to quantify

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changes in roroa behaviour after handling. We examined nightly hours of activity before and after handling and post-handling change in the distribution of daytime roosts. We also examined whether behavioural changes were associated with signs of stress in hand or with the difficulty of capture. The roroa in this study were translocated to the study area by the Department of Conservation (DOC) and the community group Friends of Flora Inc. between 2010 and 2016 in a project approved by the Kiwi Recovery Group (Toy & Toy 2020). All translocated roroa were fitted with VHF GSK Diagnostic transmitters v2.0 (Wildtech/Lotec). After translocation, the location of each roroa's daytime roost was determined by radio-telemetry at approximately fortnightly intervals. We did not approach the roroa's roost burrow during such telemetry, but determined its position by triangulation of distant bearings. A triangulation accuracy test indicated an average error of 186 m (Toy & Toy 2020). The transmitters provide a rolling record of the number of hours a roroa has been active for each of the previous 14, 24 h periods. We aimed to record this information fortnightly, and consequently we archived a near-continuous activity record for each roroa. Roroa are rarely active during the day, so the activity record is essentially a nocturnal activity record. We monitored the translocated roroa for periods varying between two and eight years before removing transmitters.

The roroa were caught once a year, outside the breeding season, to replace their transmitters. Catching a roroa for transmitter change involved tracking to its daytime roost burrow and manually removing it. Great care was taken to approach burrows quietly. Most roost sites were naturally occurring cavities under tree roots. Some comprised extensive networks of cavities and tunnels from which the roroa was extracted by digging a 'window' into the burrow. A few roroa roosts were under low vegetation. If a roroa bolted when its roost site was approached, and was not caught as it did so, we waited at least 30 minutes, then tracked it again and made another attempt at capture. After a maximum of three attempts, we withdrew to try again another day. We categorised each roroa capture as easy or difficult depending on the time needed to remove the roroa from its burrow and the amount of digging necessary. We recorded signs of stress as described in the Kiwi Best Practice Manual (Robertson & Colbourne 2017) and also included prolonged agitation and bolting from the roost site as we approached. Our analysis is restricted to the behaviour of roroa that had established a home range, as described in Toy & Toy (2020).

We examined roroa behaviour following transmitter change by comparing the average number of hours each bird was active in the week before handling to the number of hours it was active in each night of the week following the day after handling. The transmitter does not record activity on the night after it is switched on, and we turned transmitters on immediately prior to fitting them, so the activity record has a one night gap on the night following handling. We had a sufficiently complete activity record to enable analysis of 69 handling events. We analysed activity in this way because the number of hours roroa are active each night is variable, depending on season and age of the bird. Two nights after handling, roroa were, on average, active for 0.81 h (SD = 1.4 h) less than in the week preceding handling. By four nights after handling, activity approximated pre-handling hours (Fig. 1). Activity on nights two to eight post-handling compared to the seven nights pre-handling, did not change on 56 occasions (81%), decreased (t-test, $P <$ 0.05) on 10 occasions (14%), and increased ($P < 0.05$) on 3 (4%) occasions. Significant decreases averaged 1.6 h (n = 10, SD = 0.91 h) with a maximum of 4.0 h. Such decreases are unlikely to be biologically significant as they are small compared to seasonal changes; during December when nights are shortest, activity is on average 3.9 h shorter than in June (n = 3,740 in June, 5,348 in December). In addition, the activity of incubating roroa is about 4 h less than that of non-incubating roroa (Friends of Flora, *unpubl. data*).

We examined longer-term behavioural changes by considering whether the first triangulated daytime roost following handling was outside the area used for roosting since the previous 1 July, referred to as the 'habitual roost area'. We had sufficient information to do this for 97 handling events (Table 1). We calculated the habitual roost area using Ranges 9 v2.02 to compute 95% probability kernels around triangulated roost locations since 1 July (average 17.2 locations, SD = 4.5), a period that was an average of 260 days (SD = 37). If the first location post-handling was outside this area, the roroa was deemed to have moved. Roroa moved from the habitual roost area following 38 handling events (39%). The likelihood of males and females moving was not significantly different ($P = 0.793$, $\chi^2 = 0.069$, n = 97, 1 df). Of the roroa that moved from their habitual roost area, 18 (47%) returned within a month, 14 (37%) took between one and nine months, but six (16%) did not return for more than nine months. Movements were on average 270 m from the habitual roost area (SD = 207 m, maximum 850 m); 22 of them were to areas in which the roroa had not previously roosted. However, at night roroa sometimes move into areas in which they do not roost (Gasson 2005; Toy & Toy 2020), so roroa moving outside their 'habitual roost area' may have been familiar with the area into which they moved.

Ten of the 97 handling events were preceded, on

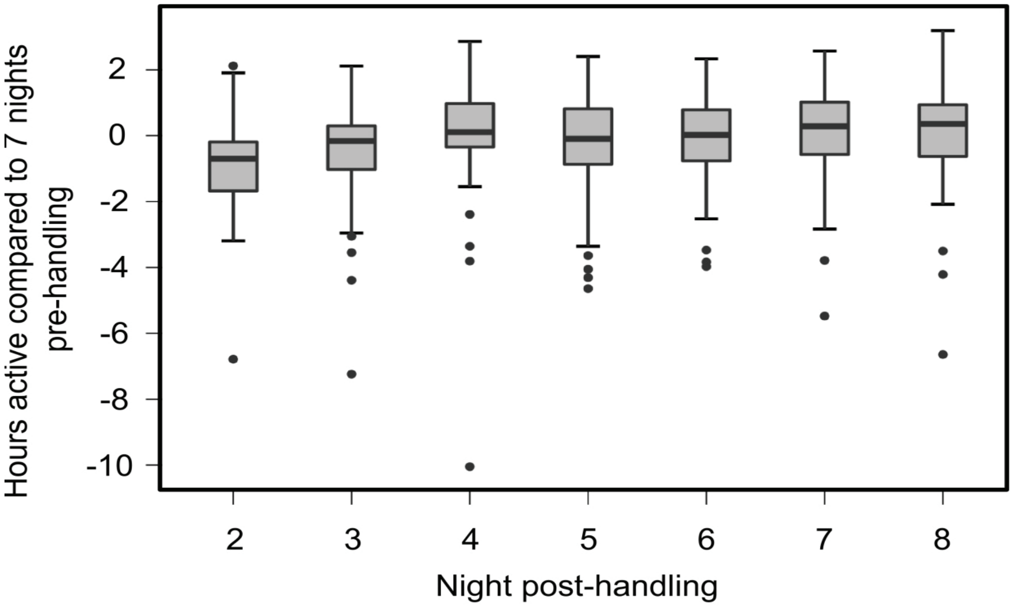

Figure 1. The difference between a roroa's (great spotted kiwi, *Apteryx haastii*) activity post-handling and its average hours of activity in the seven nights pre-handling, summarised for 69 handling events. Boxes show median values with 25% and 75% quartiles, the bars extend to minimum and maximum values excluding outliers shown as dots. Outliers are defined as values more than 1.5 times the inter-quartile range outside the 25th and 75th quartiles.

an earlier day by an unsuccessful capture attempt. Seven of these failed attempts (70%) resulted in the roroa moving outside the habitual roost area. On nine additional occasions we approached a roost, looked in, decided we would be unable to extract the roroa, and retired without attempting a capture. On four of these occasions (44%), the roroa moved from the habitual roost area.

Captures that were difficult were significantly more likely to cause the roroa to move from its habitual roost area than those that were easy ($P = 0.047$, $\chi^2 = 3.960$, $n = 97$, 1 df). This suggests that if it looks as if an extraction will be difficult it may be better to walk away and try again another day when the roroa is in a different burrow, although logistical considerations may outweigh this consideration.

Table 1. Changes in distribution of daytime roosts of roroa (great spotted kiwi, *Apteryx haastii*) following 97 handling events among 29 birds. Changes are categorised by the difficulty of capture and whether the roroa showed signs of stress during capture or handling.

Ease of capture	Visible signs of stress	Post-handling movement from habitual roost area: Yes	No
Difficult	Yes	12	8
	No	10	14
Easy	Yes	10	19
	No	6	18
Total		**38**	**59**

Some roroa bolted more often than others, of 38 we tried to capture, 19 (50%) never bolted. Bolting was more likely if the roost was open or had multiple exits. Males were as likely to bolt as females ($P = 0.774$, $\chi^2 = 0.082$, $n = 97$, 1 df). Roroa roosting with their partners were less likely to bolt than those roosting alone ($P = 0.015$, $\chi^2 = 5.942$, $n = 97$, 1 df). Some roroa always showed signs of stress during handling, others very rarely. Females were more likely to show signs of stress during handling than males ($P < 0.001$, $\chi^2 = 16.624$, $n = 97$, 1 df). However, roroa that showed signs of stress during capture/handling were no more likely to change habitual roost area than those that did not ($P = 0.243$, $\chi^2 = 1.361$, $n = 97$, 1 df). Individual roroa did not show increasing tendency to bolt or show other signs of stress with repeated handling.

This study shows that roroa moved to roost outside their habitual roosting area after 39% of handling events and some did not return for many months. Such changes in roost distribution could not be predicted from signs of stress in hand but were more likely if the capture was difficult. They may only have been possible as this is a low-density population (Toy & Toy 2020). Changes in roroa activity, usually small decreases, were also sometimes observed for two or three nights after handling. We do not know if these changes impact on roroa fitness, but a precautionary approach would be to minimise roroa disturbance, capture and handling in the wild.

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