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Footedness in North Island kākā (*Nestor meridionalis septentrionalis*)

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Abstract North Island kākā *(Nestor meridionalis septentrionalis*) often hold food in either their left or right foot when feeding. I observed kākā at Zealandia – Karori Sanctuary in Wellington in order to determine whether kākā show laterality (specifically footedness) when holding food. Laterality was seen at the individual level, i.e. individual kākā tended to consistently use the right foot or consistently use the left foot to hold food. However, there was no significant population level laterality, i.e. a similar proportion of the kākā showed bias towards using the left foot as the right foot. The kākā I studied were banded with a wide band on 1 foot and 2 narrow bands on the other foot. There did appear to be a population level bias towards holding food in the foot banded with the single wide band, but the reason for this was unknown and further study is needed.

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INTRODUCTION

Laterality is defined as either preference in use of homologous parts on one lateral half of the body over those on the other, or dominance in function of one of a pair of lateral homologous parts (Merriam-Webster 2002). It may occur at the individual level only or at the population level (Rogers 2002). Human handedness is an example of population level laterality. Bias exists both at individual level (e.g., towards either the left or right hand) and at population level (towards right-handedness). Many bird species also exhibit laterality. For example, domestic fowl chicks (*Gallus g. domesticus*) show population level bias towards using the right foot to scratch for food (Rogers & Workman 1993), and New Caledonian crows (*Corvus moneduloides*) show individual level footedness in tool use (Rutledge & Hunt 2004).

Laterality in parrots has been attributed to a variety of origins including skeletal or organ asymmetry, cerebral specialization for vocalisation, and environmental factors, such as the side from which captive parrots were fed (Harris 1989). Recently, behavioural laterality in birds has been attributed to cerebral lateralization (Rogers *et al.* 2004). Cerebral asymmetry in domestic fowl chicks, for example, was found to improve performance when feeding and simultaneously watching for overhead predators (Rogers *et al.* 2004). This asymmetry was also associated with the side bias of left eye use when viewing the predator (Rogers *et al.* 2004). Rogers (2002) suggests that at the individual level, greater laterality can be advantageous by increased skill performance and quicker reactions, whereas population level laterality can have social advantages which vary between species. Another hypothesis for the cause of behavioural laterality is that it may sometimes be due to a learning advantage, i.e., that learning the same behaviour on 2 sides takes twice as long as learning it on 1 side only (Pepper 1996).

In this study, I examined laterality in a re-introduced population of the North I kākā (*Nestor meridionalis septentrionalis*). My objective was to determine whether kākā show footedness at both

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Fig. 1. Kākā holding pellet in foot while eating.

the individual and population level when holding food. I also report observations that suggest footedness may be affected by leg bands.

METHODS

The study was carried out from Jul to early Nov 2008 at Zealandia-Karori Sanctuary (41°18′S, 174°44′E), near Wellington, New Zealand. Eleven kākā were released into the sanctuary between 2002 to 2004 (Miskelly *et al*. 2005). They have bred successfully in the sanctuary, with ~100 chicks raised from 2002 to early 2008 (Karori Reservoir Wildlife Sanctuary Trust, 2008). Since 2004, additional kākā have also been translocated or self-introduced into the sanctuary (Karori Sanctuary Trust, *unpubl. data*).

Kākā are known to eat a variety of foods including fruit, nectar, insects and foliage (Moon 1992). Supplementary food in the form of nutritionally balanced pellets and sugar water is provided to kākā at the sanctuary, and I used observations at feeders to assess laterality in food holding behaviour. Approximately 65 - 70 different kākā were seen visiting supplementary feeders during monthly surveys in 2008 (Karori Sanctuary Trust, *unpubl. data*).

Observations were made only when at least 2 or 3 kākā were near a feeder. Total observation was around 30 to 60 minutes per week, usually in 15 minute periods. When feeding, kākā removed a pellet from the feeder tray using their beak and usually climbed or flew away to perch on a nearby branch (though sometimes they remained on the feeder platform). They then transferred the pellet from the beak to either the left or the right foot and held it while eating (Fig. 1). Each time a kākā visited the feeder tray and took a new pellet, I recorded the foot used by the kākā to hold the pellet. No kākā was observed switching the foot used while eating the same pellet.

When several kākā were present, I spread observations across birds to collect a similar number of observations for each individual. However, if 1 or 2 kākā ate repeatedly while others ate only a few times, I continued to observe the frequently feeding kākā when this did not interfere with observation of the other individuals. To avoid observer bias, once an identified kākā had been seen eating using either the left or right foot the result was always recorded regardless of how many previous observations had been made for the same individual.

Only the 24 kākā that were seen eating a total of 6 or more pellets over the entire study were considered in statistical tests (each of these kākā was observed eating on at least 2 separate days – Fig. 3). Kākā were tested separately for individual level laterality (2-tailed binomial test). To test for population level laterality, kākā which showed significant individual laterality were separated into left foot and right foot dominant groups and the difference in numbers between the 2 groups was tested (2-tailed binomial test).

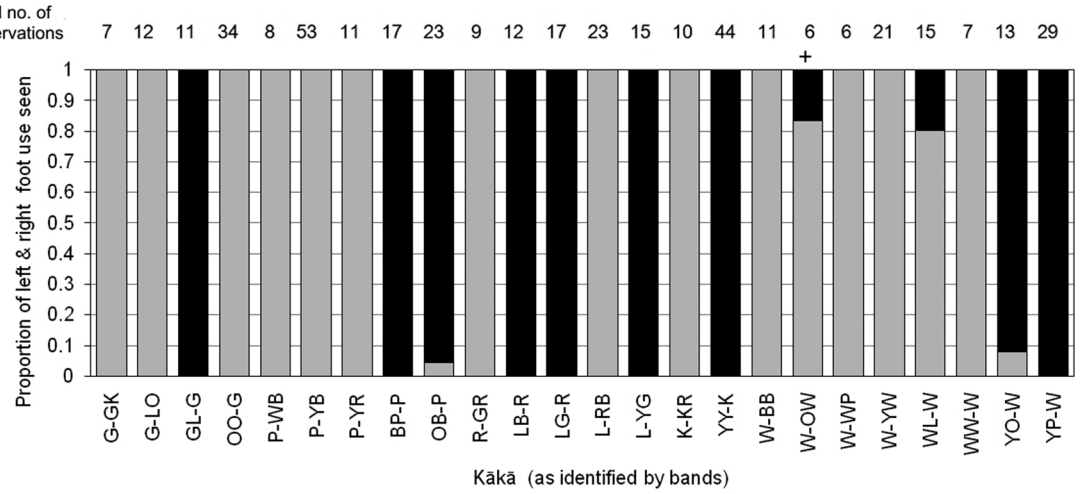

Fig. 2. Proportion of left and right foot use seen (when holding food) by individual kākā at Zealandia - Karori Sanctuary. Grey shading, left foot; black shading, right foot; +, individual with no significant bias (all 23 other individuals showed significant bias towards either the left or right foot (P<0.05)). Numbers above graph indicate total number of observations for each kākā.

RESULTS

Holding of food by kākā was strongly lateralized at the individual level. Of the 24 kākā observed 6 or more times, 23 showed significant laterality in food holding (Fig. 2). Most individuals consistently held food in either the right or the left foot and were never seen using the other foot (Fig. 2, 3). The single kākā that showed no significant laterality had only been observed 6 times and had used its left foot 5 times, suggesting a small sample size was responsible for this result.

Fourteen kākā preferred to hold food with their left foot and 9 with their right foot. This pattern does not differ significantly from equal choice of left or right foot (P=0.40, 2-tailed binomial test). Therefore, there was no population bias for one foot over the other. Although it is possible that a larger sample of individuals may detect population level laterality, this result suggests any such bias is likely to be small.

Kākā were banded with a single wide band on either the left or the right foot, and 2 slightly narrower bands on the other foot. Surprisingly, 19/23 kākā that showed significant individual level laterality used the foot with the large single band to hold food. This bias was significant (P=0.0026, 2-tailed binomial test).

DISCUSSION

The absence of (or possibly weak) laterality at population level in holding food in kākā is quite different from the strong population level laterality found in a study of the glossy black-cockatoo (*Calyptorhynchus lathami*) where all individuals showed a left bias for food holding (Pepper 1996). However, not all parrot species show laterality in food holding to this extent. A study of brown-throated parakeets (*Aratinga pertinax*) showed no population laterality in food holding with half the individuals biased towards using the left foot and half the right foot (McNeil *et al.* 1971). In a study of green-cheeked parakeets (*Pyrrhura molinae*), left foot use was seen in around 80% of observations of food holding above ground (individuals not identified) (Nos & Camerino 1984). For 3 other parrot species (*Aratinga aurea*; *Brotogeris versicolorus and Myiopsitta monachus*) studied by Nos & Camerino (1984), strong levels of individual laterality were seen, but the number of individuals studied was not sufficient to examine population level laterality. Similarly, the number of individuals of each species tested by Friedmann & Davis (1938) was low, but individual laterality was clearly seen for most parrots observed. For example in the orange-chinned parakeet (*Brotogeris jugularis*), all 3 individuals tested used their left foot to hold food in all instances (Friedmann & Davis 1938).

Somewhat unexpectedly, I found that laterality appeared related to legs bands, with kākā preferring the leg with a large single band to hold food over the leg with 2 narrower bands. It is possible that there are unknown biases affecting this result. For example, the posture held by a kākā during banding could have affected which leg a bander first selected to attach the wide band. This particular bias seems unlikely as

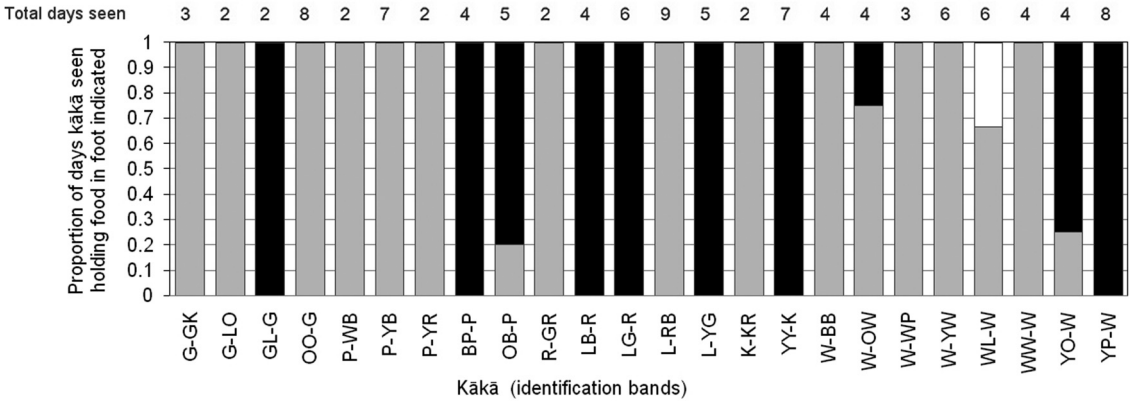

Fig. 3. Proportion of days that kākā were seen holding food at least once with left, right and both feet at Zealandia - Karori Sanctuary. Grey shading, left foot; black shading, right foot; white shading, use of left & right foot seen on the same day. Numbers above graph indicate total number of days each kākā was observed.

band combinations of kākā are decided prior to banding (M. Booth, *pers. comm*.). If other biases are excluded, this result suggests that band type affected foot choice in some way, such as through changes in balance or in ability of the bird to manipulate food, but further study is necessary before any conclusion can be drawn. For example, band size and number could be experimentally manipulated to determine whether this causes change in laterality. If kākā habitually used a particular foot to hold food they might not switch feet, even if foot use was a result of banding and bands are changed. Therefore, it would also be informative to band juvenile or newly introduced kākā with the same band type on both feet and examine footedness in these birds.

There are a number of potential sources of error in this study that may have affected the levels of laterality I observed. Firstly, because of rapid movements of birds and obscuring vegetation, it was easy to confuse the left from right in kākā as they fed. I avoided this problem by recording the band colours on the leg being used to feed and later identifying laterality from banding records. Secondly, it is possible that dominance of a particular foot could be associated with other traits, for example, wariness of humans or food preferences, causing kākā with a bias towards a certain foot to be observed more frequently. Finally, it is also possible that foot use of individual kākā within a single observation period or day is not independent, i.e. the foot used previously may affect which foot is used next. However, observations were also analysed on separate days (Fig. 3), and the foot used by an individual appears to be consistent over time. It was assumed that time of day, month or year, weather, temperature and type of food did not affect foot use but this needs to be studied further.

When using the binomial test to examine population level laterality kākā were separated into discreet categories, left footed or right footed. This did not allow for kākā being partially left footed and partially right footed. The one kākā which did not show individual laterality was excluded from testing. More complex tests should perhaps be carried out to take strength of laterality into account, however this would not have affected the overall result (i.e., no significant laterality observed at population level).

In the future it may be interesting to look at whether dominance of the right or left foot is inherited (R. Empson, *pers. comm*.), whether individual kākā continue to show footedness throughout their lifetime, and whether kākā show laterality in other behaviours. As kākā at the sanctuary are often genetically related it would be preferable to also examine kākā outside the Wellington area.

In conclusion, food holding by kākā at the sanctuary was found to be strongly lateralized at the individual level, but not at the population level. However, more kākā used their left foot than their right foot, so it is possible that a larger sample may show weak population level laterality. At the population level, there did appear to be a bias towards using the foot banded with a single wide band to hold food and the foot with 2 narrower bands for support, but this outcome requires further study.

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