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SHORT NOTE

Successful use of intraspecific parental fostering in the management of an endemic threatened bird: New Zealand's hihi (*Notiomystis cincta*)

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Intraspecific fostering of nestlings occurs naturally in some avian species (Hitchcock & Mirarchi 1985; Berggren 2006; Kazama *et al.* 2012) and is used by conservation practitioners to bolster breeding success in threatened species, or to re-introduce reared chicks into managed populations (Cade 1980; Fentzloff 1984; Synder *et al.* 1987; Romer 2000; Saint Jalme 2002; Lobo & Marini 2013; Hahn & Yosef 2020; Vigo-Trauco *et al.* 2021). Introducing chicks into surrogate nests is not a suitable option for all species as some have a higher risk of siblicide, aggression, or rejection from foster parents, or abandonment following management interventions (Synder *et al.* 1987; Vigo-Trauco *et al.* 2021). There are few documented cases of intraspecific fostering in a New Zealand passerine species (notably the North Island robin, *Petroica longipes*; Berggren 2006). Here we report the use of a surrogate nest and induced fostering to successfully raise and release a wild hihi (stitchbird, *Notiomystis cincta*) nestling at Zealandia Te Māra a Tāne sanctuary (henceforth Zealandia), Wellington. To our knowledge, the potential to use fostering or surrogate nests as a management tool has not been previously trialled with this species.

Hihi are a cavity-nesting passerine species that were previously common in forests across North Island of New Zealand (Buller 1888; Department of Conservation & Zoological Society of London 2021). Due to habitat destruction, disease, and introduced mammalian predators, the species became restricted to one offshore island (Te Hauturu-o-Toi/ Little Barrier Island) by the 1880s (Taylor *et al.* 2005; Innes *et al.* 2010). In 2005, 64 hihi were translocated to Zealandia, in the first mainland reintroduction of this species; this is one of seven re-introduced managed populations (Ewen *et al.* 2013; Salvador *et al.* 2019). The population is now *c.* 120 adults, aided by supplementary feeding, predator exclusion, and provisioning of artificial nest boxes to mimic suitable tree-cavities that would be found in old-growth forests (Department of Conservation & Zoological Society of London 2021).

Hihi are the sole members of their phylogenetic family, Notiomystidae (Driskell *et al.* 2007), and have an atypical breeding ecology (Castro *et al.* 1996). They have an unusually long nestling period of 28–31 days, and parental care continues for a further 7–14 days post-fledging (Higgins *et al.* 2001; Castro *et al.* 2003). Females often provide most of the parental care with males, sometimes multiple, contributing towards occasional feeds (Castro *et al.* 1996, 2003; Low *et al.* 2006, 2012). Although hihi typically form breeding pairs, a mixture of

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monogamy, polygyny, polyandry, polygynandry, and extra-pair copulations are commonplace in hihi populations (Castro *et al.* 1996; Low 2005).

In December 2020, during routine breeding season monitoring of nest boxes, an 11-day-old hihi chick was found to be suffering from a large air-filled swelling on the left side of its neck. The chick was the sole nestling from its nest where the other two eggs had failed to hatch. Due to the severity of the chick's condition, it was removed from its nest and immediately taken to the Nest Te Kōhanga at Wellington Zoo for veterinary treatment. Veterinary treatment was successful, although the cause of the air-filled swelling remained undetermined. The most likely causes of the swelling were air sac rupture resulting in air leaking into subcutaneous tissues, or obstruction of airflow out of the cervical air sac causing it to hyperinflate. Within 10 days the chick had recovered fully. The chick (henceforth referred to as the introduced chick) was slightly underdeveloped for its age but had gained several grams of mass from hand-rearing and was in good condition. Continuing to hand-rear was not considered to be a viable option as a release into the wild population following weeks of hand-rearing was thought to have a high likelihood of failure, behavioural abnormalities, or failure to successfully re-integrate into the wild population.

A nearby active nest had a breeding female and two male partners raising a lone chick (henceforth referred to as the natural chick) of similar age, and thus was potentially compatible as a surrogate nest. Both social males associated with the nest had been observed attending the nest and feeding the chick alongside the breeding female. Previous research has shown that hihi nestlings can naturally exhibit body size differences linked to hatch order without impacting their survival after fledging, suggesting that slight asynchrony in development between the two chicks would not be an issue (MacLeod *et al.* 2016). The introduced chick was 18 days old with a mass of 33.1 g. The natural chick was 21 days old with a mass of 37.0 g. The spread of pathogens between the introduced chick and the surrogate nest was a concern; however, as the chick had been treated with antibiotics, some of this risk had been minimised. Further pathogen screening would have delayed the release by several days, thus missing the window for re-introduction.

In January 2021, 10 days after the introduced chick had been removed from its original nest, it was transported to Zealandia to be introduced into the foster nest. The chick was fed immediately prior to being transported. To minimize disturbance and to ease the transition the introduction took place with the natural chick being removed for banding. Upon arriving at the nest site, one of the social males associated with the nest was observed entering the nest box and feeding sounds were heard. The female was observed in the vicinity and remained nearby for the duration of banding. The introduced chick was placed into the nest while the natural chick was removed for banding. The introduced chick was continually vocalizing, and the female showed interest in the nest box as well as the chick we were banding. Following banding, both chicks were placed together in the nest box and appeared to settle quickly. The female entered the nest box two minutes later and remained inside for four minutes. The nest was observed for several hours following banding to look for any signs of rejection or aggression. During this time, the female and both social males were seen separately attending the nest multiple times and both chicks could be heard responding vocally each time. A trail camera (Browning Patriot) was set up to continue observing the nest box entrance. Footage showed ongoing and consistent attendance by the female and the two social males. Both chicks fledged successfully nine days later and were resighted the following week being fed by one of the males. To our knowledge, the original breeding pair that provided the introduced chick did not renest during the remainder of the breeding season. The foster trio had an additional successful breeding attempt with three chicks fledging in March 2021.

There are many factors that must be considered before taking significant wildlife management actions such as the surrogacy used here. This includes minimising the risk of disease transmission and risks to existing nestlings and the surrogate. Further, the case described here provided many situational factors necessary for testing the approach and ultimately supporting its success; nests at Zealandia are intensively monitored, the surrogate nest had a sole nestling of similar age, limiting the risk to the other nestling's survival, and three parents were present possibly providing a greater pool of resources. However, our case study shows that fostering and nest surrogacy could be considered a feasible management option for hihi. Further investigation is required to determine if this approach remains successful under different circumstances, e.g. younger chicks or with more nestmates. Future research could also investigate the potential of using nest surrogacy, possibly alongside artificial incubation, to improve breeding success in hihi populations that struggle from low embryo and nestling survival (Low & Pärt 2009).

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