

# The influence of supplemental feeding on survival, dispersal and competition in translocated Brown Teal, or Pateke (*Anas chlorotis*)

Jennifer Rickett<sup>A</sup>, Cody J. Dey<sup>B,D</sup>, Jillian Stothart<sup>B</sup>, Constance M. O' Connor<sup>C</sup>, James S. Quinn<sup>B</sup> and Weihong Ji<sup>A</sup>

<sup>A</sup>Human and Wildlife Interactions Research Group, Institute of Natural Sciences, Massey University, Auckland Campus, Private Bag 102 904, Auckland, New Zealand.

<sup>B</sup>Department of Biology, McMaster University, Hamilton, ON, L8S 4K1, Canada.

<sup>C</sup>Department of Psychology, Neuroscience and Behaviour, McMaster University, Hamilton, ON, L8S 4K1, Canada.

<sup>D</sup>Corresponding author. Email: [deycj@mcmaster.ca](mailto:deycj@mcmaster.ca)

**Abstract.** Supplemental feeding is widely used after the translocation of animals and is presumed to increase post-release survival or reproductive output. However, the results of empirical studies on supplemental feeding are equivocal and research is needed to determine the mechanisms by which supplemental feeding affects health and behaviour. Here, we studied the effect of supplemental feeding on the Brown Teal, or Pateke (*Anas chlorotis*), an endangered duck endemic to New Zealand, following four translocations of captive-bred individuals. Radio-telemetric monitoring showed no significant effect of supplemental feeding on post-release survival. Male birds dispersed further than females, and supplemental feeding decreased post-release dispersal. To reduce heterospecific competition at Brown Teal feeders, we also tested an exclusion device designed to prevent the main heterospecific competition, the Purple Swamphen (Pukeko in New Zealand, *Porphyrio porphyrio melanotus*), from accessing supplemental food. Although this device decreased the presence of Purple Swamphens at feeders, it also decreased use of feeders by Brown Teal. Ultimately, we concluded that supplemental feeding has value as a conservation tool for Brown Teal, particularly during releases in managed areas. Further studies on feeder design, as well as spatial and temporal patterns of use of feeders, are needed to maximise the positive effect of supplemental feeding on success of translocations.

**Additional keywords:** conservation, duck, management, reintroduction, release, relocation, waterfowl.

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## Introduction

Translocations are an increasingly important tool in conservation biology. Because historically translocations have had a high rate of failure (Lyles and May 1987; Griffith *et al.* 1989; Fischer and Lindenmayer 2000), there is strong interest in studying factors affecting successful establishment, survival and reproduction of translocated individuals (Seddon *et al.* 2007; Armstrong and Seddon 2008). In some cases, the success of translocations might be highly dependent on post-release management, which is in turn dependent on understanding how translocated animals access the resources required to survive and reproduce in their new environment. However, there has been surprisingly little research investigating the effect of post-release management regimes on translocation success (Armstrong and Seddon 2008), and few studies have considered the mechanisms by which different management techniques influence the fitness of translocated individuals.

Supplemental feeding is a common element of wildlife management that is often performed in conjunction with animal

translocations (e.g. Bright and Morris 1994; Armstrong *et al.* 1999). Translocated animals might face an abrupt change in diet and are likely to be stressed from handling. As such, supplemental feeding might be a necessary soft-release technique to ease the physiological demands on translocated animals. Supplemental feeding might have the added bonus of anchoring released individuals to a particular location where other factors affecting translocation success can be managed. Furthermore, supplemental feeding could also aid in the establishment of a viable, self-sustaining population by increasing body condition, growth rates, survival, social interactions or reproductive success (e.g. Elliott *et al.* 2001; Jonsson *et al.* 2002; Brightsmith *et al.* 2005; Schoech *et al.* 2008; van Heezik *et al.* 2009). However, there are few empirical examples of supplemental feeding increasing translocation success, and its usefulness as a conservation tool is not clear. For example, supplemental feeding could increase predation rates if predators are able to exploit fixed feeding stations (Dunn and Tessaglia-Hymes 1994). Supplemental feeding can also induce behavioural or physiological dependence on artificial

food (e.g. Taylor and Castro 2000), can result in obesity (Powlesland and Lloyd 1994) and has been associated with depressed immune function (Blanco *et al.* 2011). Finally, a supplemental feeding regime will provide little benefit if most of the food is eaten by non-target species. Although existing studies on supplemental feeding have largely compared the survival and health of animals in instances where supplemental feeding was used to those where it was not, much less attention has been given to the specific factors contributing to the effectiveness of supplemental feeding (but see López-Bao *et al.* 2008). If wildlife managers are to make informed decisions regarding supplemental feeding, more information is required on variables such as the temporal and spatial variation in rates of food consumption, methods of presenting food and the interactions between target and non-target species at feeders.

The Brown Teal, or Pateke (*Anas chlorotis*), is an endangered duck endemic to New Zealand (BirdLife International 2012) whose decline is thought to be caused by introduced mammalian predators and loss of habitat (O'Connor *et al.* 2007). Because existing wild populations are too small to be harvested for translocations, successful reintroduction of captive-bred animals are required if the species is to recover (O'Connor *et al.* 2007). As a result, captive-bred Brown Teal are now being released in predator-controlled areas as a tool for creating new wild populations. Two major factors are thought to inhibit the success of such translocations: dispersal of birds out of predator-controlled areas and a high mortality rate following release (Rickett 2011). Translocated Brown Teal are prone to starvation (Moore and Battley 2003), probably as a result of the physiological challenge associated with a change from a captive to wild-food diet (Moore and Battley 2006). Thus, supplemental feeding is now used during Brown Teal relocations but little is known about the effectiveness of the feeding techniques employed. In this study, we analyse the effects of supplemental feeding on post-release survival and behaviour of Brown Teal. First, we test the hypotheses that supplemental food will increase survival and decrease dispersal of translocated Brown Teal. In addition, we investigate the proximate mechanisms of supplemental feeding by examining temporal patterns of feeder use and competition at feeders. Together, these studies will provide managers with the mechanistic details required to implement supplemental feeding regimes efficiently and effectively following Brown Teal translocations.

## Methods

### Study site

The Tawharanui Open Sanctuary (36°22'S, 174°49'E) is in the Auckland region of New Zealand. In 2004, a predator-proof fence was installed at this site and extensive trapping and poisoning of invasive mammals has ensured that the site is virtually free of all introduced mammalian predators. However, Swamp Harriers (*Circus approximans*) are present at Tawharanui and are known predators of both adult and juvenile Brown Teal (Barker and Williams 2002). Purple Swamphens (or Pukeko, *Porphyrio porphyrio melanotus*) and eels (*Anguilla* spp.) are also found at this site, and might occasionally eat Brown Teal ducklings (Rickett 2011).

### Study animals and radio-telemetry

Between 2008 and 2010, a total of 123 Brown Teal were released at Tawharanui during four releases (Table 1). All released Brown Teal were captive-bred juveniles or adults that were raised in captivity at institutions around New Zealand. Birds were transferred to a holding facility in Christchurch, New Zealand, for disease screening and pre-release training. In brief, this process included being mixed with other individuals in their release cohort, being introduced to wild foods and learning to use the supplementary feeder stations that would be provided after release. All birds were released at the same site, which was near the centre of the Sanctuary and surrounded by suitable habitat. To determine survival and dispersal of released Brown Teal, most birds (see Table 1) were fitted with a two-function radio-transmitter with a 12-month lifespan attached by a backpack harness (Sirtrack, Hawkes Bay, New Zealand). Total fitted weight of the transmitters was 18.8 g (<3.1% average body mass) and they were affixed 1 week before release. Transmitters were set with a mortality signal that was emitted if the bird had not moved in 24 h. Telemetric monitoring was undertaken approximately every other day for 90 days after release, and once per week for an additional 90 days. This period was chosen in conjunction with the New Zealand Brown Teal Recovery Group to balance monitoring of early dispersal and mortality (i.e. 0–90 days after release), dispersal related to supplemental feeding (see below), and mapping establishment of territories. Furthermore, starvation owing to dietary change is a common cause of mortality during Brown Teal translocations, and birds that survived to 180 days in this study were assumed to have successfully converted to a wild-food diet. Telemetry attempted to pinpoint and record each individual's daytime roost. If a bird was not found at a roost near the release site or its last known site, a wider search was made. Locations of roosts were recorded by GPS (Garmin eTrex 10, Garmin, Olathe, KS, USA, accuracy  $\pm 3$  m, roost estimated within 5–10 m). When radio-telemetry indicated mortality of a study animal, the carcass was retrieved and sent to Massey University's necropsy laboratory for analysis of cause of death. This research was conducted under Massey University Animal Ethics Committee permit 09/42 and New Zealand Department of Conservation permit AK-23882-FAU.

### Survival and dispersal of translocated Brown Teal in relation to supplemental feeding

To assess the effect of supplemental feeding on survival and dispersal after release, we monitored radio-tagged individuals for 180 days after each release. However, when examining the effect of supplemental feeding on dispersal, we only considered data from February 2009 (unfed) and May 2009 (fed). These releases

**Table 1.** A summary of Brown Teal releases at the Tawharanui Open Sanctuary

Date of Release	Number of individuals	Number radio-tagged	Supplementary food provided?
February 2008	24	24	No
February 2009	39	39	No
May 2009	20	9	Yes
February 2010	40	40	Yes

were selected because the presence of conspecifics is thought to influence habitat selection by translocated animals (Stamps 1991), and because no Brown Teal were present at Tawharanui before the first release in 2008, we did not consider birds released in 2008 in our comparison. Also, although supplemental feeding occurred during the 2010 release, feeder manipulations were performed and the feeding regime was not consistent with previous releases. As a result, we did not include dispersal data from the 2010 release in our analysis.

When supplemental feeding occurred, five feeders were equally spaced along a 400-m stretch of stream near the release point. These feeders each had a 'nos-lock' dispenser such that feed was only dispensed when the nozzle was contacted. Each feeder nozzle was enclosed by a steel cage ( $\sim 100 \times 50 \times 50$  cm), which had three square access holes just large enough for Brown Teal to enter ( $\sim 10 \times 10$  cm). This design was intended to prevent larger birds from accessing the food. However, Purple Swamphens were still sometimes able to access the feeder nozzle by stretching their necks through the gaps in the steel cage. During the May 2009 release, all feeders were regularly refilled so that there was always feed available for the first 46 days after release (Phase 1). From Days 47–73 a weaning process was implemented, where two of the five feeders were emptied and in the remaining three the food was allowed to run out (Phase 2). Between Days 74 and 91 no supplementary food was available (Phase 3).

#### *Temporal patterns of feeder use*

Ten individuals from the May 2009 release were tagged by subcutaneous injections at the back of the neck with  $11 \times 2$ -mm Passive Integrated Transponders (PIT) tags (Allflex, Palmerston North, New Zealand). Just before the 2009 release, each feeder was modified by the addition of a PIT tag reader attached to a circular antenna, so that a Brown Teal entering a feeder would have to pass through the antenna, which was positioned further back into the cage from the three entrance holes, in order to reach the feed dispenser. When a bird passed through the antenna the data-logger recorded the PIT tag number of the bird, along with time and date. Use of feeders was monitored in this way for all three phases of the May 2009 release.

#### *Non-target species and the Purple Swamphen exclusion device*

Purple Swamphens have been observed visiting Brown Teal feeders and could potentially disrupt Brown Teal feeding. As such, we tested the efficiency of an exclusion device designed to prevent Purple Swamphens from accessing the feeder nozzle and the area directly around the feeder where most spilt feed is present. This device was made of  $2 \times 2$ -cm wire mesh that covered the entire feeder cage with the exception of the three entrances. After the 2010 release, all feeders were refilled regularly so that there was food available for 160 days following the release. Following this period, four of the existing feeders were selected for video monitoring. At each feeder, the exclusion device was installed for 10 days (3 day acclimatisation period followed by 7 day video monitoring period; see below). Similarly, we monitored visitation rates at the same feeder in the absence of the exclusion device for 7 days (following a 3-day acclimatisation period). These treat-

ments were performed consecutively at each feeder and order was balanced between feeders. Each feeder was monitored with a motion sensitive, infrared video camera (Bushnell Optical, Brookvale, Australia) placed 75 cm off the ground, 2 m from the feeder and concealed in camouflage housing. Cameras recorded a 60-s clip whenever the motion detector was triggered. Videos were scored by a researcher who was blind to the purpose of the study and the treatments being tested.

#### *Statistical analysis*

Statistical analyses were performed with R (version 2.14.0; R Development Core Team 2012) with a level of significance ( $\alpha$ ) of 0.05. When linear models were used, model residuals were visually examined for normality and homoscedasticity. If model assumptions were not met, data were transformed. In all linear models data were scaled and centred to allow for the interpretation of main effects in the presence of interactions (Schielzeth 2010). When multiple comparison tests were required, *post hoc* Bonferroni-Holm corrected pairwise *t*-tests were used (Holm 1979).

To assess if supplementary feeding influenced survival of translocated Brown Teal, we conducted product-limit log-rank survival analysis for 180 days after each release (Kaplan and Meier 1958). This test compares mortality rates for birds in each release group following translocation. When we were unable to find individuals by radio-tracking, and they were not subsequently located during the 180-day period, individuals were censored from their last telemetry fix onwards (i.e. the last date that were confirmed alive) using the Kaplan–Meier procedure (Kaplan and Meier 1958).

To assess how supplementary feeding affected dispersal after release, we compared the location of daytime roosts across phases following the February 2009 (unfed) and May 2009 (fed) releases. We determined the distance from the release site to each bird's daytime roost using the GPS coordinates of radio-telemetry fixes. For each bird we summed all measurements within each phase, and divided by the number of fixes for that individual within the phase, so that we generated three 'distance-to-roost' values for each individual (i.e. one value for each phase). This measure was log-transformed and used as the response variable in a linear mixed model (LMM). Bird identification number was included as the sole random effect and sex, release group (February 2009 or May 2009), phase and the interaction between release group and phase, were included as fixed effects.

We were interested in temporal patterns of feeder use. First, we analysed post-release feeder use in the May 2009 group. Similar to our analysis of dispersal distance (above) we determined a daily rate of use of feeders for each bird for each of the three phases. This was calculated by dividing the number of feeder visits by the number of days in the phase. This daily rate of feeder use was then log-transformed and used as the response variable in a LMM, with bird identification number as a random effect and phase as a fixed effect. We also analysed patterns of feeder use in relation to time of day during the May 2009 release. In this analysis, we pooled visits at all five feeders. Then, we compared counts of the number of visits at night and during the day with a Wilcoxon signed-rank test. 'Night' was defined as the 12-h period between 1800 and 0600 hours, and 'Day' the remaining 12 h. These periods correspond closely with times of sunset and sunrise during our study

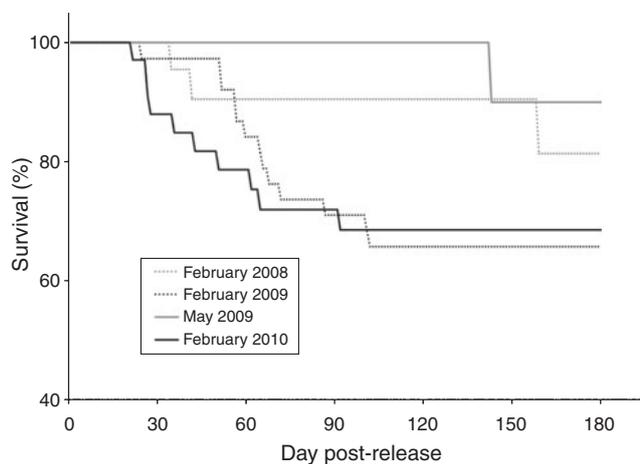
periods. The one individual who died during the May 2009 release was excluded from these analyses.

The effect of using an exclusion device on rates of visitation to feeders of both Purple Swamphens and Brown Teal was analysed with two separate LMM. In these analyses, daily rate of feeder visitation was determined for both Brown Teal and Purple Swamphen at each feeder by summing the number of each species observed on video in a 24-h period (1200–1159 hours). The daily rate of feeder visitation was square-root transformed and used as the response variable in these models. In each model, feeder location and day of videography were included as random effects to account for variation between feeders and for repeated sampling at a single feeder, respectively. Treatment (presence or absence of the exclusion device) was included as the sole fixed effect.

## Results

### Survival and dispersal of translocated Brown Teal in relation to supplemental feeding

There was no difference in survival between the four translocation groups (survival analysis,  $\chi^2 = 4.11$ , d.f. = 3,  $P = 0.25$ ; Fig. 1). In supplementary fed groups there were no suspected deaths as a result of starvation, although there were too few mortalities overall to perform statistical tests between groups. There was a significant main effect of treatment group on dispersal, with the February 2009 (unfed) birds dispersing further on average than the May 2009 (fed) birds (LMM:  $F_{1, 46} = 6.88$ ,  $P = 0.012$ ; estimate =  $-1.10$ ; Fig. 2). There was also a significant main effect of feeding phase on dispersal ( $F_{2, 79} = 54.47$ ,  $P < 0.0001$ ; estimate<sub>Phase 1</sub> =  $-0.76$ ,  $P < 0.0001$ ; estimate<sub>Phase 3</sub> =  $0.72$ ,  $P < 0.0001$ ; Fig. 2), as well as sex ( $F_{1, 45} = 6.39$ ,  $P = 0.015$ , estimate<sub>male</sub> =  $0.51$ ) and a significant interaction between treatment group and phase ( $F_{2, 79} = 15.29$ ,  $P < 0.0001$ ). *Post hoc* Bonferroni-Holm

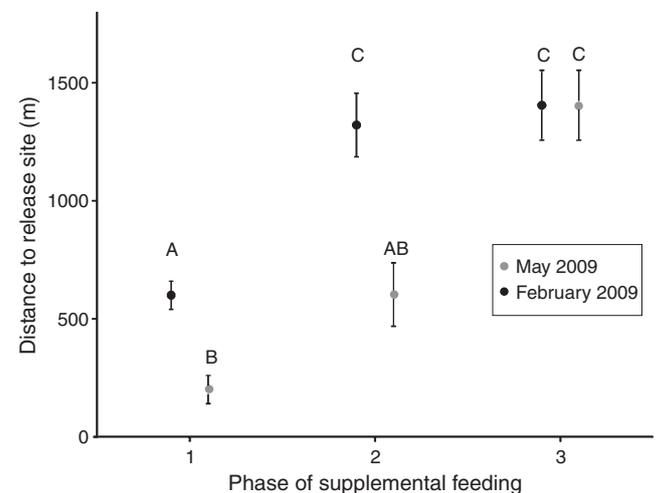


**Fig. 1.** Survival of Brown Teal following four translocations at the Tawharanui Open Sanctuary. Survival rates were determined by radio-telemetry (see Methods) and are based on the number of individuals radio-tagged in each release (see Table 1). Releases receiving supplementary food are shown with solid lines, and releases without supplementary food are shown with dotted lines. There is no significant difference in survival rates between the groups (see text for details of statistical analysis).

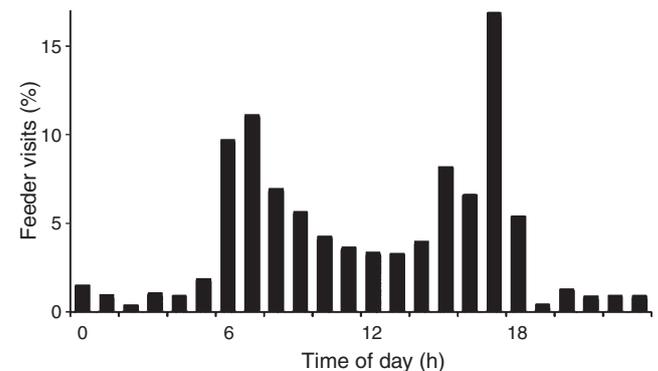
tests show that dispersal distance was lower for the May 2009 (fed) group than the February 2009 release (unfed) in the first two phases and was not significantly different during phase 3 (i.e. once supplemental food was removed).

### Temporal patterns of feeder use

In the May 2009 group, use of feeders decreased significantly across the three phases of the feeding regime (LMM:  $F_{2, 14} = 24.71$ ,  $P < 0.0001$ ; estimate<sub>Phase 1</sub> =  $1.06$ ,  $P = 0.002$ ; estimate<sub>Phase 3</sub> =  $-0.83$ ,  $P = 0.008$ ). Use of feeder was more frequent during the day (mean visits  $\pm$  s.e. =  $57.9 \pm 8.0$ ) than at night ( $11.1 \pm 1.5$ , Wilcoxon signed-rank test,  $W = 2179.5$ ,  $P < 0.0001$ ; Fig. 3).



**Fig. 2.** Dispersal from the release site following two Brown Teal translocations. Data shown are untransformed mean distances ( $\pm$ s.e.) from the release site to diurnal roosts of birds released in May 2009 ( $n = 9$ ) for each phase of the supplemental feeding program (see text for details). For comparative purposes, the same periods were applied to the February 2009 release ( $n = 39$ ). Different letters indicate significantly different values (see text for details of statistical analysis).



**Fig. 3.** Timing of use of feeders by translocated Brown Teal. Data shown are percentage of total visits to feeders following the May 2009 translocation, in periods of 1 h. Data were collected by PIT-tag readers and are pooled over the five fixed feeding stations ( $n = 4630$  visits).

### Non-target species and Purple Swamphen exclusion device

The exclusion cage was successful in reducing visits by Purple Swamphens to the feeders (LMM:  $F_{1,51} = 13.12$ ,  $P = 0.0007$ ; estimate =  $-0.68$ ). However, the exclusion cage also reduced Brown Teal visits (LMM:  $F_{1,51} = 4.18$ ,  $P = 0.04$ , estimate =  $-0.39$ ). Visits by non-target species at the Brown Teal feeders are summarised in Table 2. Purple Swamphens were the most common non-target visitor and occasionally disrupted Brown Teal feeding by aggressively chasing Brown Teal from the feeder or by occupying the feeder causing Brown Teal to avoid the area. Other non-target species occasionally disrupted Brown Teal feeding: the presence of larger ducks sometimes prevented Brown Teal from nearing the feeder and we also observed several instances of Rabbits (*Oryctolagus cuniculus*) occupying the feeder while Brown Teal waited outside.

### Discussion

The effect of supplemental feeding during Brown Teal translocations is mixed. In the current study, we failed to detect any difference in post-release survival when Brown Teal were released with or without supplemental food. Whereas 180-day survival was highest in the May 2009 release group (which received supplementary food), the survival rate of the February 2010 release group (which also received supplementary food) was near the lowest of all release groups (Fig. 1). Our study is consistent with previous research in suggesting that supplemental feeding does not always improve the survival of translocated individuals (Armstrong *et al.* 1999). However, our data do show that supplemental food might influence dispersal patterns of Brown Teal after translocation. When we compared the location of daytime roosts following the two releases in 2009, birds released with supplementary food (May 2009) dispersed more slowly than individuals released without supplementary food (February 2009). Brown Teal typically occupy breeding territories from April to October, when they are aggressive towards conspecifics (O'Connor *et al.* 2007). Because the same release site was used for all releases, suitable territories near the release site would already have been occupied during the May release (C. J. Dey, pers. obs.). Thus, it is unlikely that differences in release date are responsible for the observed differences in dispersal because we would predict that birds released in May would disperse further to avoid the territories of birds that were already established. Instead, we found birds released in May dispersed less, probably owing to the effects of supplemental feeding. Furthermore, we found a sexual bias in post-release

dispersal, with males dispersing further than females. This is not surprising given that natal dispersal in most ducks is male-biased (Clarke *et al.* 1997). However, this finding could have important implications: sex-biased dispersal might cause a local sex-ratio bias at release sites that could lead to a population sex bias if dispersing birds have higher mortality rates (see below). This could in turn have an effect on reproductive output of translocated Brown Teal because this species is primarily socially monogamous with biparental care (O'Connor *et al.* 2007).

Managers often want to reduce dispersal from the release site to a minimum, especially when releases are in areas where factors affecting translocation success can be controlled. Indeed, there is previous empirical evidence to suggest that dispersal from the release site affects subsequent survival. For example, translocated Western Barn Owls (*Tyto alba*) that immediately disperse from the release site have higher mortality rates than those that stay near the release site (Meek *et al.* 2003). Furthermore, minimising dispersal might facilitate social interactions (e.g. finding a mate) that could increase translocation success irrespective of its effects on mortality (Brightsmith *et al.* 2005). Thus, supplemental feeding might still be a useful tool during Brown Teal translocations even if it does not increase short-term survival. By reducing post-release dispersal, supplemental feeding could have both direct (i.e. increasing long-term survival) and indirect (i.e. facilitating pair-formation) effects on translocation success.

To understand how supplemental feeding affects the survival, establishment and reproduction of Brown Teal after translocations it is important to recognise how and when Brown Teal access supplemental food. Despite being described as crepuscular and nocturnal (Barker and Williams 2002), Brown Teal in this study visited supplemental feeders much more frequently during the day. Although diurnal feeder use has the potential to expose Brown Teal to depredation by Swamp Harriers, all feeders in this study were located beneath forest canopy and no predation by Harriers was suspected near feeders. It is possible that if feeders were placed in more exposed areas that Brown Teal would preferentially visit feeders at night. Indeed there is some evidence that this is the case; in a separate study of translocated Brown Teal at another location, feeders were placed in more exposed areas and nocturnal use of feeders was more common than in the current study (J. Rickett, unpubl. data). The timing of use of feeders also has consequences for heterospecific competition at feeders; diurnal use of feeders has the potential to bring Brown Teal into conflict with other birds that are also active during the day. In this study, other ducks and Purple Swamphens were both seen frequently at Brown Teal feeders (Table 2) and occasionally

**Table 2.** Species observed at Brown Teal supplemental feeding stations using motion sensitive, infrared videography

Percentage of visits was determined by dividing the number of videos in which each species was present by the total number of videos in which at least one animal of any species was observed. Percentages do not total 100% because multiple species were occasionally observed on a single video

Species	Percentage of visits	Able to enter feeder?	Typical behaviour
Brown Teal	49.9	Yes	Feeding from nozzle or eating spilt feed
Purple Swamphen	36.6	No	Feeding from nozzle by stretching neck through cage; eating spilt feed
Rabbit	9.4	Yes	Feeding from nozzle or eating spilt feed
House Mice ( <i>Mus musculus</i> )	7.8	Yes	Eating spilt feed
Passerine birds	3.8	Yes	Eating spilt feed
Other species of duck	2.5	No	Eating spilt feed

disrupted feeding attempts by Brown Teal. Both Purple Swamphens and other species of duck primarily fed off spilt feed, but Purple Swamphens were also able to access the feeder nozzle by stretching their necks into standard feeders. For this reason, we tested an exclusion device designed to prevent Purple Swamphens from accessing the feeder nozzle. However, although this feeder exclusion device prevented Purple Swamphens from accessing the feeder nozzle and decreased the rate of visitation by Purple Swamphens, it also decreased visitation rates of Brown Teal. Brown Teal also eat spilt feed (Table 2), and the exclusion device prevented them from accessing food on the ground without entering the feeder. Additionally, the exclusion device might have decreased the willingness of Brown Teal to enter the feeder as it might have served as a 'novel object' that was not present when they learned how to use the supplement feeders in captivity.

### Study limitations

This study is the first to investigate the effect of supplemental feeding on translocated Brown Teal. Although we endeavoured to use a pseudo-experimental approach to test hypotheses relating to the utility of supplemental feeding, we recognise that we did not control for several additional factors that could potentially affect post-release survival and dispersal (e.g. variation in survival and dispersal owing to 'year' or 'season' effects). Some of these issues are inherent in the study of endangered animals as it is unethical to perform manipulations that could affect the health and survival of study animals. Also, translocations are often subject to input from various stakeholders, and it is not always possible to control certain factors (e.g. number of individuals released, release date) needed to reach robust conclusions in the field of reintroduction biology. Furthermore, we recognise that the behaviour of Brown Teal in this study is likely to have been influenced by their captive rearing and ancestry. Thus, this study might not be directly comparable with translocations involving the movement of wild animals. Nonetheless, we feel the data presented in this study are the best available and provide substantial insight into the effects of supplemental feeding during Brown Teal reintroductions. We acknowledge that our data on feeder use, competition and feeder design might not be generalisable to other translocations. However, we include these data to highlight that the influence of supplemental feeding regimes will be highly dependent on these factors, and that more research on proximate issues surrounding supplemental feeding is required to improve supplemental feeding regimes.

### Management implications

We found no difference in post-release survival of Brown Teal released with and without supplemental food. However, we were only able to compare 180-day survival from four releases and it remains possible that supplemental feeding has effects on reproductive success, long-term survival, or effects on short-term survival that would be apparent given a larger sample size. We found that male Brown Teal have higher post-release dispersal than females, and that supplemental feeding has apparent effects in slowing dispersal from the release site, which could have downstream effects in improving translocation success. Thus, we advise the continuation of supplemental feeding during Brown Teal translocations. We also suggest the continued use of PIT tags

for monitoring use of feeders after translocations. Finally, we suggest that limiting the presence of non-target species at Brown Teal feeders will improve the efficacy of supplemental feeding programs. This might require new feeder designs, or pre-release training with the exclusion device tested in this study.

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