Translocation of Tuamotu Kingfishers, Postrelease Exploratory Behavior, and Harvest Effects on the Donor Population

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Translocation of Tuamotu Kingfishers, Postrelease Exploratory Behavior, and Harvest Effects on the Donor Population[1]

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Abstract: Conservationists previously described the need for research into using translocation to rescue threatened populations. We conducted an experimental translocation of Tuamotu kingfishers (*Todiramphus gambieri gertrudae*) to provide foundational information about movement ecology and inform conservation planning for the critically endangered bird. We captured and radio-marked mated pairs of kingfishers on Niau Atoll, French Polynesia, where approximately 125 individuals compose the last remaining population of Tuamotu kingfishers. One bird from each pair was translocated to a reintroduction site on the opposite side of the island, and the other pair member was released back onto the home territory. Home-ranging pair members remained on territories and used habitats disproportional to availability, as determined by Brownian bridge analysis. Translocated individuals made multiple forays from the release site to explore the surrounding landscape, during which habitats were used in proportions similar to availability. The exploratory behavior resembled that of dispersing juvenile birds, which suggested that adults retain the ability to explore, and that dispersal theory may be a useful basis for planning translocations. Vacancies on donor territories were filled within 1–10 days. Our results indicated that translocation was not effective for range expansion on Niau because birds readily returned to donor areas; however, translocation to other islands remains a potential conservation strategy for Tuamotu kingfishers.

Conservation biologists have promoted translocation as an important tool for preventing extinction (Griffith et al. 1989, Green et al. 2005, Seddon et al. 2007). Translocations are defined as the purposeful release of animals to establish, reestablish, or augment a population, and as such they encompass releases within and outside historic ranges (IUCN 1987, 1998). The intent behind translocations to areas within a species' range (reintroduction) and translocations to areas outside the original range (assisted colonization) is frequently to establish satellite populations in geographically distinct locations (Griffith et al. 1989, Derrickson et al. 1998). The hope is that new populations will help buffer against extinction from catastrophic events.

Conservation biology is a "crisis discipline" that requires action to prevent extinction (Soulé 1985), and translocations are among the most drastic tools employed by conservationists (IUCN 1998). As with most actions of last resort, translocation is characterized by benefits and risks that provoke debate about efficacy and need (Green et al. 2005, Seddon

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et al. 2007). Translocating animals to unoccupied habitats comes with inherent risks (Ricciardi and Simberloff 2009). One must question what became of the fauna that originally inhabited reintroduction release sites, or why there are no records of prior existence at assisted colonization sites (Griffith et al. 1989, IUCN 1998). Further, translocation does little to address the threats to population persistence in the existing range.

Literature about translocations has grown substantially in recent years, and authors have emphasized the need for additional research (Seddon et al. 2007, Armstrong and Seddon 2008). Translocation science lacks the benefits of theoretical developments that characterize many areas of conservation biology (Derrickson et al. 1998). For example, few programs have thoroughly documented postrelease fates of animals, despite calls for reports (Fancy et al. 1997). Reviews further indicate that translocations were historically treated as single-species management actions, rather than as a broad conservation strategy worthy of development. Armstrong and Seddon (2008) advised that new research must begin to address translocation from a conceptual perspective and that theory must be developed to support future conservation efforts. Similarly, the International Union for the Conservation of Nature (IUCN) has outlined major considerations for translocations (IUCN 1987, 1998).

We embraced concepts presented by these and other authors, and initiated a study to provide key conservation guidance for threatened Pacific island birds. Our study used one of the most imperiled birds, the Tuamotu kingfisher (*Todiramphus gambieri gertrudae*), to investigate translocation methods, exploratory behavior of translocated individuals, and impacts of harvest from the donor population. The Tuamotu kingfisher is a single-island endemic that is listed as critically endangered (CR) (IUCN 2010). The nominate subspecies was extirpated from the Gambier Islands in the late nineteenth century (Holyoak and Thibault 1984), and the remaining population of approximately 125 individuals now exists only on the French Polynesian atoll of Niau (Gouni et al. 2006, Gouni and Zysman 2007, IUCN 2010, Coulombe et al. 2011, Kesler et al. 2012). Niau is a small island (ca. 26 km^2) with intensive coconut agriculture, introduced rats (*Rattus exulans*, *R. rattus*), and a history of cyclones. These factors may act in combination to adversely affect Tuamotu kingfisher populations (Kesler et al. 2012), and they have inspired conservation practitioners to consider assisted colonization on another island (Gouni et al. 2006).

In previous work, radiotelemetry, direct observations, and repeated surveys were used to study Tuamotu kingfisher space use, resource selection, and movements to empirically define habitat requirements (Coulombe et al. 2011). We used these data to evaluate unoccupied areas on Niau and on other islands in the Tuamotu archipelago, where a second population might be established (Kesler and Gouni 2008, Albar et al. 2009).

We initiated this study to address three primary objectives. First, we aimed to evaluate our ability to safely capture, transport, and release Tuamotu kingfishers in areas on Niau with suitable habitat. Second, we intended to study movements, survival, and behavior of translocated Tuamotu kingfishers, which are year-round territorial residents. Movement ecology (the theory about individual movements [Nathan et al. 2008, Heezik et al. 2009]) is an arena of utmost importance for translocation science. Understanding how and where translocated individuals move provides key insights into how territorial adult birds might explore a novel landscape, and it may help predict where translocated individuals settle on a new island. Third, we studied breeding vacancies created by translocation harvest to determine if they would be filled fast enough for breeding to occur the following year.

MATERIALS AND METHODS

Study Area

Niau is a small coral atoll in the Tuamotu archipelago of French Polynesia (16° 10′ S, 146° 22′ W). The land area is <26 km^2 and encloses a central lagoon (Andréfouët et al. 2005). The inland consists of dense primary forest on jagged fossilized limestone coral (feo forest) (18 km^2). Coconut (*Cocos nucifera*) agriculture underlies Niau's economy, and plantations ring the island on the oceanic and lagoon shores (7 km^2) (Butaud 2007). There is a small village of approximately 170 people on the northeastern side of the island. The climate is tropical oceanic without pronounced seasons (Mueller-Dombois and Fosberg 1998). From 2006 to 2010 donor population research (Coulombe 2010, Coulombe et al. 2011) was conducted primarily on two study areas situated on the east side of the island: one on the ocean coast and one near the lagoon. Coconut forests on the two study areas are managed by the farmers using hand tools and prescribed burns to clear understory vegetation. The coconut forest is narrow (ca. 50–100 m wide) along the ocean coast and wider (ca. 100 to 150 m wide) on the lagoon side. The lagoon study area also includes mixed coconut-feo forest and wetlands dominated by *Sesuvium portulacastrum* (Butaud 2007). The small littoral zone along the ocean coast consists of coral reef with low strand vegetation and sparse coconut trees.

Reintroduction Location

Reintroduction sites were identified using observations from surveys and habitat modeling. Point-transect surveys were conducted annually from 2006 through 2009 at stations spaced by approximately 300 m along the island's ocean and lagoon coasts. Results showed regular kingfisher occurrence around the eastern half of the island, with occasional detections along the western oceanic coast (Coulombe et al. 2011). There was a notable gap in occupancy in a large agricultural area on the lagoon side of the western-central section of Niau (16° 08′ 34.26″ S, 146° 23′ 28.68″ W). Active and mixed fallow coconut agriculture, wetlands, and feo forests characterized the gap region. Agricultural coconut groves are open, and similar to those described previously as suitable habitat for the Tuamotu kingfisher (see Coulombe et al. 2011). Although it was not clear why the birds did not occur in the release location, disturbances for airport construction is likely cause of extirpation. Construction activity included transiting vehicles that may have disturbed birds, until 2005 when activities ceased. We selected the site for reintroduction after a fifth series of point-transect surveys failed to identify kingfisher occupation in 2010.

Reintroduction Design

We attempted to minimize impact to the endangered population by using a low experimental sample size (we captured and radio-marked 2%–5% of the entire population for this project). We captured, radio-marked, and relocated a single member from four breeding Tuamotu kingfisher pairs. Mates of relocated birds also were captured and radio-marked, and then released back onto donor territories. Prior study found that single Tuamotu kingfishers of both sexes maintained territory possession and attracted replacement mates, and that new pairs produced successful nests during the following breeding season (Coulombe 2010). Niau also has substantial unoccupied habitat, which indicated that birds might be slow to settle new areas, even though they readily filled single breeding vacancies. We thus reasoned that territories might not be reoccupied if we collected and relocated pairs of birds, but that vacancies were likely to be filled if single individuals were translocated. Further, this design would provide a means for comparing movements of home-ranging birds and their translocated mates. Observations of unpaired juvenile Tuamotu kingfishers are rare during the postbreeding period (Kesler et al. 2012), so we elected not to use unpaired yearling birds.

Tuamotu kingfishers were captured from 23 February 2010 through 4 March 2010 (immediately following the 2009/2010 breeding season) on previously established study areas (16° 08′ 57.41″ S, 146° 19′ 26.89″ W). On each of the four donor territories, the first captured bird became the reintroduction candidate (three males and one female). Upon capture, we radio-marked each individual (model A1020, 1.6 g, Advanced Telemetry Systems, Isanti, Minnesota). We used a modified leg-loop harness to fit transmitters that included a weak link, which allowed the bird to shed the transmitter after study completion

(Kesler 2011). Standard morphological measures and two ventral tract feathers were collected for subsequent genetic sex determination (Avian Biotech International, Tallahassee, Florida). Relocation subjects were placed inside a folding canvas pigeon basket (Northwoods Falconry, Ranier, Washington), which was then covered with opaque cloth. Birds were transported to the release site on the opposite side of Niau (16° 08′ 34.26″ S, 146° 23′ 28.68″ W) via bicycle and automobile. Immediately before hard release, several drops of 50% dextrose were administered orally. The second pair member from each donor territory was subsequently captured, similarly marked, and released back onto the donor territory (one male and three females).

Radiotelemetry

We used a combination of daily observations and intensive radiotelemetry tracking to record the movements of translocated and home-ranging Tuamotu kingfishers. Immediately after release, translocated birds were tracked for the remainder of the day and then during randomly selected sessions throughout diurnal hours thereafter. Each day was divided into four 3-hr sessions, extending from 0600 to 0900 hours, 0900 to 1200 hours, 1200 to 1500 hours, and 1500 to 1800 hours. At least one session was randomly assigned for tracking each bird during each day. Home-ranging individuals were tracked less frequently to characterize the movements within territories. Home-ranging birds were tracked during at least 1 hr every day, until the last day. In total, observers used radiotelemetry and visual observations to record 827 locations during 99 tracking periods.

We tracked birds using hand-held antennas (Yagi) and recorded coordinates of geographic locations with a global positioning system (GPS) (Garmin Vista, Olathe, Kansas) and a compass. Bird locations were recorded when birds moved >10 m, or locations were recorded every 15 min if perching birds failed to move. When kingfishers were obscured by vegetation, we collected at least three directional bearings and used triangulation to estimate locations. We used LOAS (Ecological Software Solutions, Urnäsch, Switzerland) to estimate the maximum likelihood location and the associated 95% error ellipse (White and Garrott 1990) for each bearing group ($n = 139$). We excluded triangulations with ellipses >0.6 ha, which is approximately 10% of the mean Tuamotu kingfisher breeding home-range size (Coulombe et al. 2011). Observers also noted general behaviors including calling, attempted foraging, successful foraging, and interactions with other birds. Our methods provided individual daily locations for translocated and home-ranging birds, and continuous movement paths at approximately 10 m resolution.

Movement Analysis

We used three different metrics to quantify the movements of translocated and home-ranging Tuamotu kingfishers. Minimum convex polygons (MCP) (Mohr 1947) were derived to provide a basic representation of the areas traversed by radio-marked birds. Some MCPs overlapped with Niau's lagoon because of the island's ringlike shape, so we report total MCP area and the MCP area that overlapped only with land.

We also used Brownian bridge movement modeling (Bullard 1999, Horne et al. 2007) to assess differences between habitats available and those in the movement paths of translocated and home-ranging Tuamotu kingfishers. In general, Brownian bridges produce spatial probability distributions (i.e., utilization distributions) that represent the likelihood of bird occurrence. Many analytical methods for assessing resource selection require temporal independence among observed locations (Hurlbert 1984, Kernohan et al. 2001), but Brownian bridges incorporate serial autocorrelation information and location error information to derive the utilization distribution. Brownian bridge techniques are therefore well suited to our repeated observations.

Brownian bridge analyses incorporate location error, which we estimated using two methods. For records in which observers recorded the actual location of Tuamotu kingfishers, we conservatively used 150% of the typical 3 m accuracy associated with our GPS units (95% circular error probability) (Garmin Ltd. 2007). For locations that were triangulated and estimated using LOAS, we used the ellipse area provided by the software for each location (mean 9.0 m, range 0.3 to 38.8 m). We used Animal Space Use (version 1.3) (Horne and Garton 2009) to estimate the Brownian bridge occurrence distributions for each of the translocated and home-ranging birds. Grid cell sizes were left at the 30 m default, because the Tuamotu kingfishers hunt in areas of approximately 30 m, and they rarely move more than 30 m between perches (D.C.K., pers. obs.). Further, the spatial resolution of habitat coverage maps was much greater than 30 m (Butaud 2007). Observations from the same day that were separated by >2 hr were considered to be different movement tracks. Brownian bridges could not be calculated for stationary individuals, so two sessions that tracked sleeping birds were censored.

We overlaid probability distribution grids on a vegetation cover map of Niau in a geographic information system (ArcGIS, ESRI, Redlands, California) and included 95% of the bird occurrence distribution by volume. Vegetation classes were based on a land-cover map of Niau (Butaud 2007) that delineated agricultural coconut forest, fallow coconut forest, primary feo forest, wetlands, anthropogenic development, and littoral habitats. We then measured the total utilization distribution volume associated with each habitat and for each bird.

We also returned to Niau in November 2010 to assess the fate of donor and translocated Tuamotu kingfishers. During the return trip, we surveyed the population for all color-banded birds and attempted to determine the fate of study individuals.

Statistical Methods

Habitat utilization distributions were used to address two questions. First, we examined Brownian bridge probability density volume within the available habitat area to determine whether translocated and home-ranging kingfishers were selecting or avoiding particular habitat features (design 3 sensu Thomas and Taylor [2006]). We defined habitat availability for each individual using habitat proportions within the MCP that represents the maximum extent of each bird's movements. We derived the polygons from the telemetry relocation points and measured the proportion of each habitat type using the X-Tools extension (Oregon Department of Forestry, Salem, Oregon) in ArcView (ESRI, Redlands, California). We excluded lagoon, ocean, urbanized, and littoral zones from available habitat types because they were available to few birds and they were rarely used. We analyzed these distributions in a weighted compositional analysis (Aebischer et al. 1993, Millspaugh et al. 2006). Compositional analysis has been criticized for inflating Type I error rates from rare habitat types with zero use values (Bingham et al. 2007). However, in this case the method was robust because availability was ≥5% for all habitat types. We further replaced zero use values with 0.01 as recommended by Aebischer et al. (1993). Second, we used similar methods to make a pair-wise comparison between the habitats used by translocated birds and the habitats used by mates on the donor territories to determine if translocated birds used different habitat features. We compared weighted habitat used by translocated birds with weighted habitat used by home-ranging mates. Resource use comparisons were conducted with Resource Selection for Windows (Version 1.00 Beta 8.4) (Leban 1999). We used an α of <.05 for all tests of significance.

RESULTS

Survival and Movement

Tuamotu kingfishers that were translocated to the reintroduction area on the western side of Niau, and those released back onto home territories, all survived throughout our 23-day observation period. Translocated birds remained physically robust during capture, translocation, and release, which required approximately 2–4 hr. Translocated individuals recovered quickly; birds preened and attempted to forage within several minutes of release. One bird flew directly to the treetops and began calling. Similar behaviors were observed among birds that were released back onto home territories during this and previous studies.

Movement differed between translocated and home-ranging birds (Figure 1). Translocated individuals ranged widely, made repeated forays into habitat surrounding the release site, and did not exhibit selection for specific habitat. In contrast, home-ranging birds did not engage in repeated forays; rather they remained on donor territories and exhibited selection for specific habitat types. After release, all translocated individuals flew directly to the same nearby clump of brushy vegetation (approximately 0.5 ha) from which they left within several minutes to explore the larger release site. Birds flew east toward the lagoon and in the direction of the donor area. We could not determine whether the kingfishers were actively orienting toward home territories, or whether they were attracted by the obvious coconut and wetland habitats in the same direction. All of the birds then returned to within 50 m of the actual release location and subsequently began exploring surrounding areas. Similar patterns occurred in the following days. Together, these outbound movements, followed by repeated returns to the release site, suggested that birds were exploring by orienting from the release location (Figure 2). Birds released onto home ranges also flew to nearby perches and preened. One home-ranging individual flew throughout the territory calling from treetops. However, none of the birds left their home ranges immediately after release, and there was no apparent movement from the release locations.

A pair-wise comparison indicated differences between the movement ecology of translocated and home-ranging birds. The MCP area for home-ranging birds (mean = 20 ha, SD = 19) was 25% of the MCP for translocated birds (mean = 93 ha, SD = 48) from the same territories ($P = .0227$, two sample t-test) (Table 1). Brownian bridge occurrence distributions illustrated differences in habitats traversed by translocated and home-ranging birds. Home-ranging birds used habitats disproportional to availability ($\chi^2 = 14.01$, df = 3, $P = .0029$), with habitat rankings ordered as coconut forest, wetland, fallow coconut, and feo forest (Figure 3). However, translocated birds traversed habitats in proportions similar to availability and thus did not appear to be selecting for or against particular features ($\chi^2 = 3.49$, df = 3, $P = .3216$). When habitat occurrence distributions for home-ranging individuals were compared with those of translocated mates, results indicated that proportional habitat volume distributions differed strongly ($\chi^2 = 27.62$, df = 3, $P < .0001$).

Donor Territories and Translocation Fate

None of the home-ranging birds abandoned territories after mates were harvested for translocation, and replacement mates filled vacancies on all donor territories (mean, 6 days; range, 1–10 days). Home-ranging birds of both sexes appeared to readily accept replacement birds because we observed courtship behaviors on all donor territories. On one territory the replacement individual was a color-banded breeder from a neighboring territory. The origin of replacement individuals was unknown for the three other territories because replacements were not banded. Buffy plumage on one unbanded replacement bird indicated that it was a yearling.

Two translocated birds (males 183 and 241) navigated back to their respective home territories in the donor area by the conclusion of February fieldwork. Male 303 and female 020 remained in the release area (Figure 2). Individuals that returned to donor territories during radiotelemetry observations remained at the translocation release site for 9 and 3 days, respectively, before making swift movements around the island of Niau and returning to home locations. Radio signals for birds 183 and 241 were not detected near the release area on 7 and 8 March 2010, respectively, and both were reacquired on home territories (donor sites) on 9 March. We were unable to follow the kingfishers during the homebound transit despite repeated attempts to locate radio signals. However, previous observations of exploratory movements around the island suggested that the kingfishers did

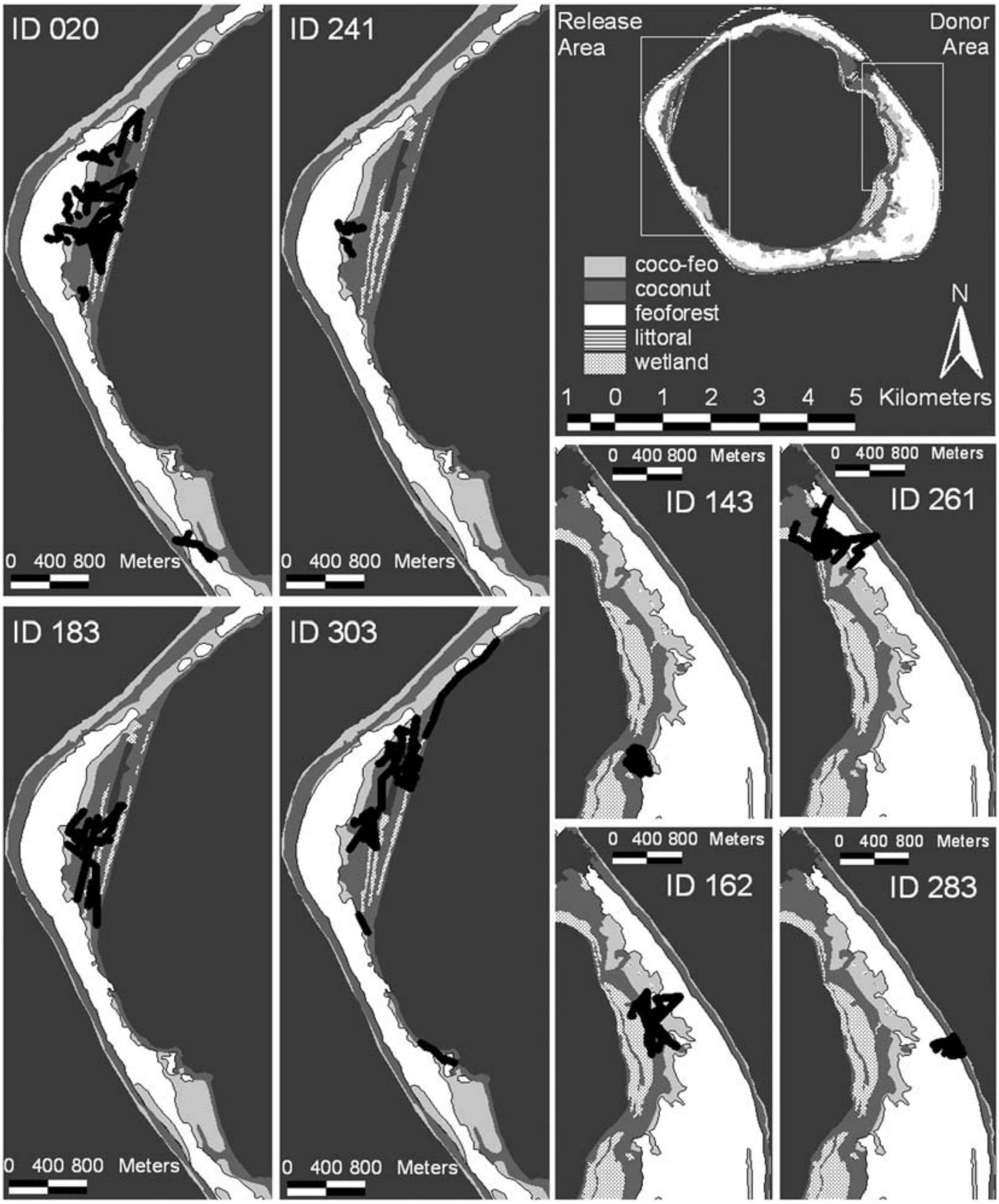

FIGURE 1. Movement tracks for Tuamotu kingfishers are presented as black lines on habitat maps for Niau Atoll, French Polynesia (*top right panel*). Four pairs of birds were identified in the donor area on the eastern side of the island. One bird of each pair was then translocated to a release site on the opposite side of Niau (020, 241, 183, and 303) and tracked with radiotelemetry (*left panels*). The remaining pair members (143, 261, 162, and 283) were similarly marked and tracked within the home territories.

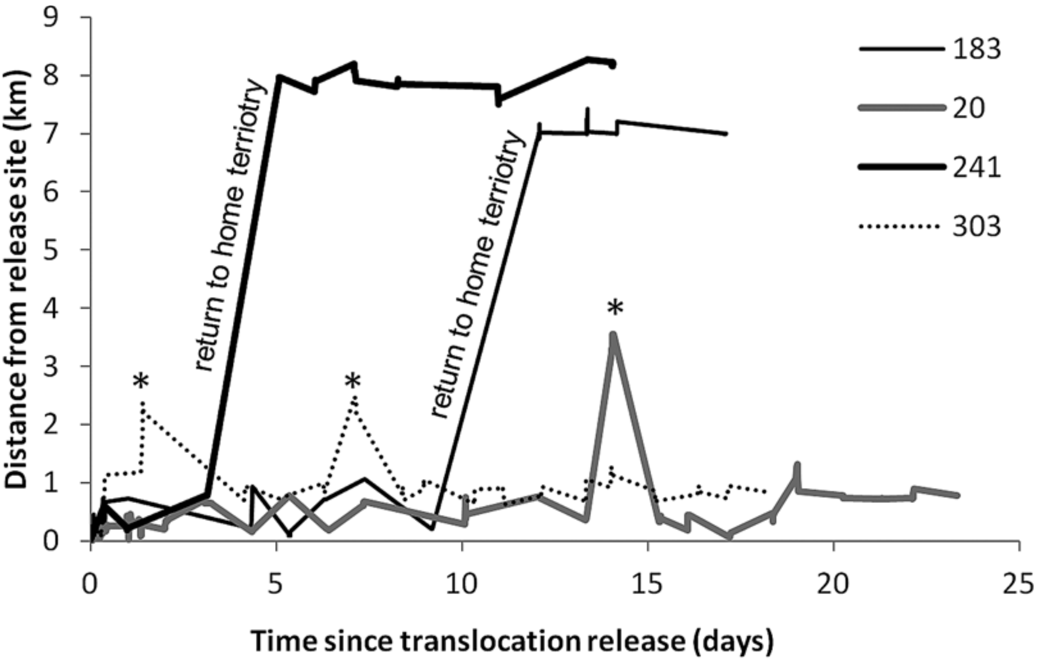

FIGURE 2. Exploration and movement behavior of translocated Tuamotu kingfishers on the island of Niau, French Polynesia. Linear distances from the reintroduction site are presented for birds that were translocated from home territories to unoccupied habitat on the opposite side of the island. Kingfishers 303 and 20 made repeated exploratory forays away from the release site (denoted by *) and then returned to the site afterward. Birds 183 and 241 remained in the release area and then made swift movements around the island and returned to home territories.

TABLE 1

Radiotelemetry Results from Translocated (T) and Home-Ranging (H) Tuamotu Kingfishers on Niau Atoll, French Polynesia

Type	Territory	ID	Sex	Locations[a]	MCP Area[b]	95% UD Habitat Volume[c]			
						Coconut	Coco-Feo	Feo	Wetland
T	A	20	F	189	163	0.54	0.16	0.18	0.11
T	B	183	M	93	58	0.64	0.22	0.01	0.12
T	C	241	M	75	77	0.42	0.21	0.37	0
T	D	303	M	148	86	0.69	0.18	0.05	0.08
H	A	143	M	87	5	0.60	0.12	0.28	0
H	B	162	F	91	29	0.60	0.13	0.03	0.24
H	C	283	F	64	4	0.34	0	0.66	0
H	D	261	F	80	41	0.45	0.31	0.09	0.15

[a] Radiotelemetry locations recorded during tracking sessions.

[b] Minimum convex polygon area (ha), excluding areas overlapping with Niau Lagoon and Pacific Ocean.

[c] Proportional habitat volume of the Brownian Bridge Movement Model utilization distributions.

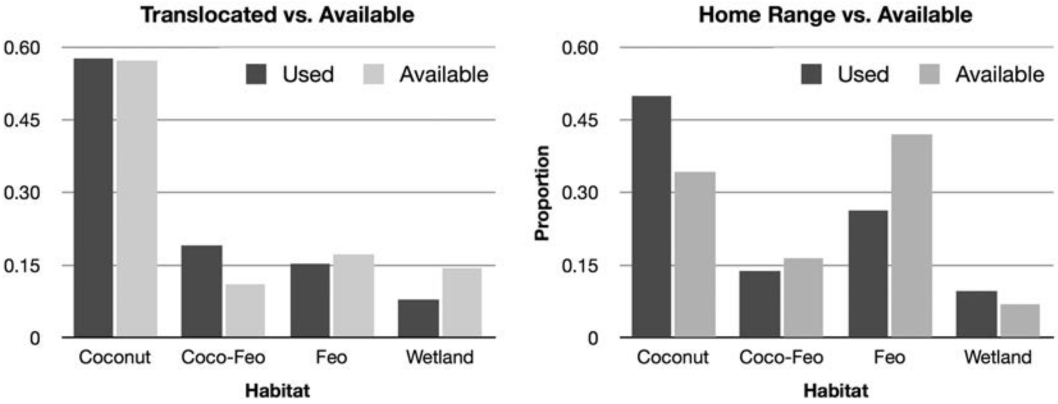

FIGURE 3. Habitat utilization distributions within areas used by home-ranging and translocated Tuamotu kingfishers on Niau Atoll, and habitats available to those same individuals. Habitats were classified as coconut forest (coconut), fallow coconut forest mixed with feo forest (coco-feo), uplifted coral feo forest (feo), and wetland. Home-ranging Tuamotu kingfishers used habitats disproportional to availability whereas translocated birds did not.

not cross over the central lagoon, but rather that they circled the island through terrestrial habitats. Male 183 evicted the new suitor male on his home territory and then reestablished a pair bond with his mate (courtship behaviors were observed on 11 March 2010). Male 241 also regained his original breeding territory after the conclusion of the telemetry study and nested with a new mate the following breeding season. The male and female that remained on the release site (20 and 303) were observed together several times. They perched in close proximity and exchanged the squawking and whining calls that are indicative of pair formation in Tuamotu kingfishers. By November 2010, however, all Tuamotu kingfishers had returned to the donor area. Male 303 was observed nesting with an unmarked bird on the donor territory. Female 20 also returned to the donor area between our field seasons, and she was observed nesting with an unmarked bird in a site adjacent to her original territory. Her previous mate remained on the original territory and was observed copulating with another unmarked bird.

DISCUSSION

We addressed three questions related to the feasibility of translocating Tuamotu kingfishers to reintroduction sites on Niau or to other off-island assisted colonization sites as a conservation strategy. First, we tested our ability to capture, transport, and safely release Tuamotu kingfishers at a reintroduction site within their historic range. Translocated birds behaved normally by calling and foraging within several minutes of release, and they explored the surrounding landscape during the postrelease observation period. However, all translocated birds returned to the donor areas. Together, results indicated that translocation within the island of Niau was not a viable strategy for reestablishing Tuamotu kingfishers in unoccupied areas. Tuamotu kingfishers rarely fly over water, so translocation may remain an option for distant islands.

Second, understanding the movements of translocated birds is key to success of future conservation release programs for territorial resident species, so we also evaluated the movement ecology of translocated Tuamotu kingfishers. If birds remain at a release site without exploring the surrounding resources, they may end up in suboptimal habitat. Alternatively, birds that explore and disperse too widely might have limited opportunities of encountering conspecific mates (Allee et al. 1949). Before fieldwork, we hypothesized that adult kingfishers might not possess the capacity to make large exploratory movements and navigate the landscape, because they were beyond the dispersal stage of their life history. Migrant and wide-ranging species must navigate and settle in new locations each year, but territorial resident species often disperse only once and during a single natal dispersal phase of their life history (Daniels and Walters 2000). However, our results indicate that Tuamotu kingfisher adults maintain the capacity to make large exploratory movements, which supports the use of adult Tuamotu kingfishers for future translocations. Additional research with juveniles, and with additional female birds, may provide similarly supportive evidence for the use of younger or sex-biased birds in translocation populations.

Our results showed stark differences in movements and habitat selection by birds on donor areas and translocated individuals. Home-ranging birds used habitats disproportional to availability, which corresponds with previous studies (Coulombe et al. 2011). Translocated kingfishers used a larger area than their home-ranging counterparts and showed unbiased utilization of available habitat. These differences indicated that translocated individuals were able to enter an exploratory state where they surveyed available habitat in the release vicinity. There may be theoretical frameworks to which postrelease behaviors could be compared, because the patterns observed in Tuamotu kingfishers were similar to stay-and-foray natal dispersal behavior seen in other species (Brown 1987, Kesler et al. 2010). For example, before natal dispersal, resident red-cockaded woodpeckers (*Picoides borealis*), Micronesian kingfishers (*T. cinnamominus*), and red-bellied woodpeckers (*Melanerpes carolinus*) make multiple outward exploratory movements before returns to natal areas (Kesler and Haig 2007*a*, Cox and Kesler 2012*a*,*b*, Kesler and Walters 2012). The underpinnings of natal dispersal behaviors have been developing rapidly in recent years, and new work might provide insights into both natal dispersal theory and postrelease exploratory movements of translocated adult birds.

Last, we assessed the response of the donor population to the removal of translocation subjects. Results suggested that breeding may continue on established territories if single adult breeders are used for translocation. During previous fieldwork we also observed breeding vacancies that were filled by replacement individuals (Kesler 2011). Nonetheless, the speed at which breeders replaced donor birds after translocation removal in this study was surprising. One replacement bird displayed the buffy-tipped feathers characteristic of first-year plumage, so he had not previously bred and might have been dispersing from the natal territory. One adult replacement was a previous occupant on a neighboring territory. The other two adult replacements may have been “floater” individuals awaiting opportunities to fill breeding vacancies, or birds from surrounding areas moving to higher-quality territories (e.g., Otter and Ratcliffe 1996). Dispersing juveniles or unpaired floaters in the study area would be indicative of a surplus of potential breeders. Limited harvest from the breeding population may have minimal impacts if breeding vacancies are filled from this pool of potential breeders. However, additional research is required to address the issue, because we did not have the ability to determine whether breeding vacancies were filled by breeders from other territories or by unpaired individuals.

Key questions related to reintroductions have been presented previously (Armstrong and Seddon 2008), and the same questions also broadly apply to assisted colonization. At the population level, Armstrong and Seddon (2008) asked how reintroduction is affected by the size and composition of the release group, how management affects postrelease survival and dispersal, what habitat conditions benefit persistence, and how genetic makeup affects reintroduction population persistence. We previously published foundational information about the ecology and natural history of Tuamotu kingfishers that describes the habitat composition needed to promote postrelease persistence and guide habitat management at donor and release sites (Coulombe et al. 2011, Kesler et al. 2012). Research presented here addresses factors likely to affect establishment of Tuamotu kingfishers at release sites, including movement and dispersal behavior, and we provide information about potential demographic impacts on the source population (Rout et al. 2007). Subsequent research should be aimed at determining optimal genetic composition of release groups, the genetic effects on the donor population at the population level, and about metapopulation and ecosystem level effects as well.

Additional investigations would bolster knowledge about translocations of territorial resident bird species in tropical Pacific Oceania (Franklin and Steadman 1991). Similar studies with extended holding times would provide information about the applicability of our findings to interisland assisted colonization. Researchers might also consider using surrogate congeneric species to test translocation methods (e.g., Work et al. 1999, Gaskins et al. 2008) or using our results for conservation programs aimed at congener species with similar natural histories (e.g., Kesler and Haig 2007*b*, *c*). For example, translocation programs for the Guam Micronesian kingfisher (*T. cinnamominus cinnamominus*) (U.S. Fish and Wildlife Service 2008, U.S. Department of Defense 2010) and the Marquesan kingfisher (*T. godeffroyi*) could both benefit from added information. Finally, we suggest that additional research focus should be aimed at the effects of translocation harvest from donor populations.

Our results suggest that translocation within the Tuamotu kingfisher's historic range on Niau is not a useful method for expanding the contemporary range of the birds. However, translocation to distant islands remains as a conservation option for the Tuamotu kingfisher. We previously identified three islands with the potential to host a rescue population, including Mangareva, the uplifted island of Makatea, and the atoll of Anaa. Tuamotu kingfishers demonstrated the capacity to survive transportation and to recover quickly from hard releases into open and unoccupied habitats. This species apparently possesses a behavioral mechanism for navigating and exploring release areas. Finally, observations from donor areas indicate that territory vacancies created by translocation harvest are quickly filled. The origin of vacancy-filling birds is not clear, however, so the overall impacts on the donor population remain somewhat ambiguous.

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