Notornis, 2025, Vol. 72: 197–203, https://doi.org/10.63172/030191yughpk
1177 7680

New insights into the behavioural ecology of the Pacific imperial pigeon (*Ducula pacifica*)

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Abstract: Pacific imperial pigeons (*Ducula pacifica*) are important seed dispersers with complex vocal and behavioural repertoires. This study documents their vocalisations, territoriality, mating, nesting, and feeding behaviours in Rarotonga, Cook Islands. Five vocalisation types were identified and described here as the *common coo*, *territorial coo*, *courtship coo*, *quiet coo*, and *growl*. The *common coo* and *growl* were most frequent, often exchanged in call-and-response between distant birds. The *territorial coo* and *courtship coo* were linked to close interactions. Territoriality involved displays, chasing, and occasional combat. Year-round aerial display flights suggest a potential role in territoriality rather than being exclusively tied to breeding season. Mating included novel post-mating courtship feeding. Feeding observations and faecal analyses confirmed an exclusive reliance on non-native plants, indicating a potential role in spreading invasive species. This study enhances knowledge of Pacific imperial pigeon vocalisations and behaviours, with implications for species identification, invasive species management, and habitat maintenance and restoration in Pacific ecosystems.

Morejohn, K.G. 2025. New insights into the behavioural ecology of the Pacific imperial pigeon (*Ducula pacifica*). *Notornis 72*(4): 197–203, https://doi.org/10.63172/030191yughpk

Keywords: copulation feeding, Cook Islands, Rarotonga, rupe, vocalisation

INTRODUCTION

Pacific imperial pigeons (*Ducula pacifica*) are large, frugivorous pigeons native to islands across the southern Pacific Ocean, ranging from the Bismarck and Louisiade Archipelagos in Papua New Guinea in the west to the Cook Islands in the east (Holyoak & Thibault 1984; Pratt *et al.* 1987; Baptista *et al.* 2020a). These birds play a crucial ecological role as seed dispersers of native vegetation, contribute to the maintenance and regeneration of tropical forests, and serve as a food source for local communities throughout their range (Beichle 1991; McConkey *et al*. 2004; Meehan *et al.* 2005; Powlesland *et al*. 2008; Pratt & Mittermeier 2016; Serra 2016; Serra *et al.* 2021).

Pacific imperial pigeons inhabit diverse tropical ecosystems, from low-lying atolls to high inland forests, and are exclusively arboreal (Holyoak & Thibault 1984). Their diet reportedly includes young leaves, flowers, and primarily dozens of species of tree fruits, and they often congregate in large feeding groups (Beichle 1991; Watling 2001; McConkey *et al.* 2004; Serra 2016; Baptista *et al.* 2020a). Fruit seeds smaller than 20 mm are typically defecated, while larger seeds are reportedly regurgitated, both in viable conditions that promote germination (McConkey *et al.* 2004). Although most seeds are voided near host trees, dispersal distances of up to 100 km are theoretically possible (McConkey *et al.* 2004).

Direct observations of Pacific imperial pigeons are challenging, with calls and dietary habits often recorded without visual confirmation, complicating species differentiation (Holyoak & Thibault 1984; McConkey *et al.* 2004; Pratt & Mittermeier 2016). Currently, their vocalisations are classified into two categories: growls, which are species-specific, and coos, which are less distinctive (Beichle 1991; Pratt & Mittermeier 2016).

Received 8 March 2025; accepted 15 October 2025
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A regular repeating coo call attributed to Pacific imperial pigeons by Beichle (1991) was attributed to the tooth-billed pigeon (*Didunculus strigirostris*) by Pratt & Mittermeier (2016) and Serra *et al.* (2021). Confusion between calls may have inflated population estimates of tooth-billed pigeons (Pratt & Mittermeier 2016).

Little is known about the nesting or mating behaviours of Pacific imperial pigeons, with no information on nesting season from the Cook Islands. They construct nests made of twigs high in trees and both parents participate in incubation of a clutch of one or possibly two eggs (Holyoak & Thibault 1984; Baptista *et al*. 2020a). In American Samoa, nesting is mainly from May to August; in Tonga, fledglings are most common from January to February. In Vanuatu, nests are most common from September to January (Gibbs *et al.* 2001). Birds are also known to perform display flights believed to correlate with breeding, though these flights remain undescribed (Powlesland *et al.* 2008; Butler 2012).

Historically inhabiting native interior forests of Rarotonga, Cook Islands, Pacific imperial pigeons began expanding into coastal regions in the late 1980s, lured by the planting of non-native Manila palms (*Adonidia merrillii*) with edible fruits (Turbott 1977; G. McCormack, pers. comm., 2023). In Rarotonga, these birds coexist with the endemic Cook Islands fruit-dove (*Ptilinopus rarotongensis*), the only other extant native columbid (Holyoak & Thibault 1984; Turbott 1977). Pacific imperial pigeons in the Cook Islands consume fruits of *Ficus* spp., Tahitian chestnut (*Inocarpus fagifer*), beach gardenia (*Guettarda speciosa*), and others, with fruit sizes ranging from 3–30 mm in diameter, though their extensive use of recently introduced plant species is unpublished (Holyoak & Thibault 1984; Staddon *et al*. 2010; G. McCormack, pers. comm. 2025).

This study provides a comprehensive description of the calls and behaviours of Pacific imperial pigeons via direct observation in the Cook Islands. It is the first account of behaviour of Pacific imperial pigeon from the Cook Islands in nearly 50 years. The findings provide new insights into previously undescribed aspects of their ecology, including specific vocalisations, diet, territoriality, display flights, mating, and nesting behaviour. Understanding the vocalisations of Pacific imperial pigeons is critical for distinguishing them from co-occurring species and improving population estimates, which are required for monitoring and conservation in the Cook Islands and other regions. Knowledge of their breeding seasons is vital for sustainable hunting management, enabling the protection of breeding individuals. Insights into their diet highlight contributions to seed dispersal, forest health, and ecosystem maintenance.

MATERIALS AND METHODS

Observations of Pacific imperial pigeon behaviour were made by the author in Tikioki, Rarotonga, Cook Islands (21.2654°S 159.7420°W) from July 2023 to June 2024. The study site was a ~5000 m^2 section of lowland area composed of non-native vegetation. Monitoring was performed during daylight hours, with 10–20 hours of direct observation each month.

All observations, including those of vocalisations and defecations were made exclusively on visually identified birds. Seeds found in faeces were measured and identified to the lowest possible taxonomic level.

Nest investigations were made by video using an iPhone X attached to the end of a 5 m pole. Videos of territorial behaviour were made with the same device. Photographs of birds were taken with a Sony a7RV with a Sony FE 100-400 lens. Sonograms were extracted from video recordings, and both sonograms and videos were archived in the Macaulay Library of the Cornell Lab or Ornithology, where they are publicly accessible (https://www.macaulaylibrary.org). Video and sonogram catalog numbers begin with 'ML'.

RESULTS

Vocalisations and associated posturing

Vocalisations were categorized into two main types: coos and growls. Using observations of call-associated posturing, time between vocalisations, and numbers of birds present during vocalisation, the coos were further subdivided into four distinct variations: *common coo*, *courtship coo*, *territorial coo*, and *quiet coo* (Table 1). The most frequent vocalisations were the *common coo* and the *growl*, with birds loudly vocalising over many minutes, and often switching back and forth between the two calls. Both the *common coo* and *growl* were used as a call-and-response, including by incubating birds, with distant birds sometimes replying. When together, mated pairs were almost always silent, except in rare cases when making the *courtship coo* or *territorial coo*. The least common vocalisations were the *quiet coo* and *courtship coo*.

Common coo

The *common coo* consisted of two or three slurred notes. Most frequent variations included a two-note, descending *OOOooh*, a three-note ascending then descending *oooOOOooh*, and a two-note ascending *oooOOH*. Occasionally, this call had a preceding element with a brief pause, followed by a louder, higher-pitched note, *hoo-OOH*. Within these variations, individual calls varied further in pitch and volume. The *common coo* was made only by solitary birds. Pauses between each call were longer than the call itself.

When calling, birds stood tall with their heads angled downward and their chests inflated (Fig. 1; ML632007918). There was minimal body movement; the head bowed slightly, and in some instances, the tail lowered during the call. After each call, birds returned to their normal posture and scanned their surroundings. The *common coo* was sometimes interspaced with the *growl* (described below).

Figure 1. Body posture of Pacific imperial pigeon (*Ducula pacifica*) during *common coo* vocalisation.

Territorial coo
The *territorial coo* consisted of one to three gentle *ooohs* separated by pauses roughly equal to the length of each note: *oooh*-pause-*oooh*, or *oooh*-pause-*oooh*-pause-*oooh* (ML632007821, ML640212799). Notes and pauses between notes were approximately one second. This call was accompanied by territorial posturing in which the bird stood tall with head pulled back and bill pressed against inflated chest (Fig. 2a), then quickly dropped into a crouched position with head facing downward (Fig. 2b). A single *oooh* was uttered during the crouch, followed by a return to the upright posture and usually repeating the whole sequence two or three times.

Figure 2 (a). Pacific imperial pigeon (*Ducula pacifica*) in upright body posture and (**b).** crouched body posture during *territorial coo* vocalisation and display.

Courtship coo
The *courtship coo* was a series of six to ten progressively shorter *ooohs* with a quick stop between each: *ooooh-ooooh-oooh-oooh-ooh-oh-oh-oh-oh-oh*. Vocalising birds bobbed their heads with each *oooh*, and occasionally the bobbing caused birds to bounce, particularly when perched on thinner branches. This call was usually made once but was occasionally repeated a second time. It was always directed by one bird towards a nearby bird that appeared to be its mate.

Quiet coo
The *quiet coo* had a distinctive windy tone, a lower volume compared to the *common coo*, and usually a single variation: *oooOOOooh* (sometimes *hoo-OOOoooh* interspaced). Birds making this call typically had their eyes closed, producing the sound with minimal body movement, and, unlike those making the *common coo*, they would not look around after each call. The *quiet coo* was repeated at regular intervals over many minutes.

Growl
The *growl* was like the common coo but with a trilling overlay. The pitch and speed varied greatly, ranging from a deep, trilling *hooo* to a high-pitched *gr-r-r-r* growl. Most common calls were *GR-R-R-r-r-r-r* and *gr-r-r-R-R-R-r-r-r* (ML632007480). Occasionally, this call was preceded by a short element: *grrr-ROOO*. Birds produced *growls* with heads facing forward or tilted slightly upward, throats expanded, and neck and throat feathers irregularly erected (Fig. 3). Birds only made these calls when they were alone, and often immediately upon landing. Pauses between each call were longer than the call itself.

Figure 3. Pacific imperial pigeon (*Ducula pacifica*) body posture during growl vocalisation.

Territoriality
Birds exhibited strong territoriality, with aggressive behaviour directed towards other Pacific imperial pigeons, except for their mates. Birds were never observed in large flocks, despite substantial availability of palm fruits. No more than two birds (a mated pair) were observed peacefully together at any one time.

Territoriality followed a three-stage escalation: (1) approaching, (2) approaching and territorial display, and (3) approaching, territorial display, and attack and/or combat.

Upon observing another bird or mated pair, a dominant bird flew or hopped through foliage to approach the other(s). This often prompted the others to flee the area.

Table 1. Descriptions of Pacific imperial pigeon (*Ducula pacifica*) vocalisations.

Vocalisation	Description	Sound	Volume	Birds present during call
Common coo	Single or repeated at irregular intervals of many seconds to minutes	*OOOooh*, *oooOOOooh*, or *oooOOH* Infrequently: *hoo-OOH*	Quiet to loud	One
Courtship coo	Produced once or twice in succession	*ooooh-ooooh-oooh-oooh-ooh-oh-oh-oh-oh-oh*	Medium	Two
Territorial coo	Produced once or twice in succession	*oooh*, *oooh*-pause-*oooh*, or *oooh*-pause-*oooh*-pause-*oooh*	Quiet	Two-Four
Quiet coo	Windy tone, repeated at regular intervals	*oooOOOooh* Infrequently: *hoo-OOOoooh*	Quiet	One
Growl	Single or repeated at irregular intervals of many seconds to minutes	*GR-R-R-r-r-r-r*, or *gr-r-r-R-R-R-r-r-r* Infrequently: *grrr-ROOO*	Quiet to loud	One

If the approach by the aggressor failed to drive the bird(s) away, the aggressive bird performed a territorial display (i.e., *territorial coo* and posturing). Frequently, a single territorial display was sufficient to cause the other bird(s) to retreat.

Occasionally, an opponent responded by attacking the displaying bird, or by maintaining its position and performing a counter-display. Counter-displaying birds hopped between branches and rotated positions until one bird attacked the other. This attack was always directed toward a bird that was mid display.

During an attack, the aggressor attempted to land on the opponent while biting and flapping wildly. Most attacks caused the opponent to retreat to a lower branch or fly away without physical contact. If the altercation continued, birds returned to the original branches and resumed displays. Some attacks resulted in both birds clutching each other and falling more than 2 m to the ground. Another attack resulted in two birds colliding while flapping violently, which led to a brief pause with one bird hanging upside down from a branch while holding the other bird in its beak.

Display flight

Aerial displays were observed throughout the year, sometimes multiple times per day. A single displaying bird took flight, flapped forcefully in a downward swoop with wings sometimes clapping together, before angling into an upward arc approximately 5-8 m high. As the flight path became vertical, the bird paused momentarily before it dived and levelled into normal flight (Fig. 4; ML632007227). Only one aerial display typically occurred per flight, though occasionally two sequential displays were performed. No vocalisations were observed during display flights.

Mating and courtship feeding

Mating was observed on 21 Dec 2023. Two birds sat side-by-side, and the female crouched and presented a horizontal back. She remained crouched in this position for 47 seconds until the male mounted her (Fig. 5a). Mating lasted 9 seconds. After dismounting, the female remained crouched and arched her head upward toward the male in a begging posture. The male responded by feeding the female for approximately 4 seconds (Fig. 5b). Following this, the pair separated and groomed. No vocalisations were observed.

Nesting

A nest was observed on 31 Mar 2024, located approximately 6 m above the ground in a weeping fig tree (*Ficus benjamina*). At first observation, the nest was fully constructed, and adult birds appeared to take turns incubating egg(s) or young. The nest was rarely left unattended. Incubating birds generally remained still and silent but occasionally modified the nest and performed common coo and growl calls.

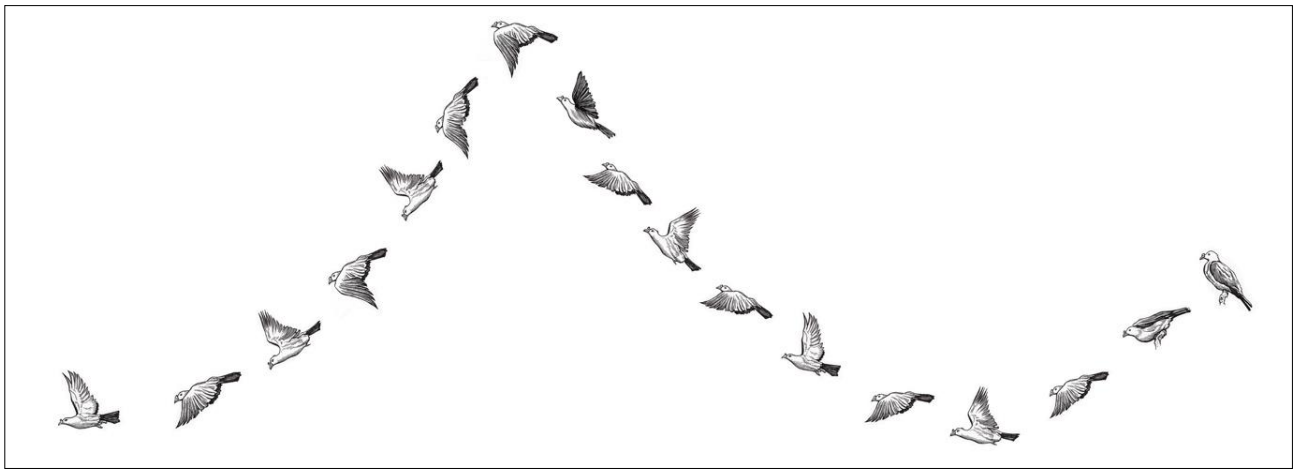

Figure 4. Display flight of the Pacific imperial pigeon (*Ducula pacifica*). Note: Bird and display flight not to scale. Illustration by Jeremy Bennett.

Figures 5 (a). Pacific imperial pigeon (*Ducula pacifica*) mating and **(b).** post-mating courtship feeding (male on right).

Attempts to film the egg(s)/young were unsuccessful. When approached with a pole camera, the incubating bird postured by raising one wing vertically (Fig. 6; ML632007650) but always remained on the nest, blocking the view. Last observations of the active nest were on 19 April. When observations resumed on 14 May, the nest was vacated or abandoned.

Figure 6. Nest guarding by incubating Pacific imperial pigeon (*Ducula pacifica*).

A fledged juvenile was observed nearby on 26 May. The juvenile had a small cere, remnant down feathers, and brown irises, unlike the red irises of adults (Fig. 7). The juvenile approached a pair of adult birds and was chased away.

Figure 7. Juvenile Pacific imperial pigeon (*Ducula pacifica*) with small cere, brown eye and remnant down.

Feeding, drinking; faecal examination

Birds were observed feeding on fruits of areca palm (*Areca triandra*), Fiji fan palm (*Pritchardia pacifica*), Macarthur palm (*Ptychosperma macarthurii*), white mulberry (*Morus alba*), and flowers of ice-cream bean (*Inga edulis*). They were also observed on the ground consuming small particles from the ground. Birds drank rainwater from leaf surfaces and from small puddles on the ground.

Thirty-five faecal specimens from defecating birds were recovered and analysed. Faeces were primarily composed of seeds and fruit skins suspended in a thick mucus. Seeds were identified as *Capsicum* sp., Manila palm (*Adonidia merrillii*), and areca palm. Faeces with Manila palm seeds contained only a single seed coated in a thin layer of mucous. The largest excreted Manila palm seed measured 19 mm wide by 31 mm long. No observations of regurgitations were made.

DISCUSSION

This study provides new insights into the vocalisations, behaviours, and ecological roles of Pacific imperial pigeons in the unique context of Rarotonga, Cook Islands by describing previously unreported vocalisations and their associated behaviours. Moreover, observations of feeding behaviours and seed dispersal patterns shed light on the pigeon's relationships with both native and non-native plant species. These findings have broader implications for columbid ecology and conservation strategies, and the management of native and invasive plant populations.

Coo and growl vocalisations have been well documented by other authors by both visual and inferred investigation (Holyoak & Thibault 1984; Beichle 1991; Pratt & Mittermeier 2016; Baumann & Beichle 2020). However, this study describes two new coo variations (the *territorial coo* and the *courtship coo*) and associated behaviour during calls. For instance, the *common coo*, *quiet coo*, and *growl* were only made by individual birds when they were alone. The *courtship coo* and *territorial coo* were only made when birds were in the presence of others. This pattern held up in reverse – when birds were first heard rather than seen, their calls always indicated how many other birds were in the immediate area. These results may allow observers to estimate how many unsighted birds are present based on the calls heard.

The *quiet coo* was most similar to the *common coo*, but was differentiated by volume, call-associated behaviour and duration of repetition. Observations of the *quiet coo* being repeated over many minutes supports those made by Beichle (1991). However, Beichle (1991) classified this as a 'territorial coo'. Rarotonga birds that made this call over many minutes appeared uninterested in a response, because after each call, they did not scan their surroundings as they did during the *common coo*. Instead, they sat nearly motionless, often with their eyes closed, and did not seem to be claiming territory or warning off rivals.

Pratt & Mittermeier (2016) noted that "An important difference is that a series of moans from a Pacific imperial pigeon usually varies in both pattern and cadence, and almost always include some growls if the sequence is long enough." These observations were the same for the majority of Rarotonga pigeon vocalisations, except the *quiet coo* that has a regular pattern and cadence and lacks interspaced growls. Pratt & Mittermeier (2016) recorded an unseen bird (ML 139904), thought to be a tooth-billed pigeon rather than a Pacific imperial pigeon. This recording sounds nearly identical to the *quiet coo* from Rarotonga birds. As noted by Baumann & Beichle (2020) though, differentiating between these species in the field is exceedingly difficult, and best done by laboratory analysis of recordings.

Identical descriptions of what was classified in this study as the *territorial coo* and posturing have been described by Forshaw & Cooper (2015) for Christmas Island imperial pigeons (*Ducula whartoni*). However, for Christmas Island imperial pigeons, this behaviour was attributed to courtship rather than aggression. For Pacific imperial pigeons in Rarotonga, however, this display was never directed towards a mate and always used to intimidate or initiate a fight.

Previously in the Cook Islands, calls containing a rapid series of coos (described in this study as the *courtship coo*) were attributed only to Cook Islands fruit-doves (G. McCormack, *pers. comm*., 2024). However, this study found that Pacific imperial pigeons make this vocalisation.

As a result, additional investigations are required to differentiate calls between these two species to aid in population estimates.

Beichle & Baumann (2016) classified the *growl* call into two categories. While this could be true of Rarotonga birds, two distinct categories were not observed, although a specialised audio recorder or software for comparisons might show them. Future studies of Rarotonga birds should include recording devices, as video recordings allow vocalisations to be interpreted as part of behavioural sequences.

Even with substantial stands of fruiting areca palms, Rarotonga Pacific imperial pigeons were extremely territorial and never tolerated the presence of other Pacific imperial pigeons, except for their mates. Large flocks sharing fruiting trees as described by Holyoak & Thibault (1984) and Powlesland *et al.* (2008) were not observed in this study. Territorial behaviour was observed throughout the year, which made it unclear which resources were being guarded. Blanvillain & Thorsen (2003) observed Marquesan imperial pigeons (*Ducula galeata*) exhibiting guarding behaviour in food trees; however, these interactions were limited to chasing. Observations of territorial displays and combat in this study appear to be the first for the genus.

Powlesland *et al.* (2008) noted that display flights of Pacific imperial pigeons could be an indicator of nearby nesting, and Butler (2012) attributed pigeon display flights to the start of breeding season. Display flights are commonly observed in other columbid genera, and in addition to mating season, are also attributed to territoriality (Cramp 1958; Powlesland 2013; Baptista *et al.* 2020b). Pacific imperial pigeons in this study displayed year-round, with no months showing heightened activity, leaving it unclear whether this behaviour serves territorial, mating, and/or other purposes.

Pacific imperial pigeon display flight is like display flights described in other *Ducula* species; however, the number of displays per flight can differ: 1-2 displays per flight by Pacific imperial pigeons from this study, and 3-4 displays per flight by mountain imperial pigeons (*Ducula badia*) (Smythies 1981; Baptista *et al.* 2020b & c; del Hoyo *et al.* 2022).

The single observation of each of mating, nesting, and fledging observed between December and May fell outside the nesting and fledging seasons recorded for Pacific imperial pigeons in American Samoa and Tonga (Baptista *et al.* 2020d) and Vanuatu (Gibbs *et al.* 2001). Based on the limited observations in this study, prohibiting hunting from December to May could provide protection to breeding birds. This date range may apply specifically to Rarotonga; however, additional data on nesting season are needed. Within the Cook Islands, Pacific imperial pigeons are found on multiple islands up to 1,000 km north from Rarotonga, and nesting season may vary (Holyoak & Thibault 1984). Because of the rarity of encountering nests, breeding season might be best determined by extrapolating backwards from emergence of fledged juveniles. Additional hunting management strategies could include a short (2-3 month) hunting season and ammunition limits as employed by the nearby island nation of Niue (Powlesland *et al*. 2008).

Observations of both adults incubating and rarely leaving their loosely made nests of twigs were the same as described by Baptista *et al.* (2020a). Unfortunately, determining the number of eggs or young, and hatching timing was not possible due to nest guarding by the incubating adults.

Courtship feeding, a behaviour observed in various bird families including Columbidae, has not been documented in *Ducula* species prior to this study (Lack 1940; Smith 1980). In wood pigeons (*Columba livia*), males feed females before mating (Lack 1940), contrasting with the post-mating courtship feeding observed in this study. Although Blanvillain & Thorsen (2003) documented mating in the Marquesan imperial pigeon, they did not report any associated courtship feeding. Overall, observations of *Ducula* mating behaviours in the scientific literature are limited.

Birds in this study consumed fruits and flowers and defecated seeds from only non-native species; none of these food sources have been previously reported for Pacific imperial pigeons (Holyoak & Thibault 1984; Beichle 1991; Watling 2001; McConkey *et al*. 2004; Serra 2016; Baptista *et al*. 2020a). The study site was dominated by non-native vegetation and located more than 50 m from the nearest native vegetation. McConkey *et al.* (2004) and Meehan *et al.* (2005) reported that nearly all seeds consumed by Pacific imperial pigeons were voided within 50 m of the trees where the fruits were eaten. Given this context and the small faecal sample size (n=35) in this study, it is not surprising that native seeds were absent. Unlike observations reported by McConkey *et al.* (2004), the birds were never observed to regurgitate seeds during this study. Even the largest seeds, such as those of the Manila palm, were defecated.

Seeds of *Capsicum* sp. and Manila palm were found in faeces, despite neither plant species being present within the study area. This indicates that these seeds were transported, although it is unclear whether they originated within 50 m of the study site. *Capsicum* sp. seeds likely came from the small, non-native, naturalised chili pepper, *Capsicum frutescens*, which is widespread on Rarotonga and commonly consumed by introduced species such as the common myna (*Acridotheres tristis*) and feral chicken (*Gallus gallus*) (*pers. obs*., 2017).

Birds can disperse non-native plant species, contributing to their invasive potential (Aslan 2011). Among the plant species recorded in this study, only the Manila palm is considered invasive in some areas outside its native range, though its invasiveness potential is unknown in the Cook Islands (Connor 2008; Smith 2010; Oviedo & González-Olivia 2015). The Pacific imperial pigeon has been observed feeding on non-native strawberry guava (*Psidium cattleyanum*), contributing to its spread in the native forests of Rarotonga (G. McCormack, *pers. comm*. 2025). Interestingly, although the native Pacific banyan (*Ficus prolixa*) in Rarotonga is found exclusively in lowland non-native forests, Pacific imperial pigeons do not frequent it or disperse its seeds, despite seed dispersal of these species by Pacific imperial pigeons elsewhere (Compton & McCormack 1999; Staddon *et al*. 2010). Vegetation surveys in Rarotonga's inland forests could help determine whether viable Manila palm or other non-native seeds are being transported and germinating, as well as their potential impact on native forests.

The direct observations and faecal analyses in this study, while limited, raise key questions regarding the movement patterns and feeding preferences of Pacific imperial pigeons in Rarotonga. It remains unclear whether the birds observed in this study are primarily residents of lowland areas dominated by non-native vegetation, if they move between lowland and native forests but preferentially feed on non-native fruits, or if they feed in both areas, but with seeds primarily voided near their respective fruiting trees, as per McConkey *et al.* (2004) and Meehan *et al.* (2005).

Future research should focus on the role of Pacific imperial pigeons as seed dispersers for both native and non-native plants in order to assess their impact on native ecosystems. Additionally, studies on seed dispersal and viability for the Mitiaro fan palm and other native plants in the Cook Islands would deepen the understanding of the ecological roles once fulfilled by bird species, offering valuable guidance for conservation strategies.

ACKNOWLEDGEMENTS

Meitaki maata e aroa nui to Gerald McCormack and Joseph Brider for first telling me about *rupe* display flight and encouraging me to take a closer look at these stunning birds. Additional thanks to Dr Jessica Cramp, Dr Brooke Kirby, Dr Douglas Pratt and an anonymous reviewer for their comments and constructive advice. Finally, I extend my deepest gratitude to Jeremy Bennett for contributing his time and expertise to illustrate the display flight of the Pacific imperial pigeon.

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