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Source: Bulletin of the British Ornithologists' Club, 139(3) : 293-302

Published By: British Ornithologists' Club

URL: https://doi.org/10.25226/bboc.v139i3.2019.a9

Nesting behaviour of Natewa Silktail *Lamprolia klinesmithi*

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Received 21 May 2019; revised 12 August 2019; published 20 September 2019
http://zoobank.org/urn:lsid:zoobank.org:pub:C337F855-B862-46C0-ADE1-58CFC59E8BF5

Summary.—I report observations on the nesting behaviour of Natewa Silktail *Lamprolia klinesmithi* on the Natewa Peninsula, Vanua Levu, Fiji. Field work in June–August 2018 located four nests of which two were closely monitored. Nest attentiveness was very low (42.58% and 42.05% of total observation time spent at the nest), as was provisioning rate (35.29% of nest visits with food) in part due to uniparental care but possibly also in response to nest predation and fecundity-survival trade-off by the parent. Nest site and habitat were significantly different from historical records pertaining to the closely related (previously conspecific) Taveuni Silktail *L. victoriae*. The close proximity of nests and presence of six individuals in the nesting area poses questions concerning the species' breeding strategy. The paucity of data surrounding the ecology of *Lamprolia* and the lack of formal protective legislation on the Natewa Peninsula highlight the need for research into this endemic and globally threatened species.

The genus *Lamprolia* (silktails), endemic to the islands of Vanua Levu and Taveuni, Fiji, has been the cause of significant taxonomic confusion since its description by Otto Finsch in 1874, having been described as 'one of the most puzzling birds of the world' (Mayr 1945). Initially, its systematic affinities were adjudged largely based on plumage and behaviour, rather than any comprehensive morphological or genetic studies. *Lamprolia* was once thought to be affiliated to Paradisaeidae due to various similarities with the genera *Manucodia* and *Ptiloris* (Cottrell 1966, Heather 1977). This hypothesis was dismissed by Olson (1980) and Coates *et al*. (2006), with more detailed morphological analysis indicating that the genus was best placed in Monarchidae. The most recent assertion based on DNA is that *Lamprolia* is most closely related to the equally distinct Papuan *Chaetorhynchus*, together within Rhipiduridae (Irestedt *et al*. 2008). Additional molecular evidence (Anderson *et al*. 2015, 2017) has helped confirm that the previously monospecific *Lamprolia* comprises two species-level taxa: Taveuni Silktail *L. victoriae* (considered Near Threatened, and restricted to the island of Taveuni) and Natewa Silktail *L. klinesmithi* (Vulnerable, and confined to 260 km² of the Natewa Peninsula on Vanua Levu) (BirdLife International 2017, del Hoyo *et al*. 2018).

This study focuses on *L. klinesmithi*, the smaller and more vibrantly spangled species, which also displays supposed ecological differences in foraging behaviour (Watling 2001). Despite the recent taxonomic split, the incentive to study both populations has not yet been a priority. As a result, far more is known concerning the more easily observed and abundant *L. victoriae* on Taveuni, where there is greater coverage of undisturbed forest and three reserves provide legal protection for the species (Masibalavu & Dutson 2006). Ornithological field work on the Natewa Peninsula has been very limited (BirdLife International 2018) meaning that research into the ecology of *L. klinesmithi* has been minimal. Despite the majority of the Natewa Peninsula being recognised as an Important Bird Area (IBA) and the existence of community agreements (BirdLife International 2018),

ISSN-2513-9894 (Online)

the area is not subject to formal protection from logging and agriculture, which has led to extensive areas of mature forest being cleared and degraded (Masibalavu & Dutson 2006). Larger scale logging has slowed substantially since the start of the 21st century, with a mere 0.19% canopy cover lost between 2000 and 2012 across the IBA (Tracewski *et al*. 2016). However, the spatial scale used by Tracewski *et al*. (2016) may not elucidate finer changes in forest type and the key threat to much of the biodiversity on Natewa; degradation of mature forest via small-scale agricultural clearance. The nest, eggs and behaviour at the nest have been described for *Lamprolia* generally, but these are based on 14 nests from Taveuni and just one on Vanua Levu (Heather 1977). My study presents observational data at four additional nests on the Natewa Peninsula, two of which were monitored, elucidating novel information on the nesting behaviour of *L. klinesmithi* and questioning previous hypotheses concerning the species' social structure.

Methods

Study site.—Field work was undertaken on the Natewa Peninsula between 11 June and 5 August 2018, at a forestry station between the villages of Natewa and Vunimokasoi (16°38′7.3104″S, 179°45′16.1784″E; *c*.230 m), from which trails were established and used to search for nests. The area represents a mosaic of undisturbed and regenerating forest from past logging, as well as patches of farmland supporting small-scale crop production, including 'dalo' *Colocasia esculenta* and 'kava' *Piper methysticum*, and hardwood plantations of mahogany *Swietenia macrophylla* and pine *Pinus caribaea*. The discovery of four nests within 0.023 km² during the last ten days of the study provided an insight into the species' reproductive behaviour.

Monitoring.—Nests were found on 26 July (hereafter, nest 1), 30 July (nests 2 and 3) and 3 August (nest 4). The location, tree species, height and stage of nesting was determined at all four nests, but monitoring was only undertaken at nests 1 and 3 due to their relative visibility. Four nest watches of varying lengths were undertaken at each nest, two in the morning and two in the afternoon, between their discovery and the end of the study. Nests were observed from *c*.15 m using a telescope and binoculars to minimise disturbance, with the observer noting and timing all behaviours by the adults using a watch to the nearest second at nest 1 and to the nearest minute at nest 2 (due to the second observer possessing a less accurate watch). A total of 654 minutes 20 seconds was spent observing nest 1 and 371 minutes at nest 3. Periods of attentiveness (time spent at nest), brooding (time spent brooding the chick), incubation, and absence (time away from nest), as well as the number of visits, calls and food provisions made by the adult were measured at nests 1 and 3.

Recordings of vocalisations were made using a Tascam DR-05 handheld recorder and a BOYA BY-PVM1000L shotgun microphone. The contents of all nests were checked upon their discovery and subsequently for the monitored nests at the start of each nest watch using a mirror mounted on a pole, with photographs taken when possible. Nest 2 was too high to determine the nest contents using this method, but sound-recordings made of a begging young in the nest enabled me to establish the nesting stage. Nest height was determined by measuring the pole using a tape measure. Tree species was determined by a knowledgable local guide. Sex of the adults could not be determined as the species is sexually monomorphic.

In addition to nest watches, mist-netting was also conducted over the course of two field trips (12–21 July 2017 and 24 July–4 August 2018) in the vicinity of nests 1 and 3, where all species trapped were ringed and processed. This permitted me to determine the number of birds present in the area, as well as the breeding condition, gender and age of those individuals with cloacal protuberence or a brood patch.

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Results

Nesting stage and location.—All nests were cup-shaped, typically Monarchidae-like in structure, largely comprised of dead leaves, vine tendrils and moss, bound together with spider web and lined with pale grey feathers, probably of Barking Imperial Pigeon *Ducula latrans*. Nest 3 differed slightly in that there was much moss hanging loosely around the outside (Fig. 1). Nests were sited 5.0–10.5 m above ground in the horizontal fork of small branches of 'makita' *Atuna racemosa* trees, the rim of the nest being level with the branches of the fork. Each nest was shaded by either the leaves of the tree or a vine, and was sited within 2 m of the main or a principal secondary trunk of the nest tree. The depth of the cup relative to the size of the bird meant only the head and tail protruded from the nest, as well described and illustrated by Heather (1977).

Nests 1–3 were all located within 5 m of a stream, and all nests were in relatively mature wet forest but very close to small-scale 'dalo' *Colocasia esculenta* and 'kava' *Piper methysticum* cultivation. Nests 1 and 3 were just 18 m apart, with nest 2 being 250 m away, above a steep stream bank. Nest 1 held a single hatchling estimated to be just a few days old given very sparse feathering, closed eyes and no audible begging. Nest 2 had a single nestling in the later stages of development based on the fairly loud begging calls recorded when the adult arrived. Nest 3 initally had one egg that hatched on 1 or 2 August 2018; its base colour was pinkish white with extensive reddish-brown speckling (Fig. 1). Nest 4 held a very similar egg. Table 1 presents the details of nest placement and nesting stage at each nest.

Nesting behaviour.—Nest attentiveness (percentage of overall observation time spent at nests by adults) was 42.58% and 42.05% for nests 1 and 3, respectively. Provisioning rate (percentage of nest visits with food) was 35.29% at both nests. Results and timings for behaviours observed at nests 1 and 3 are presented in Tables 2a and 2b, respectively. At nest 1, it appeared that just one bird attended, brooded and provisioned the chick, as two adults were never seen together at the nest. At nest 3 almost certainly a ringed female with a brood patch was the only adult seen regularly in attendance. Once, two unringed birds arrived at the nest simultaneously, silently hopped around the rim while wing flapping for *c*.30 seconds, and then flew off. I assume the unringed bird attending nest 1 was also an adult female, because neither of the males I ringed showed any evidence of a brood patch.

TABLE 1

Summary of key details recorded at four nests of Natewa Silktail *Lamprolia klinesmithi* found on the Natewa Peninsula, Vanua Levu, Fiji.

	Nest 1	**Nest 2**	**Nest 3**	**Nest 4**
GPS location	16°37′36.5406″S, 179°44′54.7188″E	16°37′45.0588″S, 179°44′57.7212″E	16°37′37.1382″S, 179°44′54.8982″E	16°37′48.5400″S, 179°44′53.0406″E
Date found	26 July 2018	30 July 2018	30 July 2018	3 August 2018
Height (m)	6.45	10.0	5.2	5.0
Tree species	Makita	Makita	Makita	Makita
Nesting stage	Feeding, chick predated?	Feeding	Incubating + feeding	Incubating
Number of eggs	NA	NA	1	1
Number of nestlings	1	1	1	NA
Number of nest-watches	4	0	4	0

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Figure 1. Two nests of Natewa Silktail *Lamprolia klinesmithi*, Natewa Peninsula, Vanua Levu, Fiji: (a) nest 1 with the adult perched on the rim, (b) nest 3 and (c) the egg in nest 3 shown in the reflection of the mirror (Joseph England)

When brooding the adult regularly sat upright and tended the chick or nest briefly before either leaving the nest or re-assuming the usual low-slung position in the nest. The bird would leave silently, dropping straight down from the nest very rapidly and always in the same direction. There was an observed preference for facing away from the apex of the fork and trunk of the tree. At least six *L. klinesmithi* were regularly seen in the immediate vicinity of the nests. At times up to four individuals would pursue each other swiftly through the

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TABLE 2a

Summary data from four nest watches conducted at nest 1 of a sample of four nests of Natewa Silktail *Lamprolia klinesmithi* on the Natewa Peninsula, Vanua Levu, Fiji.

	Watch 1	Watch 2	Watch 3	Watch 4	Total
Date	26 July 2018	28 July 2018	28 July 2018	30 July 2018	NA
Start time	15:30:00	09:09:00	14:25:11	06:53:00	NA
Duration	02:05:42	02:50:41	02:55:37	03:02:20	10:54:20
Nest visits	11	8	8	7	34
Attentiveness total	00:49:34	01:16:50	01:22:18	01:09:53	04:38:35
Attentiveness %	39.43	45.02	46.86	38.33	42.58
Attentiveness mean	00:04:30	00:09:36	00:10:17	00:09:59	00:08:12
Attentiveness range	00:00:15–00:10:10	00:00:11–00:18:15	00:00:30–00:22:39	00:07:50–00:13:56	00:00:11–00:22:39
Brooding	00:38:16	01:04:21	01:11:05	01:01:57	03:55:39
Brooding %	77.20	83.75	86.37	88.65	84.59
Provisioning chick	2	2	5	3	12
Provisioning chick %	18.18	25.00	62.50	42.86	35.29
Provisioning self	0	1	1	3	5
Mean calls prior to arrival	2	2.14	1.88	3.29	2.27
Off nest total	01:16:08	01:33:51	01:33:19	01:52:27	06:15:45
Off nest %	60.57	54.98	53.14	61.67	57.42
Off nest mean	00:06:55	00:13:24	00:11:40	00:14:03	00:11:03
Off nest range	00:00:41–00:22:36	00:02:23–00:44:15	00:00:09–00:23:56	00:03:45–00:33:58	00:00:09–00:44:15

TABLE 2b

Summary data from four nest watches conducted at nest 3 of a sample of four nests of Natewa Silktail *Lamprolia klinesmithi* on the Natewa Peninsula, Vanua Levu, Fiji.

	Watch 1	Watch 2	Watch 3	Watch 4	Total
Date	30 July 2018	31 July 2018	31 July 2018	4 August 2018	NA
Start time	15:45:00	07:45:00	14:40:00	07:37:00	NA
Duration	00:38:00	03:07:00	01:22:00	01:04:00	06:11:00
Nest visits	2	9	5	4	20
Attentiveness total	00:15:00	01:12:00	00:40:00	00:29:00	02:36:00
Attentiveness %	39.47	38.50	48.78	45.31	42.05
Attentiveness mean	00:07:30	00:08:00	00:08:00	00:07:15	00:07:48
Attentiveness range	00:07:00–00:08:00	00:04:00–00:14:00	00:05:00–00:12:00	00:03:00–00:11:00	00:03:00–00:14:00
Provisioning chick	NA	NA	NA	3	3
Provisioning chick %	NA	NA	NA	75.00	NA
Provisioning self	NA	NA	NA	0	NA
Mean calls prior to arrival	1	2	0.25	1.25	1.125
Off nest total	00:23:00	01:55:00	00:42:00	00:35:00	03:35:00
Off nest %	60.53	61.50	51.22	54.69	57.95
Off nest mean	00:11:30	00:14:22	00:10:30	00:08:45	00:11:57
Off nest range	00:05:00–00:18:00	00:07:00–00:26:00	00:07:00–00:13:00	00:05:00–00:11:00	00:05:00–00:26:00

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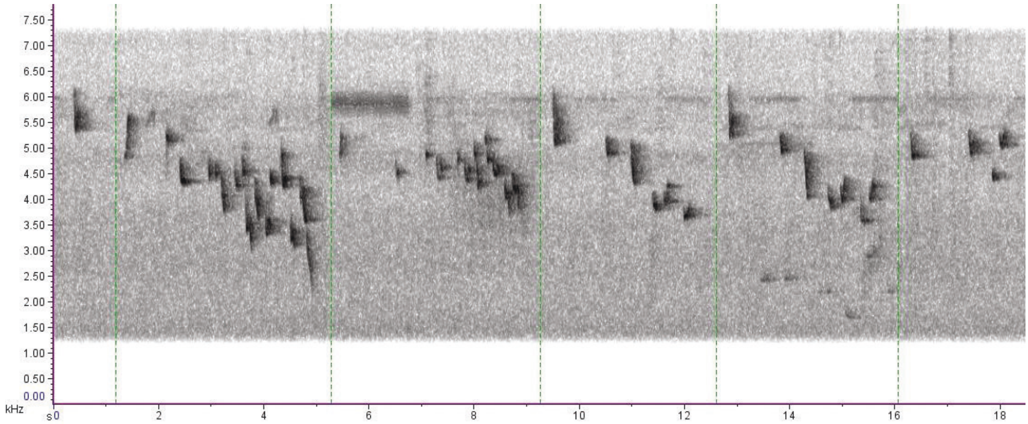

Figure 2. Sonogram showing the variation in calls given by the adult Natewa Silktail *Lamprolia klinesmithi* at nest 1, each calling event separated by green dotted lines; recording archived at https://www.hbw.com/ibc/sound/natewa-silktail-lamprolia-klinesmithi/silktail-song.

understorey, often passing directly overhead when a high-pitched rasping call was heard. Singles would occasionally pause to perch and then rejoin the chase. Despite this, there appeared to be complete tolerance of other silktails foraging and vocalising near nests. Just once was there an observed response from the nesting individual to a second bird; at nest 1 the brooding bird flew directly upwards to challenge a calling silktail causing a chase and interaction, before probably the same bird returned with a small cricket.

Vocalisations.—Prior to arrival at the nest, several calls were given as the bird got closer, ranging from a single sharp note to the full song, a series of rising and falling whistles, see https://www.hbw.com/ibc/sound/natewa-silktail-lamprolia-klinesmithi/silktail-song (Fig. 2). The number of calls given prior to arrival increased with the duration of the off-bout. Calls from the nest were rare and consisted of just one or two single notes, with no obvious purpose, or reaction from nearby individuals. A scold was also given in response to disturbance by the adult at nest 2 while constantly twitching its wings and tail, and furtively moving through the midstorey.

Provisioning.—The only identifiable food items brought to nest 1 were small crickets, although some prey was perhaps not seen due to its small size. The adult brought food to the nest five times but consumed the prey itself. Faecal sacs were apparently consumed by the adult and were not observed to be removed from the nest. There was less provisioning at nest 3 as the adult was incubating for the majority of the time spent watching.

Predation.—On 31 July nest 1 was checked and found to be empty, with the chick presumably having been predated. The adult was not seen at the nest again. Less vocalising was witnessed and there were more silent arrivals at nest 3. Nesting birds were alert to both Barking Imperial Pigeon and Fiji Shrikebill *Clytorhynchus vitiensis* that flew overhead but did not call or leave the nest. At nest 3 the nearby call of a Collared Kingfisher *Todiramphus chloris* caused the bird to depart the nest. Two silktails were observed mobbing a kingfisher in the area three weeks before the discovery of the nests. It is presumed from this behaviour that a kingfisher or possibly a shrikebill was responsible for the predation of nest 1.

Discussion

Breeding season.—There is no specific breeding season for many birds in Fiji, as appears to be also true elsewhere in the Pacific (Pyle *et al*. 2016) and perhaps across much of the tropics (Hau *et al.* 2008). Some species are known to breed in every month, presumably

ISSN-2513-9894 (Online)

in response to sporadic peaks in resource abundance (Watling 2001). Most avian breeding activity in Fiji occurs between June and August, which also appears true of *Lamprolia*, for which there are no nesting records in January–April (Heather 1977, Frith & Watling 1989, Watling 2001). The only previous nesting record of *Lamprolia* on Vanua Levu was in early September (Heather 1977). Records on Taveuni imply synchronised breeding, given the presence of multiple fledglings and vacated nests (Frith & Watling 1989), which matches the findings of the present study. Whether this reflects some form of intraspecific stimulation or environmental factors is unknown.

Nest, nest site and clutch.—The appearance of the four nests all match one of the two types described by Heather (1977). All were decorated externally with mosses and lichens, rather than with no decoration or just dry leaves and fibres. The fact two nests possessed a lining of Barking Imperial Pigeon feathers is consistent with the moss-decorated type described by Heather (1977). There was no apparent correlation between nest type and the different populations of *Lamprolia* on Taveuni and Vanua Levu, nor with season, altitude or material availability (Heather 1977). The use of feathers for nest lining is rare among birds in Fiji, having been reported only in Pacific Swallow *Hirundo tahitica*, with a single observation for Azure-crested Flycatcher *Myiagra azureocapilla* (Heather 1977). Such a lining is not required for insulation due to the warm climate in Fiji, and given that a lining of feathers is thought to increase nest predation (Møller 1984) there must be some as yet unknown net benefit. Each nest held one egg; those eggs seen, but not measured, match previous descriptions. Clutch size is usually an evolutionary trait associated with a 'slower pace of life' in the tropics (Jetz *et al*. 2008), but it is also directly linked to limited food availability and as a method of minimising predation risk (Martin *et al.* 2000), both of which could be factors at play with *Lamprolia*.

Nest height above the ground contrasted with previous observations on Taveuni. All historical nests were placed 1–3 m up (Heather 1977, Watling 2001) whereas all four in this study were 5.0–10.5 m high. As most previous recorded nests were on Taveuni, it is possible this reflects a behavioural difference between Natewa and Taveuni Silktails. Observations of the foraging behaviour of Taveuni Silktail suggest that that species is more likely to feed among the leaf litter (Heather 1977). It has been speculated that these behavioural differences are due to the absence of Taveuni's Azure-crested Flycatcher (or its congener on Vanua Levu, Chestnut-throated Flycatcher *Myiagra castaneigularis*) from the Natewa Peninsula. The *Myiagra* species are subcanopy feeders that utilise a similar niche to *Lamprolia*, which would lead to the latter's competitive exclusion on Taveuni but niche-broadening on Natewa. Alternatively, the presence of the introduced Small Indian Mongoose *Herpestes javanicus* on Vanua Levu could be the cause (Morley 2004). Although direct predation has been not observed, the mongoose can climb trees and its foraging behaviour is relatively undescribed across much of the species' introduced range (Nellis & Everard 1983).

The consistency of nesting habitat, including proximity to water and tree species used, indicate that Natewa Silktail is reliant on a fairly specialist forest type. *Atuna racemosa* grows only along creek lines in lowland valleys, which explains the preference for streamside gullies. It is used by indigenous comunities to construct corner posts and rafters for their houses due to its durable and flexible properties in strong winds, whilst smaller branches and leaves are used for waterproof roof thatching and to bind the walls as a form on insulation (V. Cegumalua pers. comm.). These properties are perhaps also utilised and beneficial to *Lamprolia*. The nest tree species was not noted on Taveuni, but it was reported that nests there were often sited on or near ridgetops, whereas the only previous Natewa nest record was in a broad level-ground gully near a sharp drop to a stream (Heather 1977). Nesting habitat is perhaps another key difference between the two species.

ISSN-2513-9894 (Online)

Nesting behaviour.—Nest attentiveness was extremely low, indeed lower than that of any passerine species subject to comparable studies (Tieleman *et al*. 2004, Chalfoun & Martin 2007). This could be a result of food limitation (Chalfoun & Martin 2007), lower latitude (Martin 2002) or to minimise the risk to the adult and nest of predation (Martin *et al*. 2000, Ghalambor & Martin 2001). Low nest attentiveness during incubation could at least partially explain the need for insulation, which a feather lining would offer (Tieleman *et al*. 2004). The low rate of chick provisioning, long off-bouts and frequency of self-feeding at the nest suggests a life history trade-off, with the adults placing their own survival above that of their offspring due to low clutch size (Ghalambor & Martin 2001). Heather (1977) concluded that one bird nestbuilds and incubates, and my study shows also that apparently one adult alone provisions the chick. Single-parent care is another factor reducing attentiveness (Matysioková & Remeš 2014).

Predation appeared to be a key factor determining much of the silktail's nesting behaviour. The evasive and defensive behaviour against Fiji Shrikebill and particularly Collared Kingfisher implies these two species are nest predators. The shading over the nest, low concealed posture of the sitting birds, and quick dropping flight when departing the nest, are common to all nests found (Frith & Watling 1989) and likely to be designed to minimise predation. The external decoration of moss and greenery would also help to conceal the nest.

The reason for the prolific vocalising prior to arrival is unknown. Although apparently paradoxical, these calls may reduce predation risk by negating untimely begging and increasing feeding efficiency (Magrath *et al*. 2010). Although a reduction in vocalisations was noted while incubating, calls were still given before arrival at the nest. This suggests they could have an alternative function, perhaps to signal their presence to other adults nesting nearby. The relationship between off-bout length and number of calls prior to arrival at the nest is interesting and, with further work, could help uncover the reason for the vocalising.

The close proximity of all nests, especially 1 and 3, is unusual. The tolerance of two or more nesting birds so close to each other is remarkable and rare in non-colonial birds. Heather (1977) described a group of three nests at various stages on Taveuni, showing that this is not a one-off. Although pursuit flights between four birds occurred in the nesting area, this behaviour appeared display-like or ritualistic rather than confrontational, as in the same area individuals were seen foraging in loose groups of up to six. This could suggest that the group comprises related individuals or that a harem-type mating system exists. Of course, it is possible that, because *Lamprolia* requires such apparently specialised habitat for nesting, habitat constraints have led to such nest proximity.

Nest attentiveness and provisioning, although low, is probably explained by small clutch size and fecundity-survival trade-off in adults. It appears the microhabitat and nest tree species are particularly important in the species' breeding biology, reinforcing the need to protect this area. Further study is certainly required to establish the benefit of vocalising before arrival at the nest, the mating system and detailed habitat requirements for foraging and nesting. A comparative study of Taveuni and Natewa Silktails would help to uncover ecological differences and understand possible impacts of different species assemblages and invasive species. Colour ringing as many indidivuals as possible in the population would be a first step to better understand nesting behaviour and responsibilities, as well as to monitor territory size and habitat usage. Genetic analysis examining relatedness within groups would help shed light on whether any form of cooperative breeding occurs in the species' population.

ISSN-2513-9894 (Online)

Unfortunately, significant time constraints on field work resulted in a small sample size of nests from just one area. Due to this small dataset, there are limitations on the conclusions that can be drawn and there is still a degree of speculation surrounding the species' reproductive behaviour. The paucity of historical field work and, therefore understanding of the region's ecology, make it difficult to reach any firm conclusions. This study serves to underline how little we know of the ecology of Pacific island birds, especially local and range-restricted species.

Acknowledgements

This study was supported by and part of the ongoing work being undertaken on the Natewa Peninsula by Operation Wallacea (www.opwall.com) in partnership with the communities of Vusaratu and Natewa. I thank all staff from Operation Wallacea for their logistical support which enabled this study, especially Tim Coles and Greg Kerr. Particular thanks go to my friend and guide Viliame 'Bill' Solomone, who spent countless hours in the field with me. Many thanks also to Thomas Martin for guidance and constructive comments.

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ISSN-2513-9894 (Online)