Chapter 2

Spatial Distribution and Abundance of the Rarotonga Starling in the Cook Islands (Pacific Islands)

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Abstract

The Rarotonga starling (*Aplonis cinerascens*) is endemic to Rarotonga in the Cook Islands. The species is listed as "vulnerable" on the IUCN red list, but there has never been a thorough quantitative survey of its numbers, and no assessments of threats to its survival. This study developed distance sampling methods to record the distribution and abundance of the starling based on point counts in nine valleys. Densities of adult birds varied between valleys, but averaged about 0.5 per hectare across the 500 hectares that were surveyed. Extrapolation based on the estimated total area of habitat available provides a conservative global population estimate of 2,350 adult starlings and suggests that its current conservation status is appropriate. Starlings were most abundant in the Takitumu Conservation Area, where there is intensive control of the introduced black rat *(Rattus rattus)*. Conversely, observation points sampled with infestations of the invasive weeds mile a minute vine *(Mikania micrantha)*, grand balloon vine *(Cardiospermum grandiflorum)* and peltate morning glory *(Merremia peltata)* supported fewer starlings, and in extreme cases no starlings.

Key Words: Alien weeds, *Aplonis cinerascens*, Cook Islands, invasive species, island endemics, rats, Sturnidae, vines.

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Résumé

Le sansonnet de Rarotonga (*Aplonis cinerascens*) est une espèce endémique de Rarotonga (îles Cook). L'espèce figure dans la catégorie « vulnérable » sur la liste rouge de l'IUCN, mais n'a jamais fait l'objet d'inventaire détaillé de sa population, ni d'évaluation des menaces pesant sur sa survie. Nous avons estimé la distribution et l'abondance du sansonnet à partir de méthodes d'échantillonnages à distance qui englobent des points de comptage dans neuf vallées. Les densités d'oiseaux adultes sont en moyenne de 0,5 individu par hectare sur les 500 hectares étudiés. Une extrapolation fondée sur une estimation de la superficie totale de l'habitat disponible conduit à avancer une estimation de la population globale à 2350 individus adultes. Ce résultat suggère que le statut de conservation actuel est pertinent. La population de sansonnet la plus abondante se trouve dans la zone protégée de Takitumu où s'exerce un contrôle intensif du rat noir introduit *(Rattus rattus)*. Au contraire, les vallées abritant peu ou pas de sansonnets étaient celles fortement colonisées par les espèces invasives notamment la liane américaine *(Mikania micrantha)*, le cœur des Indes *(Cardiospermum grandiflorum)*, *Merremia peltata* et *Hibiscus tiliaceus*.

Mots-clés : Mauvaises herbes exotiques, *Aplonis cinerascens*, Îles Cook, espèces invasives, endémisme insulaire, rats, Sturnidae, vigne.

1. Introduction

Current rates of extinction are far higher than for millions of years (Barnosky *et al.* 2011). Extinction is not a random process (McKinney 1997) and extinctions have been particularly high among island endemics (Pimm *et al*. 1995). Historically, more than 90% of bird extinctions have taken place on islands, with the greatest number of extinctions recorded from the Pacific (Johnson and Stattersfield 1990). Starlings (Sturnidae) are one of the more numerous land bird families in the Pacific islands and have contributed 15 of the 82 species of passerines known to have become extinct since human colonisation of Oceania (Steadman 2006).

Current threats to surviving island endemic birds have probably been underestimated (Brooks *et al.* 2002). They typically have small population sizes that make them extremely vulnerable to the habitat loss and fragmentation associated with human colonisation (Duncan and Blackburn 2004; Johnson and Stattersfield 1990; Pimm *et al.* 1988). In addition, humans have introduced invasive species and diseases to many Pacific islands, and these have had strongly negative effects on endemic bird species, many of which evolved in the absence of predators (Clavero *et al.* 2009; Blackburn *et al.* 2004; Duncan and Blackburn 2004; Frankham 1998; Johnson and Stattersfield 1990; Diamond 1985).

The loss of endemic bird species can have broader significance. On Pacific islands they provide a range of ecosystem services such as seed dispersal (Barlow and Schodde 1993) and insect control (Fullard *et al*. 2010) and these services are not necessarily compensated for by introduced species (Staddon *et al*. 2010). Successful conservation of these birds depends on knowledge that allows prioritization of those species most at risk and allows the factors responsible for population declines to be addressed. For many such species, relevant up-to-date knowledge is inadequate or absent, with the result that extinctions can be occurring but remaining undetected (Grant *et al*. 2005; Thibault and Meyer 2001).

1.1 The Rarotonga Starling

Several island starlings in the genus *Aplonis* have already become extinct (Feare and Craig 1998) including the Cook Islands endemic Mauke starling *(Aplonis mavornata)* (McCormack 2007) and the Huahine starling *(Aplonis diluvalis)* from the Society Islands (Steadman 2006). *Aplonis cinerascens* is an island endemic starling found only on Rarotonga, a 67 square kilometre island in the Cook Islands (Fig. 1), where it is restricted to inland forested valleys (Tiraa 2010; Holyoak 1980). Small populations are inherently at greater risk from stochastic events and the Cook Islands are subject to frequent cyclones, almost a third of which reach hurricane force (De Scally 2008). The Rarotonga starling is currently listed as vulnerable (IUCN 2010), but its small range means that any decline in population size would necessitate a review of its threat status (IUCN 2001).

Previous estimates of the abundance of the Rarotonga starling have been based on limited evidence. Earlier population estimates ranged from as low as 100 (Hay 1985) up to 1,000-3,000 (Holyoak and Thibault 1984), while more recent estimates have varied from 500 (McCormack 1997) up to 1,200 (Tiraa 2010). The 1984 and 1985 estimates were based on brief visits to the island and comparisons with historical records, while the 1997 estimate was based on numerous, but un-quantified, observations. The 2010 study was the first attempt at a quantitative population estimate for the Rarotonga starling, but was based on extrapolation from counts in the 155 hectares Takitumu Conservation Area (TCA), an area where there has been intensive conservation activity, rather than from the whole range of the bird. A reliable population estimate has therefore been lacking.

There is also limited knowledge of the Rarotonga starling's ecology. Much of the literature is again based on historical records and brief personal observations. The current understanding is that the starling is an inconspicuous, shy bird of native steeply-sloping forest found at elevations from 150 to 600 m (Holyoak and Thibault 1984). It has been observed nesting in tree cavities, with nests consisting of dead leaves and plants (Holyoak and Thibault 1984; Holyoak 1980) in the Polynesian chestnut *(Inocarpus fagifer)* and bishofia (*Bishofia javanica*) (Tiraa 2010). Pairs are believed to hold large exclusive territories around these nests (Holyoak 1980).

The starling's known diet consists of berries, insects and nectar, which are foraged from the canopy (Holyoak 1980). A main food source is provided by the flowers of the Rarotonga fitchia *(Fitchia speciosa),* which is pollinated by the starling (McCormack *et al.* 1995). It is also thought to be the only bird on the island which disperses red mistletoe (*Decaisnina forsteriana)* (Brockwell 1992). Consequently, the Rarotonga starling is likely to be an important component of natural forest functioning on the island.

Figure 1. The Rarotonga starling (*Aplonis cinerascens*) in the field. Photos courtesy of Gerald McCormack.

1.2 Threats to the Starling

Historical observations suggest that the Rarotonga starling was originally found throughout Rarotonga (Wyatt-Gill 1885 cited in Tiraa 2010), but lower altitude areas have now largely been converted to agriculture, human habitation or scrub (Merlin 1985). Tree hibiscus *(Hibiscus tiliaceus),* dominates the lowlands of Rarotonga after forest clearance has taken place (McCormack 2007). It is debated whether this is a native species or a naturalised introduction, yet either way it is a rapid coloniser. Albizia (*Falcataria moluccana)*, introduced in 1937, also encroaches on agricultural land and fernland slopes (McCormack 2007). Therefore today, only the upland native forest at the centre of the island provides the conditions required by the Rarotonga starling for nesting and foraging (McCormack *et al*. 1995; Merlin 1985). Additionally, introduced vine species pose a potential threat to the remaining areas of native forest favoured by the starling. They include the grand balloon vine *(Cardiospermum grandiflorum)*, first recorded in 1929 in one area of the island, and mile a minute vine *(Mikania micrantha)*, introduced after 1930. Peltate morning glory *(Merremia peltata)* also threatens native plant species, smothering other plants and breaking branches with its heavy weight (McCormack 2007). These invasive species are all fast growing and increasingly widespread in inland Rarotonga (McCormack 2007).

Introduced animal species may also represent a threat to the starling. The black rat (*Rattus rattus*) was introduced to the island in the 1880s (Robertson et *al*. 1994). Its effect on the starling is unknown, but it has been the primary cause of the decline of the endemic Rarotonga flycatcher (*Pomarea dimidiate*) (Robertson and Saul 2007; Robertson *et al*. 1994). Introduced cats (*Felis catus*) are another potential predator (Robertson and Saul 2007). The common myna (*Acridotheres tristis*) was introduced to Rarotonga in 1906 in an attempt to control stick insect populations (Nagle 2006).

This aggressive species has reached high densities in urban and agricultural areas and been held accountable for driving native birds, including the starling, to higher altitudes (McCormack 2008; Peacock *et al.* 2007; Nagle 2006; Parkes 2006).

2. Materials and Methods

2.1 Habitat Assessment and Sampling Technique

Aspects of the habitat surrounding each observation point were recorded: general vegetation structure, presence of native vegetation, presence of invasive vine species, presence of rats and presence of mynas.

Males hold a territory around each nest site (Holyoak 1980). Our observations suggest that only male birds sing. We used this behaviour to estimate the minimum number of Rarotonga starling territories in each of the nine valleys, from which counts were then extrapolated to suitable areas of Rarotonga as a whole. Although our observations were conducted outside of the breeding season, it is believed that territories are held all year round (McCormack 2011) and male starlings were calling during the count period. Each territory was assumed to have one adult male and one adult female, with only the male singing.

Distance sampling was used to estimate the number of territories. This technique is based on measurements of the distance from the observer to birds that are recorded from transect or point counts (Bibby *et al.* 2000; Lloyd *et al.* 1998). The four basic assumptions of distance sampling include; transects and points are chosen representatively; birds at the centre of the observation point are always detected; birds are detected in their original position and are not affected by presence of the observer; and finally that distances are measured as accurately as possible with minimal error (Bibby *et al.* 2000; Lloyd *et al.* 1998).

We recorded starlings in nine inland valleys (Fig. 2), including the recently surveyed TCA (Tiraa 2010). They were selected to be representative of the island interior as a whole. Point counts, rather than transects, were employed because of the steep and densely-wooded terrain of interior Rarotonga. The observation points could not be selected randomly due to accessibility problems. Within each valley, observation points were chosen on fernlands and ridges overlooking potential starling habitat. Sites were chosen to provide a 360^{o} view and listening capability whenever this was possible. The coordinates of each observation point and its altitude (m) were recorded using Global Positioning System (GPS). To avoid repeat counts, the minimum distance between observation points in forest areas should be 200-250 m (Bibby *et al.* 2000; Lloyd *et al.* 1998). We confirmed that our observation points were sufficiently far apart by sitting two observer groups on opposite ridges and checking via walkie-talkies whether both groups could see or hear the same birds.

Fifteen minute point counts were made. This is longer than the usual 5-10 minutes (Bibby *et al.* 2000; Lloyd *et al.* 1998) and reflected the thick vegetation and inconspicuous behaviour of the birds. Counts were carried out in teams of two or more people, beginning at 17.00hrs. Because two groups were often recording in different locations on the same evening, the counts were started on the quarter hour to ensure synchrony and avoid double counting. Sampling continued every fifteen minutes until 18.15hrs, when the sun was beginning to set. Distances to calling birds was placed in bands of ≤50 m; 51-100 m; 101-150 m; 151-200 m; 201-250 m; 251-300 m; 301-350 m and 351-400 m, as in the fixed-width circular plot method (Bibby *et al.* 2000; Lloyd *et al.* 1998).

Score sheets recorded the direction to the birds using a compass. When a starling was detected, the distance to each bird was measured using laser range finders or by visual estimation. If a bird was in flight the place it was first seen was recorded along with the direction of flight and its end position. Care was taken to avoid recording the same individual twice during each point count, but if a bird moved between point count locations it could have been recorded again. Behavioural observations were also recorded.

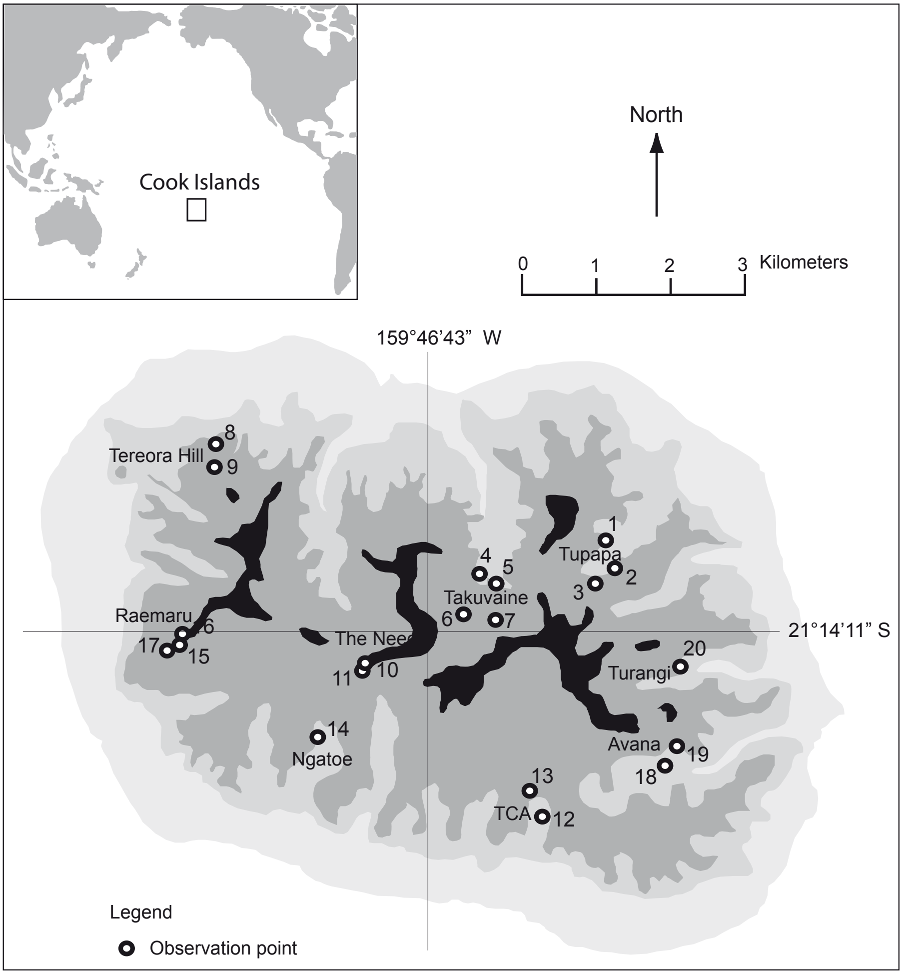

Figure 2. A map to show the twenty observation points in the nine valleys sampled across the island of Rarotonga (Cook Islands).

2.2 Population Estimates

Bearings and distances to each detected bird were plotted on a large-scale map of the area. Each male bird was assumed to have its own territory in the area. If two birds were observed together, they were assumed to be a pair sharing one territory. If birds flew straight over the count area their territory was not considered to be in that area.

As there was some doubt over whether some repeat observations were of the same bird in the same territory, minimum and maximum territory counts were estimated. For the minimum estimate of territory numbers, if two birds were detected close to each other then they were counted as the same bird, for the maximum estimate they were assumed to be distinct. Where replicate counts were made from the same areas, the largest territory count was used (Table 1) because all the territories had been detected in the same evening. A male may not have been calling, or was not detected, on evenings when lower counts were obtained.

Estimates of the area of land around each observation point that was contributing sight or sound records were based on the maximum distance that birds could be seen or heard. This generated an initial circular observation zone around each observation point, from which portions were subtracted if there were directions where detection was obscured (Fig. 3). The minimum number of territories and the area that had been sampled were combined to provide estimates of territories per hectare.

Non-parametric Kruskal Wallis tests (SPSS inc., Chicago, Illinois, USA) were used to compare territory densities between valleys.

A minimum global population estimate for the starling was obtained by extrapolation from the mean density of territories (two birds assumed per territory) within suitable habitats. The area of suitable habitat (inland forest on steep slopes) was estimated as the interior of the island above the 30 m contour line (Leslie 1980). Both the estimates of territory densities and of the area of suitable habitat treated the land surface as flat, with inevitable associated errors.

Table 1. Example summary of data collection from observation points and data processing (here in Tupapa Valley). The estimated minimum number of territories present was used for the overall starling population estimate.

Observation point number	Replicate observation	Min. no. of territories observed	Max. no. of territories observed	Min. no. of territories present	Max. no. of territories present
1	1	6	10		
1	2	7	8		
1	3	7	8	7	10
2	1	6	6		
2	2	6	9		
2	3	9	10	9	10
3	1	9	12		
3	2	10	13	10	13

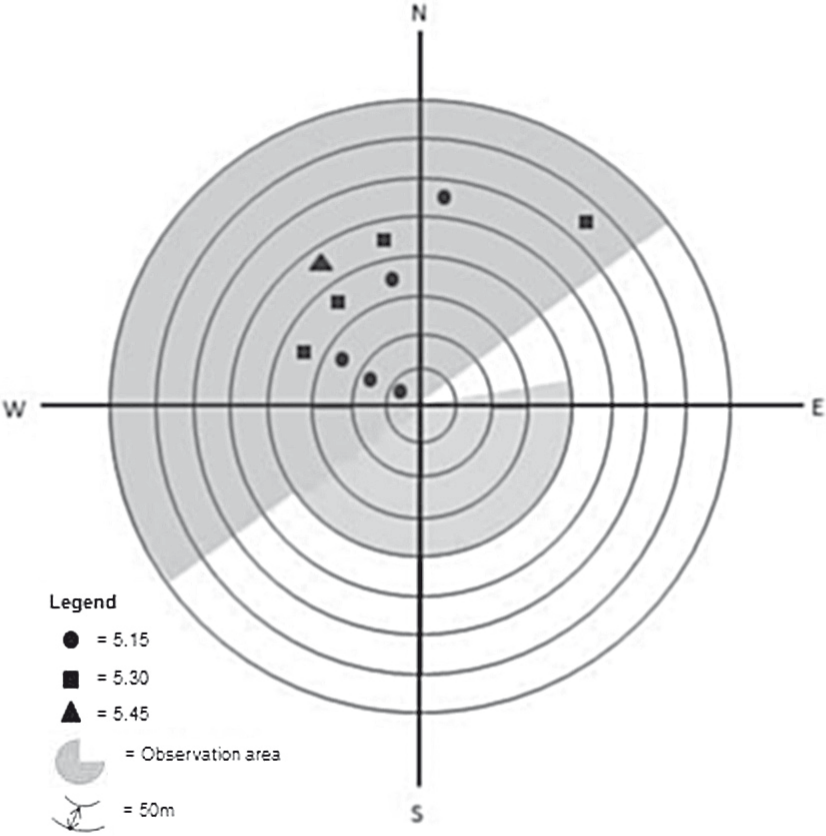

Figure 3. An illustration of bird detections from observation point 1 in Tupapa valley, showing the birds detected in each of three fifteen minuet point counts; 5.15, 5.30 and 5.45pm and the observation area in which detection was possible.

3. Results

3.1 Habitat Assessment

The vegetation differed greatly between valleys (Fig. 4, Table 2). Tupapa, Avana and the TCA had a high proportion of native vegetation, whereas Takuvaine was particularly overgrown with mile a minute and balloon vines, together with cultivated taro patches in the lower valley. Raemaru was similarly dominated by introduced hibiscus.

The common myna was present and abundant at every observation point, including the most isolated locations. Polynesian rats were observed in the TCA and Turangi, but no black rats or feral cats were recorded.

Figure 4. Top: view of native vegetation taken from observation point 1, Tupapa valley. Bottom: vegetation overgrown with invasive vines viewed from observation point 6, Takuvaine.

Table 2. The number of observation points in each valley and a description of the vegetation present in each valley.

Valley	No. of observation points	Vegetation type
Tupapa	3	Mainly native vegetation including Rarotonga fitchia *(Fitchia speciosa),* Cook Islands homalium (*Homalium acuminata*), elaeocarpus (*Elaeocarpus tonganus*) and red mistletoe (*Decaisnina forsteriana)*. Some tree hibiscus *(Hibiscus tiliaceus)* and introduced vines.
Takuvaine	4	Very overgrown, with high proportion of the invasive vine species; mile a minute vine *(Mikania micrantha)*, grand balloon vine *(Cardiospermum grandiflorum)* and peltate morning glory *(Merremia peltata)*.
Tereora Hill	2	Overlooking the airport and houses but generally native vegetation and much Polynesian chestnut *(Inocarpus fagifer)*.
The Needle	2	Mainly native vegetation with the same species as Tupapa valley, some hibiscus and introduced vines.
TCA	2	Area of intense conservation activity. Mostly native vegetation, though some areas of disturbed forest with hibiscus and introduced vines.
Ngatoe	1	Mainly native vegetation, some hibiscus and introduced vines.
Raemaru	3	Slopes of Albizia (*Falcataria moluccana)* and hibiscus with areas of introduced vines, little native vegetation.
Avana	2	Principally native vegetation as in Tupapa, some hibiscus and introduced vines.
Turangi	1	Again principally native vegetation like Tupapa, some hibiscus and introduced vines.

3.2 Starling Density

Twenty observation points were present across the nine valleys, with a mean of 0.48 (± 0.35, SD) adult male and female starlings recorded around each point (Tables 3 & 4). Starling densities ranged between zero and 0.95 per hectare around different observation points. The densities differed significantly between valleys (Kruskal Wallis, X^2= 17.82, P = 0.023, d.f = 8), with high densities in the TCA, lower than average numbers at Raemaru and no starlings sighted in Takuvaine (Fig. 5). A minimum of 125 territories were estimated to be present in the 489.77 hectares that were sampled. This represents a total of 250 adult birds (male and females combined) at a density of 0.51 per hectare.

3.3 Population Estimate

The interior of Rarotonga above the 30m contour covers 4,605 hectares and was taken as the area of habitat suitable for the starling by Tiraa (2010) when extrapolating from counts in the TCA. However, the 4,605 hectares varies in suitability and some inland valleys support lower starling densities than others, or no starlings at all. We assumed that the valleys we surveyed were typical of the range of habitat quality across the island and that our estimate of 0.51 birds per hectare was therefore typical (Tables 3 & 4), giving an estimated population size of about 2,350 adult birds for the island as a whole. This can be regarded as a conservative estimate of the population size, because it is based on the minimum recorded number of territories at each observation point, and only adult birds are included.

Table 3. The areas where birds could be detected around each observation point and the estimated minimum number of starling territories detected. This was doubled to give the number of birds detected from each observation point and an estimated density of birds per hectare.

Valley	Point Number	Detection area (Ha)	No. of territories	No. of birds	Density (bird/Ha)
Tupapa	1	27.23	7	14	0.51
Tupapa	2	29.33	9	18	0.61
Tupapa	3	28.28	10	20	0.71
Takuvaine	4	28.28	0	0	0.00
Takuvaine	5	19.24	0	0	0.00
Takuvaine	6	19.24	0	0	0.00
Takuvaine	7	25.66	0	0	0.00
Tereora Hill	8	17.28	4	8	0.46
Tereora Hill	9	28.28	6	12	0.42
The Needle	10	31.81	6	12	0.38
The Needle	11	27.93	9	18	0.64
TCA	12	31.42	15	30	0.95
TCA	13	24.60	13	26	1.06
Ngatoe	14	22.98	9	18	0.78
Raemaru	15	15.50	3	6	0.39
Raemaru	16	15.50	2	4	0.26
Raemaru	17	19.24	0	0	0.00
Avana	18	21.21	10	20	0.94
Avana	19	34.77	13	26	0.75
Turangi	20	21.99	9	18	0.82
Total		489.77	125	250	0.51
Mean		24.49	6.25	12.5	0.48

Table 4. A summary of the minimum estimated densities of starling territories and therefore estimated number of adult starlings in the nine valleys that were surveyed.

Valley	Detection area (Ha)	No. of territories	No. of birds	Density (bird/Ha)
Tupapa	84.84	26	52	0.61
Takuvaine	92.42	0	0	0.00
Tereora Hill	45.56	10	20	0.44
The Needle	59.74	15	30	0.50
TCA	56.02	28	56	0.95
Ngatoe	22.98	9	18	0.78
Raemaru	50.24	5	10	0.20
Avana	55.98	23	46	0.82
Turangi	21.99	9	18	0.82
Total	489.77	125	250	0.51
Mean	54.42	13.89	27.78	0.57

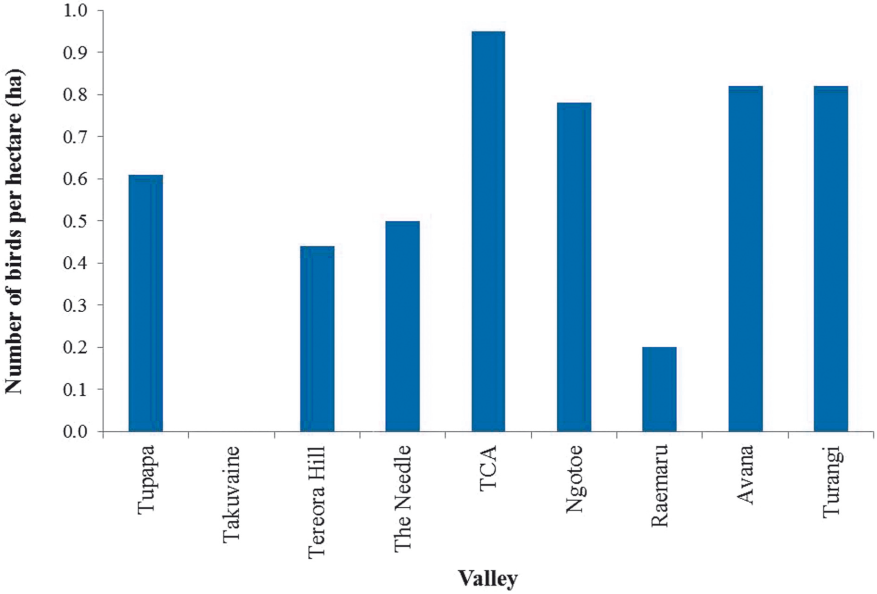

Figure 5. The density of birds in each of the valleys sampled, estimated from the number of territories detected at observation points in each valley divided by the estimated detection range of the observation points. There was a significant difference in starling density between valleys (Kruskal Wallis, X2= 17.82, p=0.023, 8d.f).

4. Discussion and Conclusion

The Rarotonga starling is widespread but not ubiquitous in the mountainous interior of Rarotonga. We estimate that there is a world population of approximately 2,350 adult Rarotonga starlings. This figure agrees with that of Holyoak and Thibaults (1984) but is higher than all other previous estimates. We regard 2,350 as a conservative estimate because if two birds were detected is close proximity then they were counted as the same bird. There is no evidence of recent declines in its numbers and in those valleys that provide good habitat the starling is abundant. This suggests that its current status as 'Vulnerable' is probably appropriate. However, the area of suitable habitat on the island is already less than would have been available in the past and changes that are currently taking place on the island raise concerns about its long term survival.

The varying density of Rarotonga starlings in different valleys appears to be largely in response to the extent to which native vegetation has been replaced by alien weeds. The starling was relatively abundant in Avana, Turangi and Tupapa, where the native forest is less disturbed and native vegetation such as Rarotonga fitchia, Cook Islands homalium (*Homalium acuminata*), elaeocarpus (*Elaeocarpus tonganus*), and red mistletoe are numerous. Also in these valleys the introduced, naturalised Polynesian chestnut, used by the starling for nesting, was present. In contrast, the starling was uncommon in Raemaru, where there is a high proportion of hibiscus and introduced albizia, and entirely absent from Takuvaine, which has heavily overgrown with tree of hibiscus, balloon vine, mile a minute vine and peltate morning glory. Clearly, the further expansion of invasive plants on Rarotonga represents a long-term threat to the survival of this species.

The TCA supported the highest densities of starlings. This may be in response to the continuing control of black rats in this area. The rats have not decimated starling populations elsewhere, so the starling can co-exist with rats. This is in contrast to the Rarotonga flycatcher, which only survives in the TCA because of the rat eradication programme. Rats may nonetheless be depressing population levels of the starling.

Mynas are often considered to be a species of urban and agricultural areas, but we found that this bird was abundant at all our observation sites, including the TCA. This implies that the starling may not have been driven inland by interactions with mynas, but leaves open the question of whether the myna and starling are competing for nest sites and other shared resources throughout the island. However, it may simply be that the myna birds are visitors of the inland, especially since mynas have only been observed being aggressive to starlings and other tree-nesting birds such as fruit-doves *(Ptilinopus rarotongensis)* in the lowland where they are known to hold territories (McCormack 2011).

The starling is likely to be only one species among many that will decline as further native forest is lost. There may also be secondary effects. The starling feeds on red mistletoe, and may be its only seed dispersal agent on Rarotonga (Barlow and Schodde 1993). The link between alien weeds, declining habitat quality and the distribution of Rarotonga starlings emphasises the threat that these alien species pose for the broader biodiversity of Rarotonga. Regular mapping of the spread of alien weeds will provide some indication of how urgent a threat they represent. Mechanical control is expensive and labour intensive and it may not be feasible on Rarotonga. Biological control using introduced insects or diseases may offer the only long term hope for the Rarotonga starling and the forests where it lives (Shen *et al.* 2011; McKay *et al.* 2010; Ellison *et al.* 2008).

Acknowledgements

We would like to especially thank Gerald McCormack for his help and advice. This study would not have been possible without the help of field assistants provided by the National Environment Service (NES) and volunteers from the Te Ipukarea Society funded through a grant to BirdLife International Pacific from the Critical Ecosystem Protection Fund.

Literature Cited

Barlow, B.A. and R. Schodde. 1993. Bird dispersal of Loranthaceous mistletoes to remote Pacific islands: symbiosis in default. *Beaufortia* 43:124-129.

Barnosky, A.D., N. Matzke, S. Tomiya, G.O.U. Wogan, B. Swartz, T.B. Quental, C. Marshall, J.L. McGuire, E.L. Lindsey, K.C. Maguire, B. Mersey and E.A. Ferrer. 2011. Has the Earth's sixth mass extinction already arrived? *Nature* 471:51-57.

Bibby, C.J., N.D. Burgess, D.A. Hill and S. Mustoe. 2000. *Bird Census Techniques.* Elsevier, London.

Blackburn, T. M., P. Cassey, R. P. Duncan, K. L. Evans and K. J. Gaston. 2004. Avian extinction and mammalian introductions on oceanic islands. *Science* 305:1955-1958.

Brockwell, J. 21 September 1992. Letter to G. Mccormack.

Brooks, T. M., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, A. B. Rylands, W. R. Konstant, P. Flick, J. Pilgrim, S. Oldfield, G. Magin and C. Hilton-Taylor. 2002. Habitat loss and extinction in the hotspots of biodiversity. *Conservation Biology* 16:909-923.

Clavero, M., L. Brotons, P. Pons and D. Sol. 2009. Prominent role of invasive species in avian biodiversity loss. *Biological Conservation* 142:2043-2049.

De Scally, F. A. 2008. Historical Tropical Cyclone Activity and Impacts in the Cook Islands 1. *Pacific Science* 62:443-459.

Diamond, J. M. 1985. Population processes in island birds: immigration, extinction and fluctuation. *International Council for Bird Preservation technical publication* 3:17-21.

Duncan, R. P. and T. M. Blackburn. 2004. Extinction and endemism in the New Zealand avifauna. *Global Ecology and Biogeography* 13:509-517.

Ellison, C. A., H. C. Evans, D. H. Djeddour and S. E. Thomas. 2008. Biology and host range of the rust fungus Puccinia spegazzinii: A new classical biological control agent for the invasive, alien weed Mikania micrantha in Asia. *Biological Control* 45:133-145.

Feare, C. and A. Craig. 1998. *Starlings and mynas.* Christopher Helm Ltd, London.

Frankham, R. 1998. Inbreeding and extinction: Island populations. *Conservation Biology* 12:665-675.

Fullard, J. H., R. M. R. Barclay and D. W. Thomas. 2010. Observations on the behavioural ecology of the Aitu Swiftlet *Aerodramus sawtelli*. *Bird Conservation International* 20: 385-391.

Grant, P. R., B. R. Grant, K. Petren and L. F. Keller. 2005. Extinction behind our backs: the possible fate of one of the Darwin's finch species on Isla Floreana, Galapagos. *Biological Conservation* 122:499-503.

Hay, R. 1985. Bird conservation in the Pacific Islands. *Topic Review No.25.* SPC.

Holyoak, D. T. 1980. *Guide to Cook Island Birds.* Cook Islands Library and Museum Society, New York.

Holyoak, D. T. and J. C. Thibault. 1984. Les oiseaux de Polynésie orientale. *Mémoires Museum national Histoire naturelle, Ser. A.* 127:1-209.

IUCN. 2001. *IUCN Red List Categories and Criteria: Version 3.1.* IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN. 2010. *International Union for the Conservation of Nature* [Online]. Available: http://www.iucnredlist.org/ [Accessed April 2011].

Johnson, T. H. and A. J. Stattersfield. 1990. A global review of island endemic birds. *Ibis* 132:167-180.

Leslie, D. M. 1980. *Soil Map of Rarotonga, Cook Islands*, 1:10,000. New Zealand Soil Bureau Map 163, New Zealand.

Lloyd, H., A. Cahill, M. Jones and S. Marsden. 1998. Estimating bird densities using distance sampling. In: C. Bibby, M. Jones, and S. Marsden, (eds). *Expedition field techniques: bird surveys.* London, UK: Expedition Advisory Centre, Royal Geographical Society.

McCormack, G. 1997. The status of Cook Island birds. *World Birdwatch* 19:13-16.

McCormack, G. 2007. *Cook Islands Biodiversity Database, Version 2007.2.* [Online]. Cook Islands Natural Heritage Trust, Rarotonga. Available: http://cookislands.bishopmuseum.org [Accessed June 2011].

McCormack, G. 2008. *The Rimatara lorikeet or kura on Aitu (Cook Islands).* Cook Islands Natural Heritage Project, Cook Islands.

McCormack, G. June. 2011. Conversation to C. Easby.

McCormack, G., J. Künzle and C.I.N.H. Project. 1995. *Rarotonga's Mountain Tracks and Plants: A Field Guide.* Cook Islands Natural Heritage Project, Cook Islands.

McKay, F., M. Oleiro, A. Fourie and D. Simelane. 2010. Natural enemies of balloon vine *Cardiospermum grandiflorum* (Sapindaceae) in Argentina and their potential use as biological control agents in South Africa. *International Journal of Tropical Insect Science* 30:67-76.

McKinney, M.L. 1997. Extinction Vulnerability and Selectivity: Combining Ecological and Paleontological Views. *Annual Review of Ecology and Systematics* 28:495-516.

Merlin, M.D. 1985. Woody vegetation in the upland region of Rarotonga, Cook Islands. *Pacific Science* 39:81-99.

Nagle, B. 2006. *Protection of Tokelau Fakaofo from myna bird (Acridotheres spp.) invasion. Report of a Feasibility Study.* Pacific Invasives Initiative, Auckland, New Zealand.

Parkes, J. 2006. *Protection of Tanga'eo, the endemic Mangaia kingfisher (Todiramphus rufficollaris) from common myna (Acridotheres tristis). Report of a Feasibility Study.* Pacific Invasives Initiative, Auckland, New Zealand.

Peacock, D.S., B.J. Van Rensburg and M.P. Robertson. 2007. The distribution and spread of the invasive alien common myna, *Acridotheres tristis L*. (Aves: Sturnidae), in southern Africa. *South African Journal of Science* 103:465-473.

Pimm, S.L., H.L. Jones and J. Diamond. 1988. On the risk of extinction. *American Naturalist* 132:757-785.

Pimm, S.L., G.J. Russell, J.L. Gittleman and T.M. Brooks. 1995. The Future of Biodiversity. *Science* 269:347-350.

Robertson, H.A., J. Hay, E.K. Saul and G.V. Mccormack. 1994. Recovery of the kakerori: an endangered forest bird of the Cook Islands. *Conservation Biology* 8:1078-1086.

Robertson, H.A. and E.K. Saul. 2007. *Conservation of kakerori (Pomarea dimidiata) in the Cook Islands in 2005/06.* Science and Technical Publishing, Department of Conservation, Wellington, New Zealand.

Shen, H., L. Hong, H. Chen, W.-H. Ye, H.-L. Cao and Z.-M. Wang. 2011. The response of the invasive weed *Mikania micrantha* to infection density of the obligate parasite *Cuscuta campestris* and its implications for biological control of *M. micrantha*. *Botanical Studies* 52:89-97.

Staddon, S.C., S.G. Compton and A. Portch. 2010. Dispersal of fig seeds in the Cook Islands: introduced frugivores are no substitutes for natives. *Biodiversity and Conservation* 19:1905-1916.

Steadman, D.W. 2006. *Extinction and biogeography of tropical Pacific birds.* University of Chicago Press, Chicago.

Thibault, J.C. and J.Y. Meyer. 2001. Contemporary extinctions and population declines of the monarchs (Pomarea spp.) in French Polynesia, South Pacific. *Oryx* 35:73-80.

Tiraa, A. 2010. *Ecology, abundance and distribution assessment of the endemic Rarotonga Starling (Aplonis cinerascens).* Natural Resources Management, Asian Institute of Technology.