HAVE RODENTS IMPACTED THE BREEDING AND DISTRIBUTION OF BLACK NODDY *ANOUS MINUTUS* ON LORD HOWE ISLAND?

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ABSTRACT

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Rodents are well known to impact nesting seabirds. However, not all seabird species are equally susceptible to rodents due to variations in size, nest-site selection, or nesting behaviour. The Black Noddy *Anous minutus*, a common tropical, tree-nesting species, began colonisation of North Bay on Australia's Lord Howe Island in 1989, 70 years after the establishment of Black Rats *Rattus rattus*. In 2014, when the breeding colony consisted of 560 pairs, we commenced a pilot study to assess impacts of rodents. Ten motion-triggered cameras monitoring 12 nests showed no rodent presence on any branches within view; 11 of those nesting attempts (92%) resulted in fledglings. A further 38 nests were monitored for breeding success, of which 28 (74%) produced a fledgling. In 2019, coincident with the eradication of rodents from Lord Howe Island, noddies started breeding in small numbers in the Settlement Area. In 2020, visitor disturbance was low at this colony due to COVID-19 lockdowns and by the 2022 season, the entire original North Bay colony had relocated here. From initial colonisation until 2014, the population grew at 10% per annum, but it increased only marginally (0.7% per annum) during 2014–2024. It appears that neither colony establishment nor breeding by the Black Noddy is affected by the presence of Black Rats. Contributing factors may include the selection of tree nest sites, which reduces rodent access and provides only one point of contact to a nest, and the presence of adults at nests during all nocturnal periods, which enables nest defence.

Key words: *Anous minutus*, breeding, distribution, *Rattus rattus*, Lord Howe Island, Black Noddy, Black Rat

INTRODUCTION

The deleterious impacts of rodents on seabirds are well documented (Jones *et al.* 2016). The type and level of impact varies, depending on the behaviour and nesting habits of different seabird species as well as the behaviour of different invasive rodent species. Black Rats *Rattus rattus* and Polynesian Rats *R. exulans*, for example, are arboreal and are more likely to affect tree-dwelling species than Norwegian Rats *R. norvegicus*, which more heavily prey on ground- or burrow-nesting species (Moors *et al.* 1992). Rodents affect all life stages of seabirds, consuming eggs, chicks, and adults (e.g., Ruffino *et al.* 2015, O'Dwyer *et al.* 2024), and the consequences range from suppression of populations (Dilley *et al.* 2017) to extirpations (Jones *et al.* 2008).

Black Noddies *Anous minutus* nest mostly in trees and shrubs, but they will nest in cliffs if these are lacking (i.e., López-Victoria & Estela 2006, Champeau *et al.* 2011). It has been assumed that this species would be susceptible to rodent predation. Pitman *et al.* (2006) suggested that, without the removal of Black Rats on Clipperton Island, Overseas France, Black Noddies and other small seabird species were likely to become locally extinct. In Fiji, Polynesian Rats are thought to prey on nesting Black Noddies (Tarburton 1987), but evidence is lacking for the rodents' specific impacts on the local noddy population. On Australia's Lord Howe Island, Black Rats were accidently introduced in 1918 (McCulloch 1921). Within a short period, four species of tree-nesting terrestrial birds went extinct, presumably due to rat predation of their arboreal nests (Hindwood 1940). It is assumed that, despite the noddies' persistence on Lord Howe Island, rats may still be impacting their nesting.

Black Noddy is one of three seabird species on Lord Howe Island that nests off the ground, along with Brown Noddy *A. stolidus* and White Tern *Gygis alba* (Hutton 1991). Black and Brown noddies have different nesting requirements, which reduce nest-site competition and allow breeding to occur in mixed colonies. Black Noddies build substantial nests in tree-branch forks while Brown Noddies build nests atop clumped leaves on the outer branches of shrubs (Higgins & Davies 1996). The White Tern uses no nesting material and selects large, flat branches or abruptly terminated limbs (Hull 1910) with a depression for their egg. Previously used Black Noddy nest sites remain extant until at least the following season, when pairs will build a new nest on the remaining material (Gauger 2020). The island additionally supports loose breeding colonies of Blue Noddy *Anous ceruleus* (previously Grey Ternlet *Procelsterna cerulea*), six burrowing procellariids, Red-tailed Tropicbird *Phaethon rubricauda*, and Masked Booby *Sula dactylatra* (McAllan *et al.* 2004).

The Black Noddy was first recorded breeding on Lord Howe Island in 1989, with an initial population of 36 active nests in Tea-tree *Melaleuca howeana* at Old Gulch (Hutton 1991), at the northern end of the main island (colony 1 on Fig. 1). Black Noddy had been known to be present around the island group (Edgecombe 1987), but nesting had not been confirmed. Breeding here occurs annually between September and May (McAllen *et al.* 2004). In 1995, the birds were documented changing their colony location from Old Gulch to trees

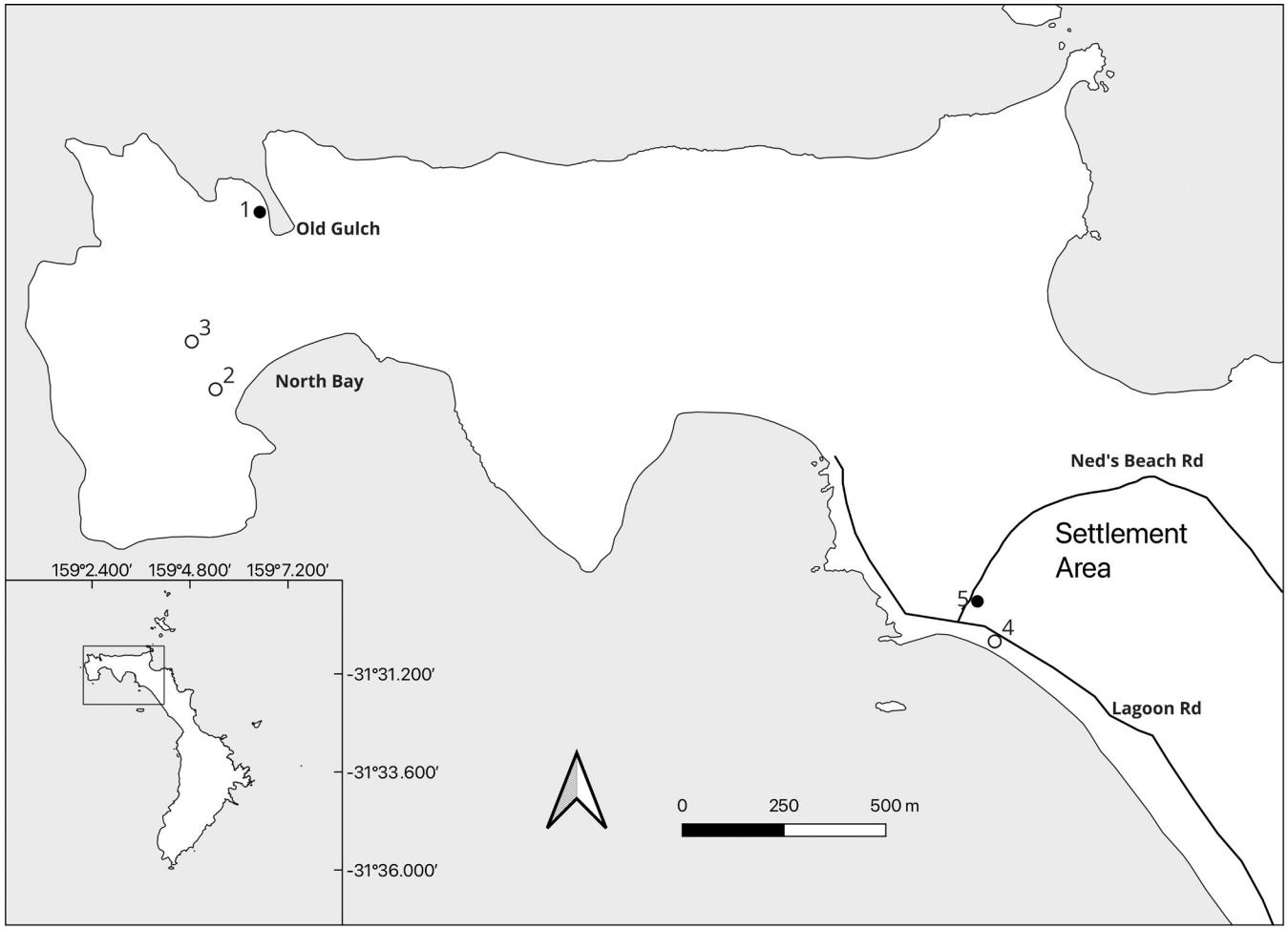

Fig. 1. Locations of past (open circles) and current (filled circles) Black Noddy *Anous minutus* breeding colonies on Lord Howe Island, Australia. 1. Tea-tree at Old Gulch (1989–1994, 2019 to present). 2. Norfolk Island Pines at North Bay (1995–2021). 3. Greybark at North Bay (2014). 4. Norfolk Island Pines along the foreshore of the Settlement Area (2012). 5. Norfolk Island Pines/Sallywood in the commercial precinct of the Settlement Area (2019 to present).

on the foreshore of North Bay; on 13 December 2003, a direct count of the North Bay colony found 143 active nests (McAllan *et al.* 2004). The population change over the 14 years since colony establishment amounted to an increase of 10% per annum.

In 2019, a program was implemented to eradicate introduced rodents (Black Rat and House Mouse *Mus musculus*) from Lord Howe Island (Harper *et al.* 2020). To better understand the ecological benefits of rodent removal from the island, a range of research projects were undertaken on seabirds to look for rodent impacts prior to the eradication (i.e., O'Dwyer *et al.* 2023), including one involving a Black Noddy colony. This initial research was continued through ad-hoc monitoring of the breeding and colony locations of Black Noddies here. The aim of the present study was to investigate the dynamics of a Black Noddy colony in the presence and absence of rodents.

METHODS

Study sites

Lord Howe Island (LHI; 31°30′S, 159°05′E) is a subtropical landmass (1455 ha or 14.55 km^2) of volcanic origin that is largely forested. It is located in the South Pacific Ocean, 580 km east of the Australian state of New South Wales (NSW). At the southern end of the island are two volcanic mountains reaching 777 m and 875 m above sea level; at the northern end, the hills of a former caldera reach 209 m. European settlement of the central lowland areas commenced in 1834 (Rabone 1940), with sections progressively cleared for agriculture. The native vegetation is now dissected by a network of grassy pastures and narrow roads.

Black Noddies established a significant colony on LHI at North Bay, an area of early settlement (Rabone 1940, colony 2 on Fig. 1), where they nested predominantly in introduced Norfolk Island Pines *Araucaria heterophylla*. During the present study, an additional nesting site was found in native regrowth forest just inland from the North Bay foreshore (colony 3 on Fig. 1). Further colonies were later established in the Settlement Area (2 km to the southeast), again in Norfolk Island Pines (colonies 4 and 5 on Fig. 1).

A systematic rodent-control baiting programme commenced at North Bay in 1980 to protect the commercial harvest of Kentia Palm *Howea forsteriana* (Billing & Harden 2000). This programme also

reduced predation pressure on local fauna, including the endemic Lord Howe Island Skink *Cyclodina lichenigera*, Lord Howe Island Gecko *Christinus guentheri*, and the Lord Howe Flax Snail *Placostylus bivaricosus* (DECC 2007). While rodent-detection devices were not deployed during the current study to determine rodent presence at North Bay, nocturnal observations made while carrying out other research projects (i.e., O'Dwyer *et al.* 2024) indicated that rats and mice were an active component of the fauna across the island, including North Bay, prior to the eradication program. Extensive control measures for rodents also occurred in the Settlement Area (Wilkinson & Priddel 2011).

Nest monitoring

Motion-sensing surveillance cameras (HC600 Hyperfire game camera, Reconyx; Holmen, USA) were used to monitor 12 nests 2.5–3.5 m above the ground in Norfolk Island Pines at North Bay. Cameras were fixed to vertical tree trunks or installed on short steel posts screwed into horizontal branches; in neither case would the cameras have impeded the passage of rodents along the branches. Researcher access to tree branches occurred via an extendable aluminium ladder. Cameras were set for continuous monitoring of movement, with batteries and SD memory cards serviced during monthly site visits. Nine cameras were initially installed on 03 October 2014 when nest-building was still active in the surrounding trees. Less than 20 nests were already undergoing incubation within the immediate study area and an accessible portion of these provided the initial monitoring sample. An additional camera was added in November 2014, allowing 12 nests to be monitored from the 10 cameras.

Additionally, 37 nests were monitored monthly during in-person visits (i.e., no cameras) to record breeding success and to test whether the presence of cameras attracted aerial predators such as Lord Howe Pied Currawong *Strepera graculina crissalis* to the camera-monitored nests. Control nests were on branches in the same or adjacent trees as those where cameras were fitted. All monitoring took place in trees bordering the edge of the colony to reduce general colony disturbance during monthly visits, which would last for more than an hour.

Nest monitoring was undertaken between October 2014 (i.e., the commencement of egg laying) and January 2015 (i.e., after most chicks had fledged). Population estimates were made in mid-October 2014 or mid-November 2023 (see below) within all trees and shrubs in an area; this is the period of greatest nest activity during the breeding season. Changes in breeding locations were assessed annually during other research activities that took observers to North Bay and other lowland areas during the austral spring and summer. Observations in the Settlement Area were also made during each research visit to the island (Carlile *et al.* 2018; Carlile & O'Dwyer 2022; O'Dwyer *et al.* 2023, 2024), as new colony activity was often readily audible and visible during daylight hours.

RESULTS

Expansion of breeding population

In 2011, breeding continued at North Bay, but nesting was also observed for the first time within the Settlement Area. This initial attempt occurred along the lagoon foreshore in Norfolk Island Pines, two kilometres southeast from North Bay (Fig. 1). Breeding was confirmed here during the 2012/13 season, with fewer than five fledglings present on 24 March 2013. On 04 April 2013, the remnants of 10 nest-building attempts and completed nests were recorded. By October 2014, nesting materials had been removed from the branches and no birds were observed during visits to undertake the North Bay camera studies in 2014/15 (see below).

On 13 November 2014, 520 nesting pairs were recorded in the Norfolk Island Pines on the foreshore at North Bay (colony 2 on Fig. 1), in an area of tree canopy covering 560 m^2. The birds had established nests 1.5–6.0 m above the ground. An additional 40 pairs were based around a large sheltered Greybark Tree *Drypetes deplanchei* located 170 m inland, nesting 1.5–3.5 m above the ground (colony 3 on Fig. 1). The rate of increase in population from previous counts 11 years prior is equivalent to 13% per annum. During the December nest check, the sub-colony around the Greybark Tree contained nests with incubating adults while the main colony supported well-advanced chicks. Thus, this smaller sub-colony had established their nests later than the main colony in that season.

A resumption of nesting within the Settlement Area was recorded on 18 November 2019. Six active nests containing incubating adults or adults with young chicks were noted in Norfolk Island Pines behind the main commercial precinct along the western end of Ned's Beach Road (colony 5 on Fig. 1). This location is 150 m from where the species originally attempted colony establishment along the Settlement Area foreshore, six years earlier (colony 4). Also in November 2019, fewer than five pairs were noted in Old Gulch (colony 1, J. Gilligan pers. comm.), the same area as the original founding colony. These birds continued to occupy the area during the four subsequent seasons. In October 2023, 11 active nests were observed at the Old Gulch area as a mixed colony with Brown Noddy, which preferentially nest on clumped Tea-tree leaves on outer branches or directly on the ground; ground-nesting is now likely in response to the lack of rodents. Since January 2022, no Black Noddy has been observed nesting in the Norfolk Island Pines at North Bay, and this population appears to have entirely shifted to the commercial precinct in the Settlement Area. On 15 October 2023, 608 nesting pairs were directly counted in the Settlement Area in 708 m^2 of tree canopy cover that included two small Sallywood *Lagunaria patersonia* trees. The birds had established nests between 2.5–6.0 m above the ground. The increase in the total island population between 2014 and 2023 (five years prior to rodent removal and four years since rodent removal) is equivalent to less than 1% per annum. Table 1 shows the change in colony sizes over time, using an estimated per-annum growth rate between known counts to fill in gaps where counts were not made.

Breeding success

Over 380 000 images of breeding activities from 950 camera-trap nights were captured between 03 October 2014 and 06 January 2015. Egg survival to hatching was high, with only two eggs lost—one fell from the nest and one cracked. A second egg was laid in the nest from which the egg fell, giving a total of 13 eggs monitored in 12 nests. The replacement egg was successfully incubated, providing an overall hatching success of 91%. All remaining active nests (n = 11) fledged a chick, giving an overall

TABLE 1
Colony sizes and presence over 34 years of Black Noddy *Anous minutus* breeding on Lord Howe Island, Australia. Colony identification numbers relate to Fig. 1.

	Colony 1	Colony 2	Colony 3	Colony 4	Colony 5	Total island population
1989	**36 pairs**	No colony	No colony	No colony	No colony	**36 pairs**
1995	No colony	65[#] pairs	No colony	No colony	No colony	65[#] pairs
2003	No colony	**143 pairs**	No colony	No colony	No colony	**143 pairs**
2011	No colony	383[#] pairs	No colony	**4 pairs**	No colony	387[#] pairs
2014	No colony	**520 pairs**	**40 pairs**	No colony	No colony	**560 pairs**
2019	**4 pairs**	587[#] pairs	No colony	No colony	**6 pairs**	597[#] pairs
2023	**11 pairs**	No colony	No colony	No colony	**608 pairs**	**617 pairs**

[#] Implied from assumed annual growth between known counts. Actual counts are in **bold**.

breeding success of 92%. Importantly, there was no evidence on camera that rodents visited or preyed upon the species at their nests. There was no evidence of any predation at any monitored nest. The survival of all chicks suggests that adult attendance was high, likely preventing rodent access to young chicks. This was corroborated by the surveillance cameras, which showed adults on or at the nest during all 950 camera-trap nights.

Among the 37 additional nests monitored for breeding success during the initial study at North Bay, one failed just after hatching, but an egg was present in the same nest at the following visit and was assumed to be laid by the same pair. Thus, we observed 38 nesting attempts of which 28 successfully produced fledglings. Four nesting attempts failed at the egg stage and six failed at the chick stage. As the monitoring of these nests was infrequent, we could not calculate hatching success, but breeding success was 74%. Breeding success was not significantly different between these nests and the camera nests (two proportion z-test: $z = 1.348$, $P = 1.770$), indicating that camera presence had no impact on breeding success. Overall, 39 of 51 nesting attempts produced a fledgling (76% breeding success).

DISCUSSION

The population of Black Noddies at North Bay grew in the presence of rodents from 36 pairs in 1989 to 560 pairs in 2014, an expansion of 10% per annum. On Australia's Lady Elliot Island (24°07′S, 152°43′E) within the Great Barrier Reef, a founding population of 30 pairs of Black Noddies in 1985 grew at a rate of over 100% per annum to 570 pairs by 1989 (Walker 1986, 1989). That population continued to increase less rapidly thereafter (30% per annum) and by 2012, it numbered approximately 30 000 breeding pairs (Tidemann 2014). The proximity to other significant colonies within the same island group in the southern Great Barrier Reef may have contributed to their dramatic colony expansion (Tidemann 2014), as immigrants and first-time breeders would have been attracted to underutilised habitat on Lady Elliot Island. On the other hand, LHI is 900 km southwest of the nearest colony (Norfolk Island; 29°02′S, 167°57′E) and is unlikely to receive the same level of immigration as Lady Elliot Island.

It has been suggested that rodents are a threat to noddy survival elsewhere (Tarburton 1987, Pitman *et al*. 2006), and the relatively slower expansion of the breeding colony on LHI could have been attributed to the impacts of rodents on nesting. However, our nest monitoring in 2014 showed no evidence of rodent presence at noddy nests and that overall breeding success was relatively high (76%). These findings, coupled with the observation that the colony has not expanded significantly since the removal of rodents in 2019, suggests that rodents, particularly Black Rats, have had little impact on this tree-nesting species on LHI.

The low impact of rodents on Black Noddy has been noted elsewhere. Despite the presence of mice on Ile Longue within the Chesterfield Group in the Coral Sea (19°05′S–21°50′S and 158°15′E–159°35′E), the population of Black Noddy was stable over almost 20 years (Borsa *et al.* 2010). On Vatu-i-Ra, Fiji (17°19′S, 178°28′E), Tarburton (1987) considered that Pacific Rat may prey on Black Noddy but have a lower impact than on the ground-nesting Brown Noddy. Philippe-Lesaffre *et al.* (2023) found that there was a significant increase in noddies breeding on Surprise Island north of New Caledonia (18°28′S, 163°05′E), 16 years after Black Rat and House Mouse removal. However, the authors did not distinguish between populations of ground- and shrub-/tree-nesting noddies, which are likely to be impacted by rodents differently. Indeed, following the removal of rodents, we have observed Brown Noddy nesting on the ground on LHI, where they were previously found breeding strictly on the outer branches of shrubs.

It is likely that removal of feral Cats *Felis catus* from LHI by 1983 (NSW National Parks and Wildlife Service 2002) allowed Black Noddy to establish initially. However, the birds can survive the presence of feral cats if nesting sufficiently high in Norfolk Island Pines (Director of National Parks 2010), as found on Norfolk Island. The movement of the entire North Bay population to the commercial precinct of the Settlement Area in 2020 may have been influenced by island's COVID 19-related closure to tourists from the Australian mainland, under a public health order on 20 March 2020 (MHMR 2020b). This order was not repealed until 02 October 2020 (MHMR 2020a). It is possible that the lack of human activity associated with a complete stoppage of tourism on the island when Black Noddies were returning to breed in 2020 encouraged the North Bay population to coalesce around the few birds that had already commenced nesting there in late 2019.

Both negative and positive impacts to wildlife from a lack of human activity during COVID-19 lockdowns has been reported throughout the world (Bates *et al.* 2021). Seabird colonies were sometimes

more vulnerable to predation during the lockdown period (Hentati-Sundberg *et al.* 2023), as the presence of tourists reduced avian predatory activities. Conversely, the lack of humans allowed some colonial nesting birds to become more established in urban areas (Dai & Li 2021). Movements between sub-colonies of Gentoo Penguin *Pygoscelis papua* was noted in the vicinity of buildings on Goudier Island on the western Antarctic Peninsula (64°49′S, 063°29′E) when all human presence was halted there during the pandemic lockdown in 2020 (Flynn *et al.* 2023). The sub-colonies that were previously exposed to human foot traffic doubled in size during lockdown, but then returned to pre-pandemic levels in the three-year timeframe after lockdown restrictions were lifted (Flynn *et al.* 2023). These studies indicate that a range of colony-nesting birds are sensitive to human presence at the time of colony formation or when choosing appropriate sites for annual breeding. Parts of NSW, including LHI, underwent a second lockdown from July 2021 until mid-October 2021. This additional reprieve from tourist-related activities may have allowed further reinforcement of the suitability of the Settlement Area breeding site. Observations in October 2023 indicated that the breeding birds were largely unconcerned with visitor foot traffic or business activities outside the surrounding buildings. Occasionally, birds from the lower nests would vocalise and non-incubating adults would leave perch locations in response to the approach of humans.

This study shows that the Black Noddy can survive and expand breeding populations on LHI even in the presence of rodents. Several behavioural factors may allow this, including selection of nest sites that limit rodent access and provide only one point of predator contact to a nest. Colonial nesting behaviour also ensures that any climbing predator may need to overcome many individual adult birds before accessing nests. Finally, the presence of adults at nests during all nocturnal periods enables birds to defend nests when rodents are most likely to be foraging above ground.

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AUTHOR CONTRIBUTIONS

NC conceived of and designed the study. All authors conducted the field work. NC and TO'D wrote the manuscript. LO'N provided edits to the manuscript.

REFERENCES

BATES, A.E., PRIMACK, R.B., BIGGAR, B.S., ET AL. 2021. Global COVID-19 lockdown highlights humans as both threats and custodians of the environment. *Biological Conservation* 263: 109175 doi:10.1016/j.biocon.2021.109175

BILLING, J. & HARDEN, R. 2000. Control of introduced *Rattus rattus* L. on Lord Howe Island. I. The response of mouse populations to warfarin bait used to control rats. *Wildlife Research* 27: 655–658.

BORSA, P., PANDOLFI, M., ANDRÉFOUËT, S. & BRETAGNOLLE, V. 2010. Breeding avifauna of the Chesterfield Islands, Coral Sea: Current population sizes, trends, and threats. *Pacific Science* 64: 297–314. doi:10.2984/64.2.297

CARLILE, N. & O'DWYER, T. 2022. At-sea movements of the White Tern *Gygis alba* in waters off eastern Australia. *Marine Ornithology* 50: 151–158.

CARLILE, N., PRIDDEL, D. & O'DWYER, T. 2018. Preliminary surveys of the endangered Lord Howe Island cockroach *Panesthia lata* (Blattodea: Blaberidae) on two islands within the Lord Howe Group, Australia. *Austral Entomology* 57: 207–213. doi:10.1111/aen.12281

CHAMPEAU, J., BUTAUD, J.-F., WAUGH, S.M. & CRANWELL, S. 2011. The first comprehensive bird survey of Hatu-Iti Island, Marquesas Islands, French Polynesia. *Marine Ornithology* 39: 255–259.

DAI, R. & LI, Y. 2021. A new heron colony in Yunnan, China, survives amid the COVID-19 pandemic. *Journal of Heron Biology and Conservation* 6: 3.

DECC (DEPARTMENT OF ENVIRONMENT AND CLIMATE CHANGE (NSW)). 2007. *Lord Howe Island Biodiversity Management Plan*. Sydney, Australia: Department of Environment and Climate Change (NSW).

DILLEY, B.J., SCHRAMM, M. & RYAN, P.G. 2017. Modest increases in densities of burrow-nesting petrels following the removal of cats (*Felis catus*) from Marion Island. *Polar Biology* 40: 625–637.

DIRECTOR OF NATIONAL PARKS. 2010. *Norfolk Island Region Threatened Species Recovery Plan*. Canberra, Australia: Department of the Environment, Water, Heritage and the Arts.

EDGECOMBE, J. 1987. *Lord Howe Island: World Heritage Area*. Sydney, Australia: Australian Environmental Publications.

FLYNN, C.M., HART, T., CLUCAS, G.V. & LYNCH, H.J. 2023. Penguins in the anthropause: COVID-19 closures drive Gentoo Penguin movement among breeding colonies. *Biological Conservation* 286: 110318. doi:10.1016/j.biocon.2023.110318

GAUGER, V.H. 2020. Black Noddy (*Anous minutus*), version 1.0. In: BILLERMAN, S.M. (Ed.) *Birds of the World*. Ithaca, USA: Cornell Lab of Ornithology. doi:10.2173/bow.blknod.01

HARPER, G.A., PAHOR, S. & BIRCH, D. 2020. The Lord Howe Island rodent eradication: Lessons learnt from an inhabited island. In: WOODS, D.M. (Ed.) *Proceedings of the 29th Vertebrate Pest Conference*. Vol. 29, paper no. 31. Davis, USA: University of California, Division of Agriculture and Natural Resources.

HENTATI-SUNDBERG, J., MELCHIORI, S., BERGLUND, P.-A. & OLSSON, O. 2023. Eagle effects on seabird productivity: Effects of a natural experiment. *Biological Conservation*. 284: 110145. doi:10.1016/j.biocon.2023.110145

HIGGINS, P.J. & DAVIES, S.J.J.F. 1996. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 3: Snipe to Pigeons.* Melbourne, Australia: Oxford University Press.

HINDWOOD, K.A. 1940. The birds of Lord Howe Island. *Emu - Austral Ornithology* 40: 1–86.

HULL, A.F.B. 1910. The birds of Lord Howe and Norfolk islands. *Proceedings of the Linnean Society of New South Wales* 34: 636–693.

HUTTON, I. 1991. *Birds of Lord Howe Island: Past and Present*. Coffs Harbour, Australia: Ian Hutton.

JONES, H.P., HOLMES, N.D., BUTCHART, S.H.M., ET AL. 2016. Invasive mammal eradication on islands results in substantial conservation gains. *Proceedings of the National Academy of Sciences* 113: 4033–4038.

JONES, H.P., TERSHY, B.R., ZAVALETA, E.S., ET AL. 2008. Severity of the effects of invasive rats on seabirds: A global review. *Conservation Biology* 22: 16–26.

LÓPEZ-VICTORIA, M. & ESTELA, F.A. 2006. Additions to the breeding seabirds of Malpelo Island, Colombia. *Marine Ornithology* 34: 83–84.

MCALLAN, I.A.W., CURTIS, B.R., HUTTON, I. & COOPER R.M. 2004. The birds of the Lord Howe Island Group: A review of records. *Australian Field Ornithology* 21: 1–82.

MCCULLOCH, A.R. 1921. Lord Howe Island: A naturalist's paradise. *Australian Museum Magazine* 1: 31–47. doi:10.3853/j.0155-3496.1921.1.2

MHMR (MINISTER FOR HEALTH AND MEDICAL RESEARCH). 2020a. *Public Health (COVID-19 Lord Howe Island) Order (No 4) Repeal Order 2020*. St Leonards, Australia: New South Wales Ministry of Health.

MHMR. 2020b. *Public Health (COVID-19 Lord Howe Island) Order 2020*. St Leonards, Australia: New South Wales Ministry of Health.

MOORS, P.J., ATKINSON, I.A.E. & SHERLEY, G.H. 1992. Reducing the rat threat to island birds. *Bird Conservation International* 2: 93–114.

NSW NATIONAL PARKS AND WILDLIFE SERVICE. 2002. *Approved Recovery Plan for the Lord Howe Woodhen*. Hurstville, Australia: New South Wales National Parks and Wildlife Service.

O'DWYER, T.W., CARLILE, N., O'NEILL, L., FAIRLAMB, H. & BOWER, H. 2024. Protection and mortality of non-target terrestrial bird species during the eradication of rodents on Lord Howe Island. *Biological Invasions* 26: 155–167. doi:10.1007/s10530-023-03161-w

O'DWYER, T.W., CARLILE, N., O'NEILL, L. & HALPIN, L. 2023. Changing fortunes of the Black-winged Petrel *Pterodroma nigripennis* following the Lord Howe Island Rodent Eradication Project - interactions with other recovering species. *Bird Conservation International*. 33: e18. doi:10.1017/S0959270922000132

PHILIPPE-LESAFFRE, M., THIBAULT, M., CAUT, S., ET AL. 2023. Recovery of insular seabird populations years after rodent eradication. *Conservation Biology* 37: e14042.

PITMAN, R.L., BALLANCE, L.T. & BOST, C. 2006. Clipperton Island: Pig sty, rat hole and booby prize. *Marine Ornithology* 33: 193–194.

RABONE, H.R. 1940. *Lord Howe Island: Its Discovery and Early Associations 1788 to 1888*. Sydney, Australia: Australis.

RUFFINO, L., ZARZOSO-LACOSTE, D. & VIDAL, E. 2015. Assessment of invasive rodent impacts on island avifauna: Methods, limitations and the way forward. *Wildlife Research* 42: 185–195.

TARBURTON, M.K. 1987. Migration and breeding strategies of the Black Noddy, Fiji. *Emu - Austral Ornithology* 87: 50–52. doi:10.1071/MU9870050

TIDEMANN, S.C. 2014. Nest sites and breeding estimates of the Black Noddy *Anous minutus* on Lady Elliot Island. *Corella* 38: 43–46.

WALKER, T.A. 1986. The birds of Lady Elliot Island. *The Sunbird* 16: 73–82.

WALKER, T.A. 1989. Seabird islands No. 201: Lady Elliot Island, Great Barrier Reef, Queensland. *Corella* 13: 118–121.

WILKINSON, I.S. & PRIDDEL, D. 2011. Rodent eradication on Lord Howe Island: Challenges posed by people, livestock and threatened endemics. In: VEITCH, C.R., CLOUT, M.N. & TOWNS, D.R. (Eds.) *Island Invasives: Eradication and Management. Proceedings of the International Conference on Island Invasives.* Gland, Switzerland: International Union for Conservation of Nature, Species Survival Commission, Invasive Species Specialist Group.