Predation of seabird eggs by Common Mynas *Acridotheres tristis* on Bird Island, Seychelles, and its broader implications

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Prédation d'œufs d'oiseaux de mer par le Martin triste *Acridotheres tristis* à **Bird Island, Seychelles, et ses implications plus larges.** Des études récentes sur des oiseaux de mer nichant à Bird Island, Seychelles, ont démontré la capacité des Martins tristes *Acridotheres tristis* d'infliger une prédation importante à des œufs si d'autres facteurs, en particulier le dérangement par l'homme, entrent en jeu. Des observations sur d'autres îles des Seychelles indiquent que la prédation et l'ingérence des Martins tristes pourraient également empêcher l'etablissement de colonies fondatrices par des oiseaux de mer qui sont en train d'étendre leur aire de distribution, ou des tentatives de ré-établissement de colonies d'oiseaux de mer sur des îles d'où elles ont été éliminées par des activités humaines. Des Martins tristes ont été introduits sur maintes îles tropicales dans les trois océans majeurs, et les impacts sur les oiseaux de mer identifiés ici sont insidieux et peuvent être plus répandus que l'on ne pense. Ceci doit être pris en compte par les chercheurs concevant des études d'oiseaux de mer et par ceux entreprenant des projets d'éco-tourisme sur des îles où se trouvent des Martins tristes.

Summary. Recent studies of nesting seabirds on Bird Island, Seychelles, have demonstrated the capacity for Common Mynas *Acridotheres tristis* to inflict high predation on eggs when combined with other factors, especially human disturbance. Observations on other islands in Seychelles suggest that predation and interference by Common Mynas might also inhibit the establishment of founder colonies by seabirds that are expanding their ranges, or attempts to re-establish seabird colonies on islands from which they were once extirpated by human activities. Common Mynas have been introduced on many tropical islands in the world's three major oceans, and the impacts on seabirds identified here are insidious and may be more widespread than presently appreciated. This must be taken into account by researchers designing studies of seabirds and by those undertaking eco-tourism developments on islands where Common Mynas are present.

Common Mynas *Acridotheres tristis* have been introduced from their native range in southern Asia to many tropical islands and to some subtropical / temperate / continental regions (Feare & Craig 1998). Where introduced they are considered to be invasive aliens (IUCN 2014) on account of their alleged impacts on indigenous biota (along with some agricultural and public health concerns). Robust evidence for negative effects on indigenous birds has proved difficult to demonstrate (e.g. Pell & Tidemann 1997, Tindall *et al.* 2007) and such effects can vary with environmental conditions (Lowe *et al.* 2011, Grarock *et al.* 2012, 2013). Information on the impacts of Common Mynas on indigenous biota in different environments can thus be important to inform what mitigation measures, if any, are appropriate, practicable and justifiable. Here we report new findings on Common Myna (hereafter 'myna') predation of seabirds on Bird Island, Seychelles, western Indian Ocean, and the influence that human disturbance can have on the extent of predation. In light of these observations, we consider possible effects of mynas, and their management, on other islands with seabird breeding colonies within the Seychelles archipelago.

All of the islands considered here, except Récif, underwent habitat transformation in the late 19th century with the planting and management of coconut trees *Cocos nucifera*, involving the removal of indigenous woodland and maintenance of minimal ground layer vegetation, until the demise of the coconut industry in the 1960s.

Islands considered

Bird Island (03°43'S 55°12'E, 90 ha, low-lying coral sand cay)

Until the late 19th century largely treeless Bird Island hosted a huge Sooty Tern *Onychoprion fuscatus* colony (Thomas & Robinson 1771, Coppinger 1887, Fryer 1910) of possibly *c.*5,000,000 pairs (CJF unpubl.) and other ground-nesting seabirds, including Masked *Sula dactylatra* and probably Brown Boobies *S.*

leucogaster (Coppinger 1887, Fryer 1910, Vesey-Fitzgerald 1941). Coconut planting led to a considerable reduction in the Sooty Tern colony, with only *c.*18,000 pairs remaining in 1955 (Ridley & Percy 1958). Boobies ceased breeding during this period.

Removal of coconut trees around the Sooty Tern colony commenced in 1967, and by 1973 *c.*395,000 pairs were breeding (Feare 1976a). The colony is now a tourist attraction for visitors to the small hotel. Cessation of maintenance of short vegetation between the remaining coconut trees led to the development of a woodland of native broadleaved trees, especially *Pisonia grandis*, *Cordia subcordata*, *Thespesia populnea* and *Guettarda speciosa.* Additional woodland species were introduced for ornamental reasons. This woodland provides habitat for tree-nesting seabirds, including Brown Noddies *Anous stolidus*, White Terns *Gygis alba* and, more recently, Lesser Noddies *Anous tenuirostris.* Tourists are permitted to walk anywhere on the island, but are discouraged from entering the Sooty Tern colony; many of the island's breeding seabirds, especially those that nest around the hotel, can therefore be subjected to human disturbance.

Black Rats *Rattus rattus*, introduced among building materials during hotel construction in the late 1960s, were successfully eradicated in 1996–97 (Merton *et al.* 2002). Mynas were first documented on Bird Island in 1972 (Feare 1979), but the details of their introduction is unknown. Vesey-Fitzgerald (1941) did not record them.

Denis (03°48'S 55°41'E, 140 ha, low-lying coral sand cay)

When first described, Denis Island supported a large population of seabirds among grassy vegetation and in trees—from the description probably *Pisonia grandis* (de Trobriand 1777). Early reports, however, are too vague for specific identification (Stoddart & Fosberg 1981).

Since the 1960s a tall diverse woodland has developed, while maintenance of the island is supported by tourism and farming. Recent island rehabilitation has included the eradication of cats *Felis catus* and Black Rats (Millet *et al.* 2004), replacement of coconut trees with broadleaved species and the introduction of four of Seychelles' threatened endemic landbirds—Seychelles Fody *Foudia sechellarum* and Seychelles Warbler *Acrocephalus sechellensis* (2004) and Seychelles Magpie Robin *Copsychus sechellarum* and Seychelles Paradise Flycatcher *Terpsiphone corvina* (2008)—to establish 'insurance' populations.

The date of introduction of mynas is unknown, but prior to the introduction of the endemic birds an eradication attempt was unsuccessful (Millet *et al.* 2004). A second attempt was initiated in 2010 and is ongoing; >90% of the original population has now been removed (CJF unpubl.).

Frégate (04°36'S 55°57'E, 220 ha, hilly granitic island)

From the 1960s to the 1990s, Frégate was the only island on which the Seychelles Magpie Robin survived, with a population of just *c.*12 individuals, and mynas were found to be interfering with breeding attempts (Komdeur 1996). Various attempts were made to reduce their numbers and by 2002 only eight mynas were estimated to remain (Millet *et al.* 2004). Thereafter control ceased and numbers increased to >700 individuals until complete eradication was successful in 2010–11 (Canning 2011).

From the 1990s to the present, island rehabilitation has included restoration of indigenous woodland following the demise of the coconut industry, and eradication of cats in 1977 and Brown Rats *Rattus norvegicus* in 2000 (Henriette Payet 2007).

Aride (04°13'S 55°40'E, 70 ha), ***Cousin*** (04°20'S 55°40'E, 30 ha) ***and Cousine*** (04°21'S 55°39'E, 26 ha), all hilly granitic islands

These three islands had remained rat-free and had retained large seabird populations and some endemic birds and reptiles. All have undergone restoration of native woodland and removal of exotic vegetation, to the extent that all are now largely wooded with little open space and have only small human populations. These habitats are not favoured by mynas (Feare & Craig 1998) and they do not breed on any of these three islands. Any mynas that arrive from nearby islands are shot as soon as possible (e.g. Samways *et al.* 2010).

Récif (04°35'S 55°46'E, 20 ha, rocky islet).

Dominated by herbaceous vegetation, the only bushes being a clump of low *Scaevola sericea* restricted to a small sand spit, Récif supports ground-nesting Sooty and Bridled Terns

Onychoprion anaethetus. Mynas do not occur. Lesser Noddies did not breed in the mid-1990s but had established a small colony in the *Scaevola* by 2002 (Feare 2003). The island is uninhabited and not visited by tourists, but Environment Department staff are stationed there during the main nesting season (May–August) to prevent poaching of seabird eggs.

Observed effects of mynas on seabirds on Bird Island

During the day Common Mynas are found throughout the island, in woodland and especially in areas of open grassland around the hotel and on the airstrip. Pairs remain together year-round (Feare & Craig 1998), but they sometimes coalesce into larger flocks, especially on grassland in the evenings prior to roosting communally. Observations in 2014 of pairs, in which one member was individually identifiable by its plumage abnormalities, showed that they occupied consistent feeding areas by day but defence of these against neighbouring pairs was lax, leading to overlap in their feeding ranges (CJF pers. obs.). During the Sooty Tern breeding season, from May to October, Feare (1976a) reported mynas taking unguarded eggs from around the colony's periphery but concluded that they had no significant impact on the population. When Sooty Terns are absent from the island, mynas regularly feed in the deserted nesting area, mainly on insects. In July 2014 the myna population, estimated from a count of birds entering their communal roost in a large *Calophyllum inophyllum* tree in the evening, was a minimum of 150 birds.

In the absence of disturbance, Sooty Terns leave eggs unguarded for brief periods when incubating adults fly to the sea close inshore to drink, and sometimes to wet their feet and belly feathers with which they moisten the surface of the egg on returning to the nest (Schreiber *et al.* 2002). Such absences are thus a natural and regular occurrence, but adults also leave their eggs during disturbances by large potential predators, especially humans. Mynas appear reluctant to enter the colony; on Bird Island Sooty Terns nest densely (Feare *et al.* 1997) with a median nearest-neighbour distance of 38 cm (Feare & Larose 2014) and mynas would be subjected to powerful stabs from Sooty Tern bills, as are humans and land crabs *Ocypode cordimana*. Sooty Terns at the edges of the colony are more prone to leave their eggs during disturbances than birds in the heart of the colony, and in 2014 mynas were seen to take advantage of such disturbance. Pairs of mynas perched in trees and bushes around the colony margins, flying down to seize unprotected eggs. The frequency with which CJF & CSL encountered a small group of mynas (4–5 pairs) on an access path into the colony, used daily by them to check the progress of specific Sooty Tern nests and also by tourists to view the colony, raises the possibility that mynas might maintain vigilance for, or even follow, potential sources of disturbance in anticipation of feeding opportunities.

Prior to the planting of coconuts, Brown Noddies nested in coastal *Scaevola sericea* and *Tournefortia argentea* bushes (Fryer 1910), as they do today. The crowns of coconut palms provide abundant nest sites, however, and in 1972 the island's population was estimated at *c.*10,000 pairs (Feare 1979). Following the eradication of Black Rats, Brown Noddies began nesting on the ground at the bases of trees, especially *Casuarina*, and also in unmown grass and other herb vegetation in the otherwise mown lawns of the hotel. These nests are single or clumped in small groups in the available habitat. In 2014 clumps contained 2–19 nests with a median nearest-neighbour distance of 1.5 m (n = 46 nests).

While catching incubating ground-nesting adult Brown Noddies for ringing and other studies in 2013 and 2014, CL & MD discovered that while adults were being processed, mynas rapidly approached the unguarded nests and took the eggs. Eggs were sometimes taken less than one minute after the breeding adult was captured and the egg was left unguarded. Of the 31 nests on the ground that were monitored for the purpose of the ringing study, egg predation by mynas was observed in three cases. Four other eggs were lost the day after the noddies were processed, potentially also resulting from myna predation, although we cannot exclude the possibility that other potential predators, Common Moorhens *Gallinula chloropus* or land crabs, could have been involved. After CL & MD realised that such rapid and frequent myna predation was occurring, all eggs of birds caught for processing were temporarily covered with a cloth, which was removed only after the noddies were observed

Figure 1. Common Myna *Acridotheres tristis* apparently attempting to distract an incubating Brown Noddy *Anous stolidus* at its nest on the ground, Bird Island, August 2014 (Chris J. Feare)

Martin triste *Acridotheres tristis* essayant apparemment de distraire un Noddi brun *Anous stolidus* en train de couver, Bird Island, août 2014 (Chris J. Feare)

flying back to their nests (usually within five minutes). This simple protection method was successful as none of the eggs in the remaining nests that we monitored was predated within the 24 hours after the birds were captured.

In addition to responding to disturbance caused by people, we observed mynas approaching incubating Brown Noddies on nests on the ground on many occasions. One member of a foraging pair walked towards an incubating noddy and approached it to within *c.*0.5 m. This myna either stood looking at the noddy (Fig. 1) or walked backwards and forwards around the incubating bird while the myna's mate continued foraging in nearby grass, periodically looking at its mate. We did not see a myna take an egg during these observations, but it appeared that any further disturbance that would have led the noddy to leave its egg would have resulted in its loss.

The initiation of breeding by Lesser Noddies on Bird Island in 1984 (G. Norah pers. comm.), which pre-dated the eradication of Black Rats in 1996–97, was preceded by the roosting at night by more than 10,000 birds in trees in the centre of the island (Feare 1979). This large potential founder group might have facilitated breeding in the presence of both an established myna population (but relatively small compared to that on neighbouring Denis Island, see below) and a large population of Black Rats. Lesser Noddies now nest in tall *Pisonia grandis*, *Guettarda speciosa*, *Calophyllum inophyllum*, *Cordia subcordata*, *Thespesia populnea*, and, especially, introduced *Cordia sebestena* in the hotel area. These ornamental trees are rarely taller than *c.*5 m and Lesser Noddies nest densely in them (median nearest-neighbour nest distance 50 cm; $n = 70$ nests). At the approach of humans, nesting Lesser Noddies become agitated and highly vocal, and in 2011–14 CJF & CSL noticed that such agitation and calling was also stimulated by the arrival of a pair of mynas in a nesting tree (Fig. 2). Closer observation revealed that pairs of mynas climbed among the branches, sometimes leading a Lesser Noddy to leave its nest in an attempt to deter the myna, but the unattended egg was quickly taken. The members of the pair appeared to be working together, one creating a distraction that permitted the other to take the egg. Disturbance by humans, including unwitting tourists when taking photographs, could leave eggs open to predation when mynas are present.

In June–July 2014, 82 incubating Lesser Noddies were caught for ringing and other investigation and CL, MD & CSL noticed that before some adults returned to their nests, which was usually within 5–10 minutes after catching, their eggs had been taken. This occurred with four of the first five nests from which breeding adults were captured. Although predation by mynas was not directly observed, due to the density

Figure 2. Common Mynas *Acridotheres tristis* approaching Lesser Noddy *Anous tenuirostris* nests in **(a)** living and **(b)** dead *Cordia sebestena* trees, on Bird Island, July 2014 (Camille Lebarbenchon)

Martins tristes *Acridotheres tristis* s'approchant de nids du Noddi marianne *Anous tenuirostris* dans des arbres *Cordia sebestena* vivants **(a)** et morts **(b)**, Bird Island, juillet 2014 (Camille Lebarbenchon)

of leaves in the trees used for nesting, previous observations on Brown Noddies suggested that a similar scenario probably occurred. To prevent further predation each egg was covered with a cloth or large leaf that was only removed after the captured birds returned to the vicinity of their nest. This prevented further egg predation.

Mynas and seabirds on other Seychelles islands

The other main seabird islands of Seychelles, Aride, Cousin and Cousine, host large seabird populations with both tree- and ground-nesting species, but largely lack mynas. In the early 1970s these were the only islands on which Lesser Noddies nested in Seychelles (Penny 1974). Cousin and Cousine lost their small colonies of Sooty Terns in the mid-20th century, probably as a result of excessive harvesting of their eggs (Feare 1976b) but Aride retains a large but declining Sooty Tern colony (probably due to forest growth). Cousine retained some open grassy slopes on hillsides and over the last 15 years a small Sooty Tern breeding population has re-established (Samways *et al.* 2010). Tourists visiting these islands have controlled access to minimise disturbance and rapid removal of any arriving mynas ensures that they are not a threat.

Denis Island is largely wooded and has fewer breeding seabirds than the islands mentioned above, restricted largely to small numbers of Brown Noddies and White Terns. Introductions of endemic landbirds did not achieve the success of endemic bird introductions on other islands and research on one species, Seychelles Warbler, revealed low breeding success and poor adult female survival, for which myna predation was suspected (van der Woude *et al.* 2013). Following the large reduction in myna numbers that commenced in 2010, populations of the four species of endemic birds have increased, as has female survival in Seychelles Warblers (van

der Woude *et al.* 2013, Bristol 2014). Seabird populations on Denis Island are not formally monitored, but during a visit in April 2012, CJF was struck by the number of White Terns, which appeared to have increased considerably since his previous visits in May and October 2011. In addition to the larger numbers, in April 2012 many White Terns were nesting much lower in trees and bushes than on previous visits.

Small numbers of Lesser Noddies have roosted at night in tall *Casuarina* trees at the southern end of Denis Island, some of them remaining during the day, since at least the early 2000s. In this area, an understorey of young *Pisonia grandis* has developed, possibly introduced from seeds carried on the plumage of Lesser Noddies. In May 2014 CJF & CSL failed to find roosting Lesser Noddies here, but <100 birds were observed in the evenings flying into tall trees in the centre of the island to roost. In August 2014, however, *c.*25 active nests were reported in two small groups near the south of the island (M. Mason & A. Labiche pers. comm., CJF pers. obs.). Initiation of breeding on Denis Island by Lesser Noddies followed the main reduction in the number of mynas in 2011–12 and coincided with a further attempt to complete their eradication that began in May 2014.

Colonisation of Frégate Island by Lesser Noddies in the early 1990s occurred at a time when the number of mynas was being reduced (Millet *et al.* 2004). Mynas were successfully eradicated in early 2011 (Canning 2011) and the island now has a large Lesser Noddy population. On a visit to Frégate in June 2013, CJF & CSL found exceptional numbers of nesting White Terns, along with huge numbers in the air, appearing to them to represent the densest colony they had seen in Seychelles. E. Henriette (pers. comm.) reported that White Terns were plentiful on Frégate in 2001–03 but that numbers declined subsequently. This reduction in White Tern numbers coincided with a cessation of myna control, which had reduced the island's population to an estimated eight mynas, and the ensuing increase to >700 birds, prior to their eradication. However, E. Henriette also noted that the death, due to disease, of *Pterocarpus indicus* trees that had provided important nest sites, might also have contributed to the decline in the White Tern population since the early 2000s. If the apparent recent increases in White Tern populations on Frégate and Denis are genuine, the rapidity of the increases following myna reduction / eradication suggests that increased breeding success on the islands might be accompanied by immigration.

On Récif, Lesser Noddies established a breeding colony in low bushes that elsewhere in Seychelles would have been considered entirely inappropriate habitat. This suggests that expansion of Seychelles' Lesser Noddy population at the turn of the century involved seeking new islands on which to establish colonies. Colonisation of Récif was probably facilitated by its lack of predators, including mynas, and minimal human disturbance.

Discussion

Common Mynas have previously been reported taking eggs of gulls (*Larus*) and terns (*Onychoprion*, *Anous*), and attacking adult Black Noddies *Anous minutus* and White Terns on Midway Atoll (Grant 1982, Tyler 1988, Richardson 1992), but to our knowledge this is the first time that predation of eggs of Lesser Noddies has been documented. In most cases the impact on susceptible populations has been considered minimal (Feare & Craig 1998) but on Kauai, Hawaii, Byrd (1979) recorded mynas taking 23% of Wedge-tailed Shearwater *Puffinus pacificus* eggs from their burrows. The low impact of myna predation on Sooty Tern eggs on Bird Island stems from the species' inability to enter the colony (Feare 1976), but where Sooty Terns nest at lower densities predation can be more damaging. On Ascension Island, South Atlantic, nest density of Sooty Terns is lower than on Bird Island (Ascension <2.5 nests/m^2, Hughes 2014; Bird Island <6 nests/m^2, Feare *et al.* 1997) and, in addition to taking eggs, myna predation on Ascension leads to the desertion of eggs by surrounding birds, leaving spatial voids where predation has occurred (Hughes *et al.* 2008). It thus appears that mynas take advantage of low nest density in colonies to enter without risk of attack from closely packed birds. This also seems to be the case with Brown and Lesser Noddies on Bird Island.

The establishment of Lesser Noddy breeding populations on Denis and Frégate at the time of reduced numbers of mynas suggests that the presence of large numbers of mynas might also prevent the establishment of new colonies, as small numbers of nesting birds could be more

susceptible to predation than birds nesting in large colonies, on otherwise apparently suitable islands.

Bird Island's ground-nesting Brown Noddies were dispersed in small groups, in which nests were more widely separated than those of Sooty Terns. The arrival of an intruder promoted some individual Brown Noddies to leave the nest and fly at the intruder calling loudly, leaving the egg unprotected. This wide spacing of both groups and nests confers no protection from neighbours for unguarded eggs. Although Lesser Noddies nest at higher densities than Brown Noddies on Bird Island, the communal defence of Lesser Noddies is largely vocal, with most birds in the group calling loudly and some disturbed birds flying towards intruders, but fluttering around them, rather than attacking. However, the dispersion of nests of Lesser Noddies is three-dimensional within the tree canopy, providing mynas with opportunities to create their own disturbance and approach unguarded eggs from directions that can minimise interference from neighbouring nest owners. Lesser Noddies are much smaller (on Bird Island in June–July 2014, mean 96 g, n = 173) than Brown Noddies (mean 190 g, n = 151) and Sooty Terns (mean 199 g, n = 104; all authors' unpubl. data). Although Lesser Noddy defence is more communal than that of Brown Noddies, their behaviour, to the human intruder at least, appears to be less intimidating than that of their larger relatives.

Mynas are opportunistic predators and appear to capitalise on any disturbance, including that due to passing humans. The impacts on seabirds that we observed, however, are insidious and easily overlooked. There are clear implications of our observations for research, island rehabilitation and tourism. In the absence of frequent disturbance, myna predation may be inconsequential in terms of seabird population sustainability. On islands where tourism is an important activity, myna predation could have more serious effects. This could be especially significant on islands that support small populations of endangered seabirds, but will be less important where seabird breeding colonies can exchange individuals with other colonies within a metapopulation, as with Sooty Terns in Seychelles (Feare & Lesperance 2002). Conservation managers and advisors on islands that support tourism should plan tourist access, and the planting of trees likely to be colonised by seabirds, to minimise disturbance to the seabirds that form part of the island's attraction. Investigators of seabird biology on islands inhabited by mynas must be aware that their own activities could significantly depress nesting success unless protective measures are taken. In addition, those seeking to establish new breeding seabird colonies, especially of those species that nest in small colonies with widely spaced nests, should be aware that the presence of large numbers of mynas on islands could be a constraint on success.

All of these problems could be avoided, however, by preventing the establishment of mynas on offshore islands and eradicating existing myna populations (Feare 2010, Canning 2011), which would certainly benefit endemic landbirds (van der Woude *et al.* 2013, Bristol 2014) and possibly other biota, and especially when attempting to re-introduce birds to former strongholds.

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