Eradication of invasive common mynas *Acridotheres tristis* from North Island, Seychelles, with recommendations for planning eradication attempts elsewhere

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Abstract

Introduced common mynas (*Acridotheres tristis*) can negatively impact native wildlife throughout the mynas’ non-indigenous range, and in Seychelles myna eradications have been attempted on some smaller islands to protect endemic and indigenous fauna. Initial attempts, relying on a quick knock-down of the population using toxicants, failed. Here we describe an eradication on North Island, Seychelles, that was accomplished by trapping, supported by shooting in the final stages. This eradication attempt was ultimately successful but took place in two stages spanning seven years and involved removing 1641 birds. During the second, successful, stage, morphometric data collected from caught mynas provided pointers to optimum times during the mynas’ annual cycle to target control activities. During both stages the trapping of non-target species interfered with the capture of mynas. The six main conclusions from this eradication are (i) eradication of mynas from small islands is feasible and achievable by trapping and shooting, without recourse to the use of toxicants; (ii) provision of adequate resources for the life of an eradication attempt, especially ensuring continuity of funding and staffing, is essential for the efficient removal of the whole population; (iii) knowledge of myna phenology can be used to target the optimal timing of an eradication attempt, (iv) post eradication, vigilance and capacity for immediate action must be maintained to remove any immigrant mynas, (v) further research on trap design is needed to minimise the capture of non-target species, and (vi) introduced endemic bird populations should be monitored to assess their responses to myna removal.

Key words: introduced birds, invasive species, eradication methodology, seasonal vulnerability, island rehabilitation, economics
Introduction

Remote oceanic islands have historically provided opportunities for biota that reached them to evolve in environments different from those on the continents where they originated (e.g. Ashmole and Ashmole 2000; Steadman 2006; Cheke and Hume 2008). Divergence from the original stock was also facilitated by reduced species richness on isolated islands (MacArthur and Wilson 1967). Genetic drift and new selection pressures (Clegg 2010) led colonisers to follow new evolutionary pathways, leading to high degrees of endemism (Kier et al. 2009). Some of the evolved traits, such as lack of wariness of novel situations, and for birds the extreme condition of flightlessness (Sayol et al. 2020), rendered island endemics vulnerable to human activities, including the deliberate or accidental introduction of alien invasive species. This has exposed many small island endemics to levels of competition and predation to which they were not adapted (Duncan and Blackburn 2007). These have led to population declines and extinctions, with direct human predation and introduction of alien invasive species (especially mammalian) as significant causative agents.

BirdLife International (2020) estimates that 75% of extant island endemic birds are threatened by invasive species, compared with only 13% on continental land masses. These serious impacts of invasive species have led to requirements for interventions, with some alien bird species among the targets where sufficient evidence of adverse impacts has accrued (e.g. Veitch et al. 2019).

Human settlement of Seychelles in the late 1700s in tandem with invasive species introductions led to major ecological changes on most islands, and island extinctions and range contractions of some of the archipelago’s endemic birds ensued (Stoddart 1984). Recognising the ongoing threat to some of Seychelles’ endemic taxa, conservation organisations, island owners and government agencies commenced rehabilitation projects on some smaller islands from the late 1960s onwards (Feare 2017). Rehabilitation has included replacement of exotic vegetation with indigenous flora and eradication of invasive mammals (Rocamora and Henriette 2015). These projects aimed primarily to safeguard surviving populations, and later to establish insurance populations of some of the most threatened endemic birds on islands with restored habitats (Richardson et al. 2006; Rocamora and Henriette-Payet 2008; Burt et al. 2016).

Introduced invasive bird species included common mynas Acridotheres tristis (Linnaeus, 1766) (hereafter “mynas”). They are native to south-east Asia but were widely introduced to tropical islands in the expectation of controlling insect pests (Feare and Craig 1998). Where mynas are indigenous they are commensal with humans and introduced birds readily adapt to human-modified habitats in their new environments (Blackburn et al. 2009). On small islands, however, human settlements are inevitably close
to less disturbed areas that might support remnant endemic bird populations, putting the endemics at risk. Mynas are recognised as a major threat to endemic and indigenous birds through predation of eggs and chicks, disturbance to and injury of breeding adults, and food and nest site competition (Komdeur 1996; van der Woude and Wolfs 2009; Feare et al. 2015; Hughes et al. 2017). Several attempts have been made to eradicate mynas from some small Seychelles islands (< 200 ha, with estimated populations of ca. 750–1000 mynas) using toxicants applied to rice or bread bait to quickly reduce numbers (Millett et al. 2004; Rocamora and Henriette 2015), but this approach failed and was not followed by alternative methods. Opportunistic shooting on Frégate (Millett et al. 2004) and North Island (G. Wepener unpublished) was insufficient to achieve eradication. More recently, trapping has proved more effective in reducing myna numbers but the efficacy of different trapping techniques varied between islands or habitats (Canning 2011; Feare et al. 2016).

North Island (201 ha, 4°23′S; 55°14′E) is privately-owned and managed as a high-end tourism resort with strong conservation interests. Black rats *Rattus rattus* (Linnaeus, 1758) and cats *Felis catus* Linnaeus, 1758 (Rocamora and Henriette 2015) and domestic farm animals (recommended by Hill et al. 2002) were removed from the island between 2003 and 2005, and the initiation of a vegetation rehabilitation programme was begun in 2002. In 2012 island conservation staff decided that a concerted effort should be made to eradicate the breeding population of mynas, estimated to have been ca. 890 birds (Rocamora and Henriette 2015). The longer-term aim of these initiatives was to provide suitable habitat for the (re)introduction of some of Seychelles’ endangered endemic bird species. Seychelles white-eyes *Zosterops modesta* E. Newton 1867 had already been introduced in 2007, despite the presence of mynas (Rocamora and Henriette-Payet 2008).

Here we document the eradication of mynas from North Island as part of a broader island rehabilitation project coordinated by Seychelles NGO Green Islands Foundation (GIF). We identify problems that must be confronted prior to the initiation of similar eradications, including lack of continuity of trapping effort and interference through the capture of non-target species. We also used this opportunity to (i) investigate habitat differences in trap efficiency, (ii) examine seasonal variation in body condition and (iii) identify times of year that might optimise trapping in relation to breeding and moult.

**Materials and methods**

*Eradication techniques*

The primary method used to capture mynas was live trapping, mainly decoy-trapping. Apart from small numbers that were retained for subsequent use as decoys, trapped birds were humanely euthanised by cervical dislocation
soon after capture (Feare et al. 2016). In the later stages, when trapping efficiency declined, shooting was introduced.

We made no attempts to locate nests in order to destroy them, along with eggs and chicks. Favoured nest sites in Seychelles are in the crowns of coconut trees (personal observations) and are very difficult to access for control. During his successful eradication of mynas on Frégate Island, Canning (2011) only destroyed nests and their contents when these had been built in nest boxes erected for endangered Seychelles magpie robins Copsychus sechellarum A. Newton, 1865, which contributed little to the eradication. So far, nest boxes have not been erected on North Island.

Twenty decoy traps, made of 50 mm × 25 mm wire mesh, were deployed. Four catching compartments surrounded a central compartment that housed a live decoy myna (Figure 1, Feare et al. 2016). Each catching compartment had an entry aperture measuring ca. 8 cm × 8 cm which was closed by a drop-door triggered by an entering bird. Three birds caught in a mist net along with the first mynas to be trapped were retained as decoys for future trapping. Decoys were provided with food (restaurant waste, primarily boiled rice with fish and meat) and water twice daily and a small amount of food was placed in the catching compartments as bait. The traps were placed on the ground in most of the island’s habitats where mynas fed: grassland, marsh, coconut and broadleaved woodland, beach crest vegetation, and organic waste disposal sites. When catch rates declined or when birds changed preferred feeding areas, traps were moved (usually within 2–4 days) to target places where mynas were observed feeding. In addition, other traps trialled were: four commercially made “Mini Myna Magnet” traps

Figure 1. A decoy trap with a decoy myna in the central decoy compartment, three birds captured in outer catching compartments and two mynas attracted to the trap vicinity (Arjan de Groene/GIF).
Eradication of common mynas


Figure 2. Number of mynas euthanised/month during the eradication on North Island, Seychelles. Phase 1, October 2012–January 2013; Phase 2, May 2016–March 2018.

(www.pestit.com.au); three small home-made walk-in traps; a ladder trap (a wooden-framed wire mesh cage ca. 2 m × 1.5 m × 1.5 m, with V-shaped roof and ladder-type openings at the base of the V); and a 4 m × 3 m wooden-framed drop-trap built to cover pits at the organic waste site and operated by an observer hidden ca. 30 m away with a pull release.

The eradication took place in two phases (Figure 2):

Phase 1. On 5 October 2012, the decoy and Mini Myna Magnet traps were deployed and baited until 9 January 2013, when island staff designated to undertake the eradication did not have the time required to maintain trapping operations.

Phase 2. New administration within GIF and new environment management staff on North Island facilitated the recruitment of dedicated eradication staff, mainly graduate volunteers, who were employed on 6-month contracts. GIF ensure continuity of staffing and decoy trapping resumed on 13 May 2016 (the Mini Myna Magnet traps were no longer serviceable). Decoy traps were the main technique used until 24 March 2017, when falling catches (Figure 2) led to the initiation of intensive shooting by two professional hunters. Most birds were killed using a silenced .22 rifle with subsonic hollowpoint ammunition, but a .25 air rifle and 12-gauge shotgun were also used. This continued until 3 April 2017 and was followed by more opportunistic shooting by island staff (trained by the marksman) using the .25 air rifle. Decoy trapping continued throughout the shooting until what was believed to be the last bird was killed on 10 February 2019.

Two constraints to the project had to be addressed, relating to non-target species entering traps and the risk of mynas habituating to shooting.
All captures of non-target birds, apart from Madagascar fodies *Foudia madagascariensis* (which were small enough to enter and escape through the trap mesh), resulted in the closure of a trap door and thereby limited myna access to the traps. Most snail and crab captures similarly closed trap doors. The larger non-target birds additionally risked damaging the trap mechanism, especially Madagascar turtle doves *Nesoenas picturatus* (Temminck, 1813) and common moorhens *Gallinula chloropus* (Linnaeus, 1758). Even the presence of one of these species in a trap deterred entry by a myna (S.R. Fenn and B. Searle *unpublished*). Madagascar turtle doves are non-native to Seychelles and are not protected, while common moorhens are indigenous and protected under Seychelles legislation. During Phase 2 some trapped individuals of both species were individually marked by clipping remiges and/or rectrices, revealing that these individuals repeatedly re-entered traps. Subsequently, Madagascar turtle doves were humanely dispatched, but moorhens and the other bird species and invertebrates were released.

Most shooting was done from golf buggies, the main mode of transport on the island. To avoid mynas associating the buggies with shooting activities, the hunters used their buggies as a “taxi” service to island staff so that much of their use on the island was not shooting-related.

Data collection

During both Phases, the daily number of mynas trapped (and shot in Phase 2) were recorded. Breeding and the annual moult involve elevated energy and nutrient demands (e.g. Freed and Cann 2012) and thus might increase the attraction of bait in traps to mynas. To procure more precise information on the timing of these events for mynas in Seychelles, the ages (adult or juvenile as per Feare et al. 2016) of trapped birds were recorded to identify when most juveniles entered the population. Morphometric data collected included body mass (Pesola balance) and head-bill length (Vernier calliper), from which an index of body condition was derived (body mass/head + bill length) (Gosler et al. 1998). Primary moult score (Ginn and Melville 1983) was recorded to identify the main period of annual moult. Sex was determined by dissection. Breeding status of adult males was assessed by measuring left testis length (mm), and ovarian development in adult females was coded as 1, ovary small with indistinguishable follicles; 2, follicles visible but < 1 mm diameter; 3, follicles < 5 mm diameter; 4, one or more follicles > 5 mm.

During Phase 1, data were recorded from the start of trapping on 5 October until 12 December 2002; thereafter data collection ceased as island staff were diverted to non-eradication duties. Data were collected throughout Phase 2.

Non-target species

The number of non-target captures in the decoy traps was recorded during Phase 2.
Table 1. The number of mynas euthanised during the two phases of the eradication, broken down by capture method and age (adult or juvenile).

<table>
<thead>
<tr>
<th>Phase</th>
<th>Age class</th>
<th>Method</th>
<th>Decoy</th>
<th>Mini Myna</th>
<th>Drop</th>
<th>Other*</th>
<th>Shot</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 1</td>
<td>Adult</td>
<td>433</td>
<td>220</td>
<td>–</td>
<td>28</td>
<td>–</td>
<td>–</td>
<td>681</td>
</tr>
<tr>
<td></td>
<td>Juvenile</td>
<td>6</td>
<td>3</td>
<td>–</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Not aged</td>
<td>2</td>
<td>0</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>441</td>
<td>223</td>
<td>–</td>
<td>42</td>
<td>–</td>
<td>–</td>
<td>706</td>
</tr>
<tr>
<td>Phase 2</td>
<td>Adult</td>
<td>683</td>
<td>–</td>
<td>30</td>
<td>1</td>
<td>87</td>
<td>–</td>
<td>801</td>
</tr>
<tr>
<td></td>
<td>Juvenile</td>
<td>96</td>
<td>–</td>
<td>1</td>
<td>3</td>
<td>16</td>
<td>–</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>Not aged</td>
<td>3</td>
<td>–</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>–</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>782</td>
<td>–</td>
<td>35</td>
<td>9</td>
<td>109</td>
<td>–</td>
<td>935</td>
</tr>
</tbody>
</table>

* “Other” includes birds caught by hand (trapped inside buildings or unhealthy), caught in a mist net or in other trap types trialled for a short time.

Post-eradication vigilance

As North Island lies only 7 km from much larger Silhouette Island (ca. 1995 ha), which supports a large myna population (Greig-Smith 1986), there is a risk of re-colonisation. Post eradication, 12 months of intensive searches for sightings or vocalisations of mynas were undertaken. This involved one of the original myna eradication staff or a trained observer walking regular tracks throughout the island searching for any signs of mynas. Between two and six island walks per week were undertaken during four periods of the day (dawn, before 0700 h; morning, 0700–1200 h; afternoon, 1200–1630 h; and evening, after 1630 h). In addition, island maintenance and hotel staff were instructed to report any possible sightings of mynas.

Cost

The financial outlay of the eradication process in 2012–2013, and from 2015 to 2019, were recorded by Green Islands Foundation. This covered staff and international travel, equipment, and accommodation and subsistence costs for volunteers.

Results and discussion

Number of mynas trapped/shot

During Phase 1, 706 mynas were euthanised during the 3.5 months of the eradication attempt. During Phase 2, 935 mynas were euthanised or shot during the 34 months of trapping and shooting (Figure 2, Table 1).

In both phases, trapping accounted for the majority of captures, but the efficacy of the main traps used differed between habitats (Table 1). In Phase 1, the four Mini Myna Magnet traps failed to catch mynas in grassland, beach crest vegetation, woodland habitats or among hotel or workers’ accommodation. However, they did catch where mynas concentrated in foraging flocks at the organic waste site, where organic waste from the hotel and workers’ restaurants was deposited daily in pits dug in the sand. At this site, the drop-trap successfully caught mynas in October 2016.
During both phases of the eradication, catches of adults greatly outnumbered those of juveniles (Table 1). Phase 1 coincided with a breeding season but data collection ended before most juveniles would have fledged (see below), whereas Phase 2 extended over a complete myna annual life-cycle.

**Annual cycle of mynas on North Island**

The duration of data collection in Phase 1 was too short to provide information on seasonal trends in breeding state or body condition.

In Phase 2, females were found with enlarged oocytes (> 1 mm) in October, November, January and March; sample sizes in December and February were too small to assess breeding status (Table 2).

Males with large testes (> 6 mm) were recorded in all months, suggesting some reproductive capacity year-round, but mean testis length increased from its lowest level in May–August to its highest from November to March (Figure 3).

The proportion of juveniles in the euthanised samples rose sharply in January, peaked in February and declined thereafter (Table 3). By deduction, nest-building, laying, incubation and chick rearing will have occurred mainly

### Table 2. Percentage of females with oocytes with diameter > 1mm during Phase 2, from May 2016 to April 2017. n = the total number of females whose ovary was assessed each month.

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Oocyte &gt;1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.5</td>
<td>19.1</td>
<td>0</td>
<td>18.2</td>
<td>0</td>
<td>20.1</td>
<td>0</td>
</tr>
<tr>
<td>n</td>
<td>38</td>
<td>35</td>
<td>38</td>
<td>35</td>
<td>68</td>
<td>79</td>
<td>47</td>
<td>2</td>
<td>11</td>
<td>1</td>
<td>39</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 3. The percentage of juvenile mynas in monthly catches during Phase 2 from May 2016 to April 2017. n = number of individuals aged.

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
</tr>
</thead>
<tbody>
<tr>
<td>% juvenile</td>
<td>13.5</td>
<td>6.7</td>
<td>1.4</td>
<td>1.6</td>
<td>2.3</td>
<td>4.2</td>
<td>2.3</td>
<td>0.8</td>
<td>55.8</td>
<td>80.6</td>
<td>23.5</td>
<td>25.0</td>
</tr>
<tr>
<td>n</td>
<td>96</td>
<td>90</td>
<td>70</td>
<td>63</td>
<td>131</td>
<td>166</td>
<td>86</td>
<td>12</td>
<td>43</td>
<td>31</td>
<td>101</td>
<td>16</td>
</tr>
</tbody>
</table>
Table 4. Mean indices of body condition, standard deviation (Stdev) and sample size (n), for mynas trapped or shot between May 2016 and April 2017.

| Sex  | Month | M   | J   | J   | A   | S   | O   | N   | D   | J   | F   | M   | A   |
|------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Female | Mean  | 1.92 | 1.86 | 1.89 | 1.82 | 1.85 | 1.86 | 1.86 | 1.66 | 1.64 | 1.97 | 2.04 | --  |
|       | Stdev | 0.16 | 0.12 | 0.16 | 0.19 | 0.11 | 0.14 | 0.16 | 0.16 | 0.14 | --  | 0.18 | --  |
|       | n     | 38   | 35   | 38   | 35   | 68   | 79   | 47   | 2    | 11   | 1    | 39   | 0    |
| Male  | Mean  | 1.99 | 2.00 | 2.01 | 1.95 | 1.95 | 1.98 | 1.97 | 1.69 | 1.78 | 1.70 | 2.20 | 2.12 |
|       | Stdev | 0.19 | 0.18 | 0.18 | 0.24 | 0.15 | 0.16 | 0.15 | 0.19 | 0.21 | 0.51 | 0.21 | 0.20 |
|       | n     | 35   | 30   | 24   | 27   | 59   | 78   | 37   | 8    | 8    | 2    | 23   | 8    |

Table 5. The number of non-target species caught in decoy traps throughout Phase 2 of the eradication: Madagascar turtle dove (MTD), common moorhen (CM), Madagascar fody (MF), barred ground dove *Geopelia striata* (Linnaeus, 1766) (BGD), green-backed heron *Butorides striatus* (Linnaeus, 1758) (GBH), ruddy turnstone *Arenaria interpres* (Linnaeus, 1758) (RT), Eurasian whimbrel *Numenius phaeopus* (Linnaeus, 1758) (EW), land snail *Achatina fulica* (Ferussac, 1821) (LS), hermit crab *Coenobita Latreille, 1829 sp.* (HC), land crab *Ocypode Weber, 1795 sp.* (LC).

<table>
<thead>
<tr>
<th>Species</th>
<th>MTD</th>
<th>BGD</th>
<th>CM</th>
<th>GBH</th>
<th>RT</th>
<th>EW</th>
<th>MF</th>
<th>LS</th>
<th>HC</th>
<th>LC</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1237</td>
<td>3158</td>
<td>3595</td>
<td>13</td>
<td>32</td>
<td>1</td>
<td>9</td>
<td>690</td>
<td>24</td>
<td>50</td>
</tr>
</tbody>
</table>

through November–January (supported by direct observations of main nest building activity in November–December).

Primary moult was first detected in samples euthanised in March. Most individuals of both sexes were actively replacing remiges from May to July, with the majority having completed moult by August.

In both Phases, and across all months of Phase 2, the mean body mass of adult males was consistently greater than that of adult females; (Phase 1, females 98.79 g ± 12.48 [sd], males 106.73 g ± 10.03, t\(_{490}\) = 7.75, p < 0.01; Phase 2, females 101.86 g ± 9.38; males 110.76 g ± 11.38, t\(_{717}\) = 11.48, p < 0.01).

Likewise, the body condition index of adult males was consistently greater than that of females (Table 4), (Phase 1, females 1.83 ± 0.23 [sd], males 1.92 ± 0.17, t\(_{492}\) = 5.08, p < 0.001; Phase 2, females 1.87 ± 0.16 [sd], males 1.98 ± 0.20, t\(_{730}\) = 7.80, p < 0.001).

From the gonad and moult data we identified three stages of the annual cycle: pre-breeding (September–October), breeding (November–February) and moult (May–August). Body condition indices did not differ significantly between pre-breeding and breeding stages, or between pre-breeding and moult, but in both sexes body condition index was higher during moult than during breeding (females, breeding 1.82 ± 0.18, moult 1.88 ± 0.16, t\(_{205}\) = 2.34, p = 0.02; males, breeding 1.89 ± 0.21, moult 1.99 ± 0.16, t\(_{169}\) = 2.86, p = 0.005).

Non target species caught during trapping

In Phase 2, between 13 May 2016 and 18 March 2018, there were 8809 non-target animal captures in the decoy traps (Table 5).

Post-eradication monitoring

On 29 June 2019, four months after the intensive monitoring began, a myna was seen by a staff member. This bird was unwary and was shot and
Table 6. Estimated costs (US$) of the two phases of the myna eradication.

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td>33,200</td>
<td>7,700</td>
</tr>
<tr>
<td>Consultant fees + travel</td>
<td>10,250</td>
<td>43,500</td>
</tr>
<tr>
<td>Volunteer accommodation, subsistence, boat travel, admin.</td>
<td>4,750</td>
<td>16,400</td>
</tr>
<tr>
<td>Project management</td>
<td>5,000</td>
<td>14,800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>53,200</td>
<td>82,400</td>
</tr>
</tbody>
</table>

killed on 11 July from a hide erected for the purpose. There have been no other reported occurrences of mynas on the island since then.

Cost

The combined cost of the two eradication phases came to an estimated US$ 135,600 (Table 6). Costs for Phase 1 are however likely to be an underestimate, as the time spent by island staff on myna-related activities was not calculated, and project management was undertaken as part of a wider Protected Areas project. Equipment included purchase of traps/trap-building materials and tools. Project management by Green Islands Foundation included staff time for budget procurement, cost monitoring, volunteer and hunter recruitment, negotiation for firearms permissions and liaison with island management.

Discussion

The eradication of mynas from North Island marks the third successful eradication of mynas from small islands in Seychelles, following those on Frégate (Canning 2011) and Denis (Feare et al. 2016). However, like the Denis eradication, the North Island eradication suffered from inadequate resourcing at the outset. During planning of the attempt, C. Feare (CF) and C. Larose (CL) had emphasised that two dedicated staff would need to be trained and maintain necessary trapping intensity, but at the initiation of training, two existing island staff had been allocated part-time, with hotel guest duties taking priority. It soon became apparent that these island staff could not manage their workload and that the trainers (CF and CL) were doing the bulk of the work. After the trainers’ departure from the island on 4 November 2012, weekly reports showed that the number of mynas caught dropped rapidly (Figure 2) and in mid-January island staff were removed from trapping duties. No further staff were recruited and this phase of the eradication attempt was abandoned.

Following management changes in Green Islands Foundation and on North Island, the eradication attempt resumed in 2016, leading to the success of the eradication seven years after the initiation. In total, 1641 mynas were killed on North Island. However, without the break in the eradication, fewer birds would have to have been killed, and the cost of the eradication would have been lower. The myna population was not censused before control began in 2012, but the three breeding seasons that
elapsed before the start of Phase 2 most likely allowed some population recovery. If Phase 2 is considered as an independent eradication, an overall cost of c. US$ 85,000 (Table 6) may be realistic for a ca. 200 ha island supporting ca. 1000 mynas (some of the equipment procured for Phase 1 was used in Phase 2). This cost is based on the use of volunteers to undertake most of the trapping, however, and allowance for additional labour costs must be made in the absence of volunteer availability when planning future eradications.

The Frégate, Denis and North Island eradications demonstrate that eradication of mynas from small islands can be achieved without attempting to catch adults at nests or destroy clutches; these time-consuming procedures contribute little to eradication attempts (Millett et al. 2004; Canning 2011). Additionally, success on these islands has shown that the use of toxicants, which have potential adverse environmental risks and whose contribution to eradication is difficult to quantify (Feare 2010), was unnecessary. On larger islands with small human populations, toxicants might help to accelerate eradication (G. McCormack pers. comm. on Atiu, Cook Islands), but further information on non-target risks on tropical islands is needed.

The gonad cycle on North Island confirmed that breeding was concentrated during the wetter north-west monsoon, November–March, with moult during May–August. Body condition during breeding was significantly lower than during moult, possibly associated with the higher energy and nutrient demands of breeding (Norberg 1981). Nevertheless, the annual moult imposes further nutritional demands (Lindström et al. 1993) during the dryer season when invertebrate foods, representing a source of essential animal protein (Machovsky-Capuska et al. 2015), are less abundant (Hill et al. 2002). This potential limitation of dietary protein was not reflected in a reduced body condition, however, suggesting that our simple index is inadequate for indicating stressors that might impact susceptibility to trapping where food baits are used. In planning future myna eradications, commencement early in the breeding season and continuation through to moult completion might offer the optimal trapping efficiency through attraction to baited decoy traps, as both life stages involve elevated energy/nutrient demands.

On North Island, the breeding and moult periods were identified by examination of birds trapped or shot. When planning future eradications in other parts of the world where less knowledge of myna annual cycles is known, a simpler method of identifying these events could be used. The onset of the breeding season is characterised by many birds visiting potential nest cavities and the carrying of nest material; both of these are conspicuous behaviours. Following the breeding season, birds in active wing moult can be identified when flying overhead by a conspicuous gap in the trailing edge of the open wing, where an old feather has been lost and has yet to be replaced by the growth of a new feather. Where an eradication
attempt is deemed necessary, local conservation staff could be asked to report nest-building and moult prior to the planning of the eradication in order to determine the timing of these life stages.

During moult, in addition to increased energy and nutrient requirements (Lindström et al. 1993), birds experience flight impairment due to missing wing feathers and tend to reduce activity, including vocalisation, likely as a response to increased vulnerability to predation (Barta et al. 2006). This general low-profile during moult can lead to increased wariness and a reluctance to take flight (Rivera et al. 1998; observed but not quantified in mynas in Seychelles, CF and CL pers. obs.), but once a myna has been located, its reticence to move might render it easier to shoot. On this basis, commencement of an eradication with intensive trapping at the start of the breeding season, accompanied by shooting during the annual moult, might be a more efficient and economic approach than control at other times during the annual cycle.

The capture of non-target species, especially Madagascar turtle doves and common moorhens, constrained and possibly prolonged the decoy trapping programmes. Both species are common on Seychelles’ smaller rat-free islands and are likely to interfere with myna eradication attempts on similar islands in the archipelago. Although larger than mynas, these species are capable of squeezing through the entrances designed for mynas. Trials of decoy traps with entry apertures of different sizes are needed to determine whether smaller entrances could mitigate non-target catch without compromising catches of mynas.

Shooting was delayed until as late as possible due to aversion that mynas can develop to people with weapons (Fox and Madsen 1997), but we cannot predict at what stage in a myna eradication shooting should be introduced. We do not know whether “trap shyness” is inherent in some individuals in a myna population or whether aversion to trapping is a trait learned during the course of a trapping programme. Although the Frégate eradication was achieved without resort to shooting (Canning 2011), on North and Denis Islands most of the birds that failed to be caught during the trapping stage were relatively quickly shot by professional hunters with a sound knowledge of bird behaviour. Necessary authorisations should thus be sought during the earliest stages of planning an eradication. Seeking permissions from government departments and police for the import and use of firearms, including rifle, air rifle and shotgun, can be prolonged (years rather than months) and time-consuming.

Most small islands in the Seychelles archipelago are within ca. 50 km of islands that support large numbers of mynas and are thus potential sources of immigrants. We do not yet know when or how far mynas will fly over sea. All three islands from which mynas were eradicated have had single incidents of immigration. On Frégate, a group of 14 birds was discovered in August 2015 (nearest possible source 25 km); seven of these birds were
shot, one remained on the island until at least October 2016, but the other six disappeared (J. van de Crommenacker pers. comm.). On Denis Island (nearest source 52 km) a group of three birds were discovered in May 2018; all were subsequently shot. One bird found on North Island (nearest source 7 km) in June 2019 was shot. These occurrences highlight the necessity to maintain vigilance for reinvasion, and the tools and staff to facilitate immediate removal of new arrivals.

Myna eradications were undertaken primarily to benefit the conservation status of endemic taxa, especially endangered birds (see Evans 2021). These eradications have enabled existing endemic species populations to recover (Frégate) and provided suitable habitats into which endemic species can be introduced to establish insurance populations (Denis and North). In these objectives the myna eradications, all preceded by the removal of rats and cats and by on-going habitat rehabilitation/creation, have been highly successful. Frégate’s population of Seychelles magpie robins increased from its nadir in the 1960s of ca. 12 birds (then the total world population) following mammal eradications and habitat improvement. However, myna eradication (Canning 2011) led to a more rapid increase, with the island’s population reaching over 130 birds by 2015. The population of magpie robins on Frégate is now used to (re)populate other islands in Seychelles (Burt et al. 2016). On Denis, four species of endemic birds, Seychelles warbler Acrocephalus sechellensis (Oustalet, 1877), Seychelles fody Foudia sechellarum E. Newton, 1867, Seychelles magpie robin and Seychelles paradise flycatcher Terpsiphone corvina (E. Newton, 1967) were released on the island in 2004 and 2008 and populations of all have increased (Bristol and Gamatis 2017; Bristol and Accouche 2019; Doblas et al. 2015; van de Crommenacker and van Dinther 2015). Monitoring of endemic bird responses to myna removal continues on these islands.

On North Island, Seychelles white-eyes were introduced in 2007, despite the presence of mynas, and underwent a slow but steady increase up to 2014 when the population appeared to have stabilised at this level. Subsequently, a rapid population increase coincided with removal of most of the mynas (Pietersen 2017). Now that mynas have been eradicated, proposals to introduce more endemic bird species are under way, to further increase the security of Seychelles’ endemic avifauna. Following myna eradication, monitoring of the responses of endemic bird populations will provide valuable information for decision makers contemplating invasive bird eradications where these are considered to pose threats of predation and disturbance.

Having confirmed that the combination of trapping and shooting can be efficient means of eradicating mynas from small islands with few people (< 150), trials are now needed to determine the feasibility and efficiency of scaling up this approach to tackle myna populations on larger islands, and islands with more people. One successful eradication has been achieved,
over a period of c. 9 years, on 2,900-ha Atiu island (Cook Islands, south Pacific). There, ca. 26,000 mynas were killed by trapping, shooting and using a toxicant (Lieberman et al. 2018, G. McCormack pers. comm.) but Atiu has only limited human occupation. In all cases it will be essential to ensure the full support of the human population to avoid interference with traps, both by people and domestic animals. Additionally, high human density raises safety issues regarding shooting, although on Mahe, Seychelles (ca. 15,700 ha, human population ca. 90,000) ring-necked parakeets Psittacula krameri (Scopoli, 1769) were eradicated almost entirely by shooting (Bunbury et al. 2019). Limited experience suggests that other capture techniques, such as intensive mist-netting, can be more effective with some species in some circumstances (Bunbury et al. 2019). The trapping and shooting approach adopted for mynas is thus unlikely to be applicable to all other invasive bird species, and prior investigation is needed to establish the techniques most appropriate for each species and the environment that the invasive species inhabits.

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Ethics statement

The eradication of common mynas from North Island was a component of the North Island Environmental Management Plans 2011–2015 and 2016–2020 and was approved in its entirety by the Seychelles Ministry of Environment, Energy and Climate Change.

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