The use of Starlicide® in preliminary trials to control invasive common myna *Acridotheres tristis* populations on St Helena and Ascension islands, Atlantic Ocean

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SUMMARY

Introduced common mynas *Acridotheres tristis* have been implicated as a threat to native biodiversity on the oceanic islands of St Helena and Ascension (UK). A rice-based bait treated with Starlicide® was broadcast for consumption by flocks of common mynas at the government rubbish tips on the two islands during investigations of potential myna management techniques. Bait was laid on St Helena during two 3-day periods in July and August 2009, and on Ascension over one 3-day period in November 2009. As a consequence of bait ingestion, dead mynas were found, especially under night roosts and also at the main drinking area on Ascension, following baiting. On St Helena early morning counts at the tip suggested that whilst the number of mynas fell after each treatment, lower numbers were not sustained; no reduction in numbers flying to the main roost used by birds using the tip as a feeding area was detected post-treatment. On Ascension, the number of mynas that fed at the tip and using a drinking site, and the numbers counted flying into night roosts from the direction of the tip, both indicated declines of about 70% (from about 360 to 109 individuals). Most dead birds were found following the first day of bait application, with few apparently dying after baiting on days 2 and 3. Despite the low concentration of Starlicide used, aversion to the bait was apparent during the trials. These results indicate that Starlicide may contribute to myna control programmes but questions remain over the mode of action of the chemical (in terms of individual differences among birds the responses to its toxic properties) and the longer-term susceptibility of birds to baiting.

BACKGROUND

There is concern of potential negative impacts of non-native birds in some regions, even though their effects on biodiversity, agriculture and human and animal health and safety, have rarely been quantified (Pell & Tideman 1997). Endemic flora and fauna on small oceanic islands are considered particularly sensitive to alien invasive species although their effects are not always clear-cut (Blackburn *et al*. 2009). Following numerous intended and unintended introductions by man, the common myna *Acridotheres tristis* (native range centred on the Indian sub-continent) has established and thrived in some mainland areas but especially on many tropical islands. Here, competition with indigenous birds is widely believed to occur (Feare & Craig 1998, Tindall *et al.* 2007). For example in the Indian Ocean, Komdeur (1996) recorded interference with the incubation patterns of the then critically endangered Seychelles magpie robin *Copsychus sechellarum* on its sole native island of Fregate, and on Denis Island (Seychelles) where magpie robins were translocated as a conservation initiative to establish a new population, egg and nestling predation have been recorded. Also on Denis, common mynas have been similarly observed predating eggs and chicks of the recently translocated Seychelles flycatcher *Terpsiphone corvina* (a critically endangered endemic), and serious head injuries to 25% of introduced Seychelles fodies *Foudia sechellarum* are believed to be attributable to attack by mynas, recently confirmed in one individual by filming (Rachel Bristol, pers. comm.). On South Pacific islands common mynas are similarly suspected of competing with some endemic birds (Blanvillain *et al.* 2003, Parkes 2006).

Established protocols are now available for the eradication of some non-native mammals on islands, leading to many successes (Veitch & Clout 2002) but methodologies and attempts to eradicate non-native birds lag behind. Ongoing attempts are being made to eradicate common mynas in some areas. Small populations have been eradicated in the Seychelles archipelago on the islands of Aride, mainly by shooting (Millet *et al.* 2004), and from Cousine using a combination of trapping and shooting (Kevin Joliffe, pers. comm.). On the latter, restoration of indigenous forest and improved sanitation of man-modified areas appears to have made the island less attractive to mynas, and thus to reinvasion. However, attempts to eradicate larger populations on Denis and Fregate, mainly by shooting and using avicides, have not so far been successful. On some Iberian islands small populations have been removed by trapping (Saavedra 2006a,b). During concerted trapping effort in the environs of the city of Canberra (Australia) more than 30,000 common mynas have been trapped over 10 years and since 2006 the species has fallen from third to fourteenth in the ranking of common garden birds (Canberra Ornithologists' Group 2007; Martin Butterfield pers. comm.) suggesting some measure of control success. Trapping has also been shown to be effective in catching large numbers of mynas on St Helena (Feare & Saavedra 2009) and Ascension (Saavedra 2009).

However, other techniques are needed for integrated control programmes as an adjunct to trapping, which may be less successful in urban areas prone to disturbance by humans and domestic animals. Few avicides that provide reasonable levels of environmental safety and humaneness are available but one, Starlicide® is registered for restricted use by trained government staff against mynas in New Zealand and Samoa, and has been trialled experimentally in Seychelles (Millet *et al.* 2004).

Starlicide (also called DRC1339, 3-chloro-p-toluidine hydrochloride) was developed initially to kill non-native European starlings *Sturnus vulgaris* in North America (where they pose serious agricultural and public health problems, and compete for nest holes with some native species) and some North American blackbirds (Icteridae) considered agricultural pests (APHIS 2001). First registered for use in the USA in 1967, it continues to be used in attempts to reduce losses of food to starlings and icterids at cattle feedlots and to reduce the size of night-time winter roosts of these birds by baiting them in their evening pre-roost assemblies (West 1968). Its toxicity is higher for starlings, icterids, crows (Corvidae) and gulls (Laridae) than for some other avian taxa, especially raptors, thereby exhibiting a degree of specificity, and its toxicity to mammals is low (Schafer 1984, Eisemann *et al*. 2003). Further specificity in its use is possible by selecting appropriate baits for particular feeding situations that minimise attraction to non-target species, and by selecting feeding areas that attract few birds of other species.

Three particular advantages of Starlicide for control are: i) it is slow acting, taking several hours to 3 days to kill, so that target birds tend not associate illness with any particular food and thus do not develop bait aversion (DeCino *et al.* 1966); ii) the chemical is completely metabolised and thus does not present a secondary hazard (Schafer 1984); and iii) the uneaten chemical in bait is likely to break down under UV light thereby minimising the persistence of residues (Darden & Schwab 1970). Prior to death, affected birds ruffle their feathers before becoming comatose but show no apparent signs of distress, leading to a presumption of humaneness (Nelson 1994).

There are few published accounts of the use of Starlicide to control populations of invasive birds (e.g. Millet *et al.* 2004, Anon 2009, Division of Environment and Conservation 2009) but its use is being considered in some locations (Nagle 2006, Tokelau islands; Parkes 2006, Cook islands; Bentz *et al.* 2007, Australia; Nagle 2009, South Pacific). In this present study, the 3-year 'South Atlantic Invasive Species' (SAIS) project (Stringer 2009) enabled Starlicide to be investigated as a potential contributor to an integrated management approach, and possibly eradication, of common mynas on St Helena (15°57'S, 5°42'W; 122 ha) and Ascension Island (7°56'S, 14°21'W; 97 ha) in the tropical South Atlantic.

On St Helena common mynas (introduced in 1885) have been recorded predating wirebird *Charadrius sanctaehelenae* (St Helena's only surviving endemic bird) eggs and chicks (Maculloch 1991), they are held responsible for the dispersal of invasive vegetation (via seeds in droppings) and are considered a potential human health problem when nesting in house roofs and through noise disturbance close to large night roosts. On Ascension (where introduced in the 1880s) they are known to take eggs of sooty terns *Onychoprion fuscata*, which further may lead to desertion of eggs by other pairs close to sites of active predation, and might delay the re-establishment of other seabirds on the main island following feral cat *Felis catus* eradication (Hughes *et al*. 2008). They again are also held responsible for invasive plant seed dispersal and to prejudice human health.

The data on St Helena were collected during a feasibility study on myna eradication from 8 July to 8 August 2009 and on Ascension during a training visit on myna management from 13 to 24 November 2009. Both of these visits provided learning opportunities in relation to the use of Starlicide in common myna control.

ACTION

On both St Helena and Ascension common mynas are widespread but generally do not form large feeding aggregations where avicide-treated bait could be safely deployed over a small area in the expectation of achieving bait intake by a large number of mynas. However, each island has a municipal refuse tip that attracts large numbers of mynas, representing the largest feeding concentrations on these islands. On Ascension there is a second refuse tip at the US military base. During this visit (November 2009) very few mynas fed there due to a combination of a different refuse management regime (i.e. no putrescible waste at this site, frequent incineration) and an earlier trapping programme (Saavedra 2009). All references to the refuse tip on Ascension relate to the Ascension Island Government (AIG) tip. Prior observation revealed that no indigenous birds (there are no indigenous mammals) fed at the tips and thus that both appeared suitable for undertaking trials with Starlicide.

Bait preparation: The bait substrate selected was long-grained rice boiled with sugar (as a sweetener to negate the bitterness of Starlicide) and turmeric (to further mask any flavour of Starlicide). Elsewhere in their range, both natural and where introduced, common mynas are readily attracted to boiled rice (pers. obs.) and the small grains provide an ideal substrate for an avicides as they are eaten in situ, unlike larger bait materials, like pieces of bread (Millet et al. 2004), which mynas can carry away and eat elsewhere, sometimes scattering the toxic bait in the process. Mynas in the present study showed no hesitation in taking the rice presented, suggesting that the additives had no adverse effect on palatability to them.

Rice for pre-baiting (rice without Starlicide distributed for three days to accustom mynas to the new food source) was prepared by boiling approximately 1.6 kg in approximately 9 l of water to which six teaspoons of sugar and two teaspoons of turmeric were added. The rice was boiled until the outer part of the grain was soft and swollen but the interior still slightly firm. After cooking, the rice was drained in a colander and flushed with cold water to remove excess starch. Ten ml of vegetable oil were added per 3 kg of cooked rice and stirred in or mixed by rolling in a plastic bag.

In 400 ml of warm water, 3 g of Starlicide were dissolved and added to the 3 kg of cooked rice (to produce a concentration of 0.1%). This low concentration was chosen to prolong time to death and thereby minimise risk of bait aversion (DeCino *et al*. 1966). The rice was then thoroughly stirred (St Helena) or rolled (Ascension) to ensure thorough mixing of the rice and Starlicide solution.

Bait was prepared the evening before use and allowed to air-dry overnight, before being re-stirred and broadcast at the tips early the following morning. This timing is important as toxicity is considered greatest in the morning (Schwab 1968), possibly related to the birds ingesting treated bait on an empty stomach soon after leaving the roost (Glahn 1981).

Bait distribution: Starlicide treated bait was distributed in two 3-day trials on St Helena (22-24 July and 1-3 August 2009) and in one 3-day trial (20-22 November 2009) on Ascension. Bait was broadcast by hand such that it was scattered widely over the ground close to recently tipped rubbish and over the rubbish itself in order to avoid concentrations of rice that could be monopolised by dominant birds, thereby aiming to achieve bait uptake by the maximum number of mynas possible. Broadcasting precludes the subsequent collection of uneaten bait but at the St Helena and Ascension refuse tips this was considered unimportant because on most days the rice dried quickly, becoming less attractive to would-be consumers, and Starlicide is rapidly inactivated by UV light (EPA 1995). About an hour after distributing the pre-bait and treated bait, the tips were re-visited in order to check that the rice was being eaten by mynas.

Pre- and post-trial monitoring: On each morning visit to the tips during pre-baiting, baiting with Starlicide and for a few days following avicide treatment, the number of mynas at the sites were estimated (Fig. 1 for dates on St Helena, 17 to 23 November 2009 on Ascension). Birds were put to flight by sounding the vehicle horn (St Helena) or walking slowly along the edge of the tip (Ascension). The number of birds in flight was estimated as they flew away from the site, mostly to nearby loafing areas where numbers could also be counted. Following the use of Starlicide-treated bait, it became apparent that numbers at the tip later in the day were sometimes higher than during the morning counts. Some counts were therefore made later to assess the extent of this variation.

In order to discover where mynas that fed at the rubbish tips roosted at night, birds that departed from the tips in the evening were followed. On Ascension directions of morning arrival at the tip were also monitored. On St Helena this revealed four roost sites in use during the trials and on Ascension birds that fed at the tip were traced to three roost sites. One of the St Helena roosts was amenable to counting as the birds arrived from the direction of the tip. This roost was used to monitor the effects of the Starlicide trials by counting arriving birds before and after the chemical was deployed. On Ascension birds were counted arriving at and leaving all three roosts pre- and post-treatment. In addition, birds at the Ascension tip commuted throughout the day to pools of water beneath leaking water tanks, 1.3 km from the tip, and this site was visited during the day in order to estimate numbers.

Searches of roost sites for dead mynas: Where possible, roost sites used by mynas from each tip were searched for dead birds following avicide treatment at the tips and dead birds were counted. On St Helena birds were collected from one roost (but not the main roost used, in Sane Valley, which was inaccessible) and on Ascension birds from all three roosts were collected for internal examination for diagnostic signs of Starlicide toxicosis, involving white deposits of uric acid in the pericardium and on the heart (DeCino *et al*. 1966).

CONSEQUENCES

St Helena: During the first trial non-native feral pigeons *Columba livia* competed with mynas for the pre-bait, and in response during the broadcasting of treated bait additional untreated bait was deployed in clumps in an attempt to divert the pigeons from the treated bait, with some success (most pigeons observed feeding on the unbaited rice clumps). Nevertheless, about 20 pigeons were found dead at the tip site; carcasses were collected and disposed of. The same diversion tactics were used throughout the second trial. In both trials all pre-bait was eaten within 2 h of broadcasting, mainly by mynas after the diversion tactics were introduced.

During the first trial, the daily checks undertaken about 1 h after broadcasting Starlicide treated bait showed that all was consumed each day apart from the last, when all treated bait had been eaten from the ground but much of that spread on the bags of rubbish during broadcasting was uneaten. During the second trial, all rice was consumed on the first day of broadcasting treated bait. On the second day some treated bait remained uneaten at the time of the check, while on the third day approximately 30% of the bait remained and further checks during the day showed that it remained uneaten.

Early morning (pre-09:00 h) counts of mynas at Longwood rubbish tip (Fig. 1) displayed considerable variation, ranging from around 20-210 individuals. The counts suggest some reduction in myna numbers following the use of Starlicide in the two trials. However, within five days of the conclusion of the first presentation of Starlicide the number of mynas recorded in early morning counts recovered to levels seen prior to the trial. In addition, periodic counts later in the day revealed that early morning counts did not always reflect the number of birds that could appear at the tip. For example, a count at 10:00 h on 28 July produced 230 mynas, counts at 09:50 and 14:30 on 30 July revealed 220 and 210 birds respectively and a count at 13:00 h on 6 August revealed 100 mynas; all of these counts were higher than early morning counts on the same or adjacent days.

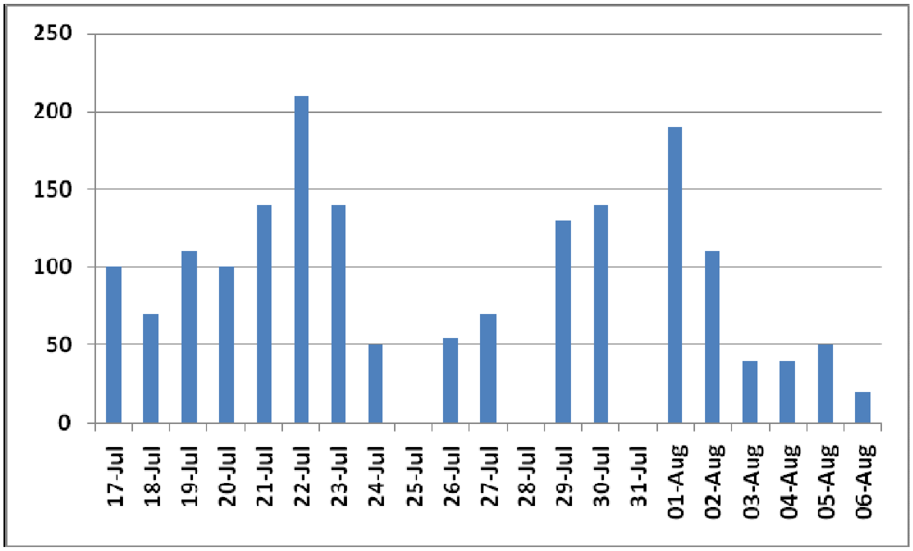

Figure 1. Number of common mynas estimated in early morning counts at Longwood rubbish tip, St Helena, 17 July to 6 August 2009. Starlicide treated bait laid on the mornings of 22, 23 and 24 July, and 1, 2 and 3 August 2009. No counts were made on 25, 28 and 31 July.

Four night roost sites were used by mynas that fed at the tip. By far the majority went to Sane Valley, a large roost 3.1 km west-south-west of the tip. A few went to roost at sites in Mulberry Gut (2.25 km west of the tip), Fishers Valley (1.25 km south) and in Deadwood Valley (3.1 km west; only discovered during the second trial). Six counts were made of mynas entering the Sane Valley roost from the direction of the tip over the 21 day period of study. These revealed 727 - 857 birds on each count but no reduction was detected following either Starlicide application. The other three roosts were comparatively small; Fishers Valley roost was not counted but single counts at Mulberry Gut (26 July) and Deadwood (3 August) produced counts of around 200 and 350 mynas respectively, though few birds entered the Deadwood Valley roost from the direction of the tip. At these three roosts estimates were not obtained before and after Starlicide use.

In a study undertaken by DeCino *et al*. (1966), most dead birds were found under night roosts following Starlicide baiting. The Sane Valley roost was at the bottom of a steep-sided valley carpeted with impenetrable vegetation (dominated by prickly pear *Opuntia*) and could not be accessed during this study to retrieve any carcases. The other three roost sites were not inspected daily following each bait application, but during the first trial 21 dead mynas were found at the Fishers Valley roost and 10 at the Mulberry Gut roost. Following the second trial fewer dead birds were found: four in Fishers Valley; five in Mulberry Gut; and one in Deadwood Valley. Searches in the vicinity of the tip and reports by local people produced another 19 dead birds. Of 16 dead birds aged, 15 were adults and one was immature. Thirteen adults had completed primary moult and the other two had not yet commenced moult, while the immature was in late moult.

Ascension: No birds other than mynas were seen at or near the rubbish tip during treatment but feral sheep visited the tip area most early mornings but moved off during bait-laying and were not seen at the tip later each day. Checks 1-2 h after broadcasting pre-bait showed that all was taken. All treated bait was taken on the first morning, an estimated 80% on the second and less than 50% on the third morning.

On the days before Starlicide treated bait was broadcast, visits to the tip revealed constant daytime commuting of mynas to a source of abundant water at some leaking water tanks at Cross Hill, 1.3 km from the tip. Counts of birds were thus made at the tip and Cross Hill since they comprised the same population, and repeat counts would allow better estimates of numbers. From 16 to 20 November, before mynas had access to treated bait, the average number of birds at the tip averaged 234 (range 110-300, n = 10 counts) while the number at the water source averaged 122 (range 100-150, n = 5).

Table 1. The number of common mynas found dead in the vicinity of communal night roosts and at their water source following broadcasting of Starlicide-treated bait at the Ascension Island Government refuse tip on the mornings of 20, 21 and 22 November 2009.

Site	**21 November**	**22 November**	**23 November**	**24 November**
Garden Club roost	37	0	0	1
Two Boats roost	15	1	1	0
US Base roost	20	0	0	0
Cross Hill water tanks	13	11	8	5
Total	85	12	9	6

During the three days of treatment with Starlicide, numbers at the tip averaged 166 (range 140-190, n = 9) and at the water source averaged 8 (range 0-20, n = 7). Following treatment, on 23-24 November, numbers at the tip averaged 108 (range 80-140) and at the water source averaged 1 (range 0-2, n = 5). Numbers at the tip thus declined by more than 50% but following the deployment of treated bait on the morning of 20 November the number of birds recorded at the drinking site dropped almost instantaneously and regular commuting between the sites ceased. Combining the averages at these sites, the total population declined by about 70% (from 360 to 109).

During the trial, counts were made of birds leaving roosts in the direction of the tip in the morning (Garden Club roost, 1.8 km E of the tip) or arriving from the direction of the tip in the evening (Two Boats, 2.4 km east and US Base roosts, 2.3 km south-west). At the Garden Club roost, counts were: 20 November (before treatment) - 194; 21 November - 102; 22 November - 32; and 24 November - 18. Before and after treatment counts at Two Boats were 91(17 November) and 67 (23 November) birds, while similar counts at the US Base were 131 (18 November) and 49 (22 November). Following Starlicide treatment declines in numbers were thus apparent in all three roosts, the overall decline being about 70 %.

During and after Starlicide use 114 dead mynas were found, 112 in the three roosts and at the water tanks, at a further two close to the tip. A sample of birds from each site examined internally all showed classic symptoms of Starlicide toxicosis on the heart and pericardium. Daily counts of dead birds at the four sites (Table 1) show that most died following the first day of treatment on 20 November (85 carcasses located on 21 November), with few (12, 9 and 6) thereafter. The first fatalities at the water tanks were found on the morning of 21 November, indicating that these birds must have died on the first day of the treatment, i.e. within 12 hours of consuming treated bait, or had failed to go to the communal roosts and had died overnight at the water tanks. However, despite the large fall in numbers that visited the water tanks following the initial use of treated bait, small numbers of mynas continued to die at the water source over the following days.

Of the 114 dead mynas retrieved, 99 were adult and 13 immature, based on the presence or absence respectively of a dark mark on the base of the lower mandible (Feare & Saavedra 2009). Eighty-five were examined for primary moult: of 76 adults, 65 (85%) had recently completed moult and most others were near completion, and of nine immatures two (22%) had completed moult while the remainder were about half way through.

Discussion: The trials investigated the potential of Starlicide as a component of integrated management aimed at eradication of common mynas and must be viewed as “learning opportunities” during the course of more extensive investigations of control possibilities, rather than controlled experiments on the efficacy of Starlicide as an avicide. The habitats for mynas on the two islands differ. St Helena (122 km^2) has extensive vegetated areas, including agricultural land, fruit trees, forest and bush containing abundant fruiting shrubs, along with a large municipal rubbish tip that is poorly managed, providing much food for mynas. Ascension (97 km^2) is warmer and more arid, less well vegetated, and mynas are similarly attracted in large numbers to the municipal rubbish tip (Ashmole & Ashmole 2000). St Helena supports a larger myna population (estimated during visits in 2009 as 5,000-10,000) than Ascension (1,000-1,500 birds). The Ascension population was estimated at 800 individuals in 2006 (John Hughes, pers. comm.) but during late September-early December 2009 more than 600 mynas were trapped (Saavedra 2009) and a minimum of 114 killed using Starlicide. Despite the removal of these birds, many remained at a roost and were feeding in gardens and forest on Green Mountain. Mynas were also widespread in more vegetated parts in the east of the island and some continued to feed at the rubbish tip and to roost at the three roost sites monitored during this study, indicating that the starting population must have increased since Hughes' estimate.

On both islands the number of mynas killed by Starlicide was unknown. Birds that died in night roosts were easy to locate and count, as long as roosts sites were accessible and had sparse understorey vegetation cover. Any that died elsewhere, especially away from human habitation, were unlikely to be located. The number found dead in the trials was thus likely to be a gross underestimate of the total number killed and this unknown element makes difficult the assessment of the efficacy of Starlicide in contributing to myna population reduction, although some indications of declines were apparent from counts at some localities.

On St Helena, counts of mynas at the rubbish tip suggested a reduction in numbers post-treatment, temporary (about 7 days) following the first trial but the persistence following the second trial was unknown as this trial was undertaken late in the study period and so censuses are lacking. However, variation in numbers at the tip over the day might indicate movement by birds that feed elsewhere for part of the day; this could only be elucidated by a mark-resighting study. No reduction in numbers arriving at the main roost (in Sane Valley) was detected but the large numbers of birds that roosted here greatly exceeded the number counted at the tip, indicating that the roost received birds from a wider area. Numbers were not monitored pre- and post-treatment at the other three roosts where several dead birds were also found.

On Ascension, with its smaller size and myna population, and with experience gained in St Helena, a more targeted approach was taken (i.e. more emphasis was placed on regular pre- and post-counts at roosts). Here, Starlicide application at the refuse tip led to a decrease in numbers feeding there and a decrease in numbers using associated roosts, both suggesting a significant decline in numbers of around 70%. An alternative explanation could be that reduced numbers feeding at the tip resulted from bait aversion, possibly leading to site aversion (as seen during trials on Samoa; Anon 2009). Bait aversion was certainly evident at the tip on the third day of the trial (large quantity of uneaten bait) and some bait was also left uneaten on the second day. However, although it was not possible to monitor all feeding sites, there was no concurrent increase in numbers foraging at the US Base tip or in the main town, Georgetown, where small numbers forage.

The pattern of deaths observed in the roosts was unexpected. Most birds died within 24 h of ingestion of Starlicide and some appeared to have died even more quickly at the water tanks. In roosts, most birds died after the first exposure to Starlicide-treated bait, with very few freshly dead birds discovered thereafter, whereas birds were found dead daily at the water tanks and some of the few living birds there were clearly unwell. One of the main attributes of Starlicide is claimed to be its slow action (i.e. up to three days; DeCino *et al.* 1966) but in this case its action appeared rapid, at least on the first day, and this may have contributed to the observed bait aversion. The almost complete cessation of visits to the drinking area following the first application of Starlicide was dramatic. Early symptoms of intoxication involve an increase in water intake followed by a sharp drop in intake (Nelson 1994). On this basis we might have predicted that each day's broadcast of treated bait should have been followed by a surge in drinking activity. This did not happen, raising the possibility that the onset of illness following the first day's treatment could have occurred while affected birds were drinking, promoting an aversion to the drinking site. This could have been reinforced by the absence of large numbers there on subsequent days, accompanied by the presence there of a small number of birds most of which were moribund and behaving abnormally.

Among bird families toxicity is variable (Eisemann *et al.* 2003) but toxicity tests are usually undertaken on a small sample of individuals. The lack of deaths in roosts following the second and third exposures to treated bait (Table 1), despite the observed consumption of bait, raises questions about the mode of action of the chemical. Is there wide within-species variation in toxicity, allowing more susceptible individuals to succumb following their first consumption of Starlicide but leaving others to survive the low dose used in this study? Was the dose used (0.1%) too low, leading to sub-lethal exposure of many birds? Despite the wide broadcasting of the pre-bait and treated bait, did within flock competition lead subordinate birds to fail to consume a lethal dose? The small proportion of juveniles among the killed birds could be an indication of such competition.

On both islands mynas that fed at the tips appeared to roost within about 3 km of the feeding site and on Ascension there was no evidence that birds from a large roost near the summit of Green Mountain (4.3 km away) came to feed at the tip during this study. On both islands, some birds flying to or from their night roosts flew directly over other roosts that were closer to the feeding site, indicating an unexpected complexity in myna roosting behaviour. Unlike their European starling relatives (Feare 1984) and common mynas on some other islands (Feare & Craig 1998, Millet *et al.* 2004), on St Helena and Ascension mynas did not form feeding assemblies close to the roost site before entering in the evening. Instead, they arrived directly from the feeding areas, usually in twos, threes or fours, suggesting pairs or family parties (Feare & Saavedra 2009). This absence of feeding assemblies precludes the possibility of using Starlicide to bait close to roosts, as is frequently done in North America with starlings and blackbirds. In any future studies on these islands (and on others that have no indigenous birds), however, it would be worth investigating whether arriving birds could be attracted to feeding stations at which they could be baited.

Conclusions: Starlicide may play a useful role in myna control but its use is limited to places where large numbers of mynas feed, and on some islands may be further limited by the presence of potentially susceptible endemic or indigenous species. However, this study has revealed effects on mynas that are sometimes difficult to interpret. Aversion to treated Starlicide bait, and possibly also aversion to the bait site, observed in this study, along with an apparent failure to kill mynas after their first exposure to treated bait, suggests that following pre-baiting, treated bait should only be deployed on one morning; this would have minor impact on mortality in the short-term but might avoid bait and site aversion, thereby avoiding possible compromise of effectiveness of subsequent baiting programmes. The risk of bait aversion might also be reduced by presenting Starlicide on a range of bait substrates, as done by Millet *et al.* (2004), although the effectiveness of this tactic was not quantified in their study. More studies are needed to investigate the mode of action and its effects at the individual level, and on population behaviour and dynamics.

On these two islands it is clear that Starlicide use must be integrated with other control techniques, of which trapping is demonstrably effective for mynas (Feare & Saavedra 2009, Saavedra 2009). With commensal birds like mynas, however, improvement of urban hygiene and of refuse tip management could deprive mynas of a significant proportion of their food. In particular, on islands with small human populations like St Helena and Ascension, the use of animal-proof containers for day-to-day dumping and storage of refuse prior to incineration would reduce food availability to mynas, and also to rodents and feral mammals (i.e. sheep and donkeys) which are present. The use of such containers would involve extra care, and possibly some additional time, in refuse disposal, but it would reduce the amount of land required for refuse disposal and have the added benefit of restricting the dispersal of lightweight materials in windy conditions that prevail on these islands.

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