Pacific Invasives Initiative

Review of the Biology and Ecology of the Common Myna (*Acridotheres tristis*) and some implications for management of this invasive species

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Contents

(Image courtesy of Dick Watling, NatureFiji-MareqetiViti)

Summary

Project

- Both jungle myna (*Acridotheres fuscus*) and common myna (*Acridotheres tristis*) are spreading throughout Pacific Island Countries and Territories. Despite anecdotal reports of negative effects of mynas on biodiversity and livelihoods throughout the Pacific, few studies have been completed.
- Knowledge of myna biology and ecology is essential for successful management of these invasive species.
- Little is known of the jungle myna (*A. fuscus*) in non-native habitats.
- This review of the biology and ecology of the Indian or common myna (*A. tristis*) was undertaken by PII to determine potential impacts and investigate possibilities for successful management of this invasive bird.
- The review was funded by Manaaki Whenua Landcare Research New Zealand in February, 2009.

Objectives

- To review the international literature on the availability and quality of information on the biology and ecology of common myna and interpret it in the context of available information (primarily from New Zealand).
- To make management recommendations based on the potential negative effects of common mynas.
- To disseminate this information to practitioners in Pacific Island Countries and Territories to provide a baseline for myna management work in the Pacific.

Methods

- Information was obtained by: searching computer databases (CAB abstracts, Current Contents, OVID databases, Biological Abstracts, Science Citation Index) for relevant scientific papers, and technical reports; checking internet sites; cross-referencing; and contact with and querying of researchers involved in management or study of mynas or other pest birds.

Results

- Biology: Biological information about common myna would play a determinant role in its sustained control as this communal and commensal bird has adapted to greatly differing conditions in many countries. Direct application of overseas information to Pacific Island Countries and Territories may not be useful and local studies need to be conducted regarding the important biological aspects of the life of common mynas before undertaking control in any country.
- Ecology and Impact: Few studies that rigorously establish the negative effects of common mynas on native fauna are available. Nevertheless, information from local and overseas incidents of aggression and competition by mynas on native fauna and flora, especially birds, suggests it may be prudent to protect native birds from these effects.
  However, the importance of individual causes of impact, such as competition, predation and aggression, in instigating maximum damage on native fauna is still to be investigated. This would be essential to any management plan to eradicate or control mynas.

Conclusions

- Based on the biology and impact information of common mynas, it can be concluded that mynas are aggressive birds and appear to have unfavourable impacts on native fauna and flora. However, further studies are needed to quantify these impacts.

Recommendations

- Mynas could possibly be eradicated from small offshore islands.
- Mynas should be controlled in important centres of biodiversity such as mainland islands or nature reserves.
- Low threshold population level must be maintained longterm, so that minimal impact is exerted by mynas on native fauna.
- Stringent monitoring and surveillance must be applied and the outcomes fed back into the management protocol.
- Prioritisation of high importance sites such as mainland islands and biodiversity hotspots must be conducted to concentrate efforts where they will have the most effect.
- A combination of techniques would be advised for control of mynas in each conservation scenario.
- Short-term and long-term research targeting the questions highlighted in the last section of this review should be undertaken.

Common myna (*Acridotheres tristis*) damage to pawpaw (*Carica papaya*),
Mangaia, Cook Islands. (Photo: Bill Nagle)

1. Introduction

The Indian, or common, myna, *Acridotheres tristis* (Sturnidae: Passeriformes: Aves) was introduced throughout New Zealand in the 1870's by locals and Acclimatisation Societies (Bull *et al*., 1985). Birds subsequently established in most of the North Island, with high densities present in the urban and suburban areas. Common mynas continue to flourish in the northern and central North Island, and are usually more abundant than most native birds in gardens and parks (LCR, 2008).

Information on establishment and dispersal in Pacific Island Countries and Territories is less clear, as are dates of introduction. Myna eradication projects in Tokelau (Nagle, 2006) and the Cook Islands (Parkes, 2006) supported by the Pacific Invasives Initiative (PII - http://www.issg.org/cii/PII/) have shown how little is known about the management of these invasive species.

Common mynas are 25 cm in length, medium sized but heavily built with predominantly brown plumage. The head and breast are glossy black and the undertail coverts and tip of the tail are white (Feare *et al*., 1999). The bill, legs and feet and a bare patch of skin around the eyes is yellow (Feare *et al*., 1999). Common mynas are aggressive and said to be highly competitive. Less information is available for the jungle myna which is often mistaken for common myna. Watling (1975) concluded that the two species fill different places in habitats modified by man but share a wide ecological overlap.

Common myna (*Acridotheres tristis*).

Jungle myna (*Acridotheres fuscus*) a smaller (about 75%) and more secretive bird than the common myna. Little is known of the jungle myna.
(Images courtesy of Dick Watling, NatureFiji-MareqetiViti)

Mynas are communal and commensal, are highly vocal throughout the year and are therefore considered a public nuisance around human habitations. They also pose some human health risk as they carry bird mites such as *Ornithonyssus bursa* and *Dermanyssus gallinae* that may infect humans. They can also cause dermatitis, asthma, severe irritation and rashes. Their droppings can also cause Psittacosis, Ornithosis, Salmonellosis and spread arboviruses (Pers. comm. Bill Handke)

2. Objectives and Scope

The aim of this literature review is to gather information on the biology and ecology of the common myna (*Acridotheres tristis*) and recommend management strategies based on that information. Management options are also briefly reviewed and research recommendations made. It does not experimentally test any of the proposed management strategies and cannot determine the suitability of information for Pacific Island Countries and Territories beyond generalisations.

It is not an exhaustive review of the biology of the common myna (see Feare *et al.*, 1999) instead some aspects of the biology are interpreted for their management implications. It is not an exhaustive review of the ecology of the common myna and only relevant aspects of the ecology of the myna are discussed.

3. Methods

Information was obtained by: searching computer databases (CAB abstracts, Current Contents, OVID databases, Biological Abstracts, Science Citation Index) for relevant scientific papers, and technical reports; checking Internet sites of research organisations; cross-referencing; and contact with and querying of international bird researchers and pest managers. Useful and context related information was also found in University theses submitted for postgraduate qualifications.
Information was gathered on:

- Biology of common myna,
- Ecology of common myna,
- Techniques for the management of common myna populations.

Information was also received from the following specialists:

- Bill Simmons, Animal Control Products Ltd, Wanganui, New Zealand.
- Bill Handke, Canberra Indian Myna Action Group, Australia.
- Graeme Taylor, Banding and Wildlife Health, DoC, New Zealand.
- Maj De Poorter, Forest and Bird, New Zealand.
- Kate Grarock, The Australian National University, Canberra, New Zealand.

4. Biology of Common Myna, *Acridotheres tristis*

This section summarises the information on some aspects of the biology of common myna, *Acriodotheres tristis* in a tabular form (Table 1). Interpretation and relevance of this knowledge for management or management implications of the same are also provided. Most information has been collated from studies in New Zealand. If not, then the source is mentioned. A discussion on the applicability of non-New Zealand based data is also provided at the end of this section.

Table 1 Summary of biology and behaviour of common mynas, brief interpretation and management implications.

S.no	Biology	Interpretation	Management Implications
1	Medium sized bird, 25 cm and has size overlap with a number of native birds such as tuis, saddlebacks, stitchbirds.	Similar size would mean similar space requirements for nesting. Also, may cause greater competition for space to smaller birds such as silvereyes and robins. Nesting holes for endangered species such as saddlebacks can be utilized by mynas thereby limiting their use by saddlebacks (Lovegrove, 1986).	Impacts on similar sized birds would require stringent monitoring while any control of mynas is undertaken.
2	Sexual dimorphism is negligible.	Morphometric characters for have been described by Counsilman *et al.* (1994) on the mynas in Singapore. However, in New Zealand, Wilson (1973) found that only when males and females are both measured with respect to each other, can they be sexed successfully.	Sexing in the field may not be feasible. During shooting, if a pair is sighted, one of the members should at least be shot to break the pair. All culled birds (irrespective of the method), must be collected for population analysis. Measurements of hard body parts such as beak, tarsus, culmen etc., should be recorded for individual birds and birds must be sexed accordingly. See Wilson 1973 and Counsilman 1974a for details on morphometric measurements of common myna populations in New Zealand.
3	Beak gape (0.9 cm) (Clout and Hay, 1989)	Similar to gape size of Tui, Saddleback, Stitchbird and Bellbird, therefore restricted to similar sized food (seeds and insects). Very small for most native fruits and therefore regarded as a minor frugivore in a native forest (Clout and Hay, 1989). Maybe a disperser of small seeded weeds, e.g. nightshade (Wilson, 1965). In the Hawaiian islands, seed dispersal by common mynas lead to a	Bait in traps or poisoned baits must be small enough to allow the myna to eat it in one attempt to increase palatability. At forest edges where mynas may be prevalent, it would be useful to control it, as it may increase spreading of weeds into the interior of the forest.

S.no	Biology	Interpretation	Management Implications
		catastrophic increase in the populations of *Lantana camara* to weed proportions (Lever and Gillmor, 1987).	
4	Common myna is an opportunistic omnivore (Counsilman, 1974b).	Feeds on plant parts such as fruits, berries, seeds as well as insects, and other invertebrates. It makes use of whatever food source is available including skinks, and other small vertebrates such as chicks of other birds (Counsilman, 1974b).	Its opportunistic feeding can be manipulated to develop toxic baits that common myna will select for, as opposed to native birds that would choose not to. Common mynas, especially around the urban areas are very prone to feeding on bread crumbs (Counsilman, 1974b).
5	Egg-laying Nov- Feb (Wilson 1973). First clutches are heavier, larger eggs and more successful. Older females produce large clutches. Post fledging mortality is highest in early season (Wilson 1973).	Older females are better used to predict seasonal availability and local conditions. Also are larger and healthier than young females.	It is therefore useful to selectively cull older females if shooting/trap selectivity options are available. Older females or older established populations must be targeted first if choice needs to be made and history of the populations is known (e.g., in urban areas). Also, targeting earlier in the season may be beneficial before production of the first clutch of the season. Careful monitoring of the population for at least one breeding season prior to the control program must be done to identify productive females. This could be coupled with a pre-feeding program if planning a poisoning control operation.
6	Three species of cestodes namely, *Hymenolepis farciminosa*, *H. magna*, and *Choanotaenia acridotheresi* are found to parasitise the common myna in India (Saxena, 1971).	Parasites in common myna populations in New Zealand are unknown.	It may be useful to conduct survey of parasites in local common myna populations. It may also shed light on any disease or other health issues that mynas may spread to native birds. It may also enable identification of any highly specific parasites that may lead to novel biocontrol options.
7	Common mynas are important carriers of	Introduction of avian malaria and avian pox into Hawaii are classic	The further spread of mynas into native forests should be limited before their disease carrying capacity and

S.no	Biology	Interpretation	Management Implications
	hematozoan blood parasites namely, *Plasmodium* and *Haemoproteus* (Ishtiaq *et al*., 2007) (source India) and there is some evidence of this disease being carried into New Zealand by introduced mynas (Ishtiaq *et al*., 2006). However the sample size (n=41) was low for any conclusions to be drawn.	examples of bird extinctions due to introduced diseases (Atkinson *et al*., 1995). Mynas may have also introduced some avian diseases into New Zealand to which the native birds may be susceptible. Further studies need to be done to ascertain this.	potential role in spreading disease is understood.
8	Four species of pthirapterans (lice) are known from common mynas in India (Saxena *et al*., 2007). However their role in the regulation of myna population is unknown.	No data is available on the pthirapteran fauna of mynas introduced into New Zealand. This should be incorporated into disease-based studies required for local common myna populations.	
Sno.	Behavior		
9	Anti-predator vigilance: Mynas show high levels of anti-predator vigilance, at least in a resource rich urban environment (Newey, 2007).	Repeated culling in the same site may make mynas wary of workers, especially shooters.	Shooting must not be continuously used as the main method. It should be alternated with other methods of control.
10	Search image	These birds are adapted to	Some species of N.Z. native

S.no	Biology	Interpretation	Management Implications
	development is very rapid, especially of readily available insect prey species (Wilson, 1965).	insect outbreaks, leading to large quantity intakes of such insect species (Wilson, 1965). Even such large intakes however, may sometimes not form a large proportion of the diet (Tindall, 1996). For example, a few hundred cicadas may be found inside the gut of one bird, however this may form only a small proportion of the diet (Wilson, 1965). Chicks are however fed a diet of invertebrates. *Amphisalta* sp., native cicada, formed 90% of diet of young myna chicks in the summer of 1970 (Counsilman, 1971, 1974a).	invertebrates such as cicadas and stick insects, with seasonally abundant populations are therefore at risk from common mynas. It may therefore be important to control mynas in areas with endemic or protected invertebrate species that are locally or seasonally abundant.
11	Form enormous communal roosts, with up to 400 birds present at one time at a particular roost (Counsilman, 1974b).	Majority of the movement of the birds into and out of the roost happens within 45 minutes from dawn or dusk. Therefore, the largest number of birds present at any time at the roost would be about 45 minutes post dusk (Counsilman, 1974b; Greig-Smith, 1982) (Silhouette Is., Seychelles)	Mist-netting if used for control, should be conducted at least 45 min post dusk. For bird counting to estimate population size at a particular roost also, 45 minutes post dusk is advisable.
12	Common myna is a secondary cavity nester in its native range (Bhattacharyya, 1990; Dhanda and Dhindsa, 1996), but primarily a hole nester in New Zealand (Wilson, 1973). Population of	Common mynas may provide competition to native hole-nesting birds for nesting sites and may use up nest boxes established for protected birds. In a study in Canberra, mynas occupied 54% of nest boxes erected in a Nature Park, while only taking up 27% of natural hollows (Pell and Tidemann,	Nest boxes may be ideal for noose traps. It warrants the control of mynas in bird conservation areas, especially where nest boxes have been put up. Opportunistic common mynas may not only displace native birds by taking up the nest boxes, but will also have a better breeding success, hence further increase their population.

S.no	Biology	Interpretation	Management Implications
	mynas doubled in four seasons at near ideal conditions with the presence of nest boxes (Wilson, 1973).	1997a). It will make use of available nest boxes and has a better overall breeding success in nest boxes (Dhanda and Dhindsa, 1996) (Study Source: India).	
13	Mynas outcompete starlings in favourable conditions (Wilson, 1973).	Mynas survive better than starlings and reduced the reproductive success of starlings breeding nearby from 51% to 8% (Wilson 1973).	If mynas and starlings are both present, this is to be considered before controlling either of the two. Preferably multiple species control must be undertaken and interspecific interactions carefully monitored.

4.1 Applicability of Biology data

Common myna is native to the Indian subcontinent and a volume of research is conducted in its native range. In the above table, most of the data collated has been sourced from New Zealand based studies to increase its applicability to the context of this report. However, some data are available only from its native range from or other introduced ranges.

Telecky (1989) conducted a comparison of the breeding biology of common mynas introduced to Hawaii and New Zealand (using Wilson's data) to the resident populations in India. In New Zealand, temperature was found to have an effect on the timing and length of the breeding period, as opposed to rainfall in India (Wilson, 1973). Consequently, the clutch initiation period was 6 months in New Zealand, much longer than the usual 3 months in India (Bengal and Vellore) (Telecky, 1989). Egg weight was lower in New Zealand as well as Hawaii in contrast to that in the native range (Telecky, 1989). This finding is supported by the clutch size and egg weights of eight other introduced passerines in New Zealand (Cassey *et al*., 2005). However, hatching success was also lower in the introduced areas (Telecky, 1989).

This reflects the adaptability of common mynas to their novel surroundings, as New Zealand's relatively stable seasonality provides them with a longer breeding period, although with lower hatching success, due to the cooler temperatures overall. By producing more number of clutches containing smaller eggs over a longer period, common mynas strive to increase their reproductive success.

This also suggests the relatively lower direct applicability of native range life history data in areas outside the native range. Therefore, in order to be able to manage them, pilot studies looking at different life history aspects of common mynas in their introduced range is of utmost importance. If overseas information is used, it should be applied cautiously.

5. Ecology of Common Myna, *Acridotheres tristis*

5.1 Introduction, Distribution and Spread

Common mynas are native to the Indian subcontinent and surrounding regions. They have been introduced to a large number of countries and it now occurs on all continents except Antarctica and South America (Peacock *et al*., 2007). Figure 1 provides the world distribution of common mynas. Most of this section is compiled from New Zealand information as little published information from elsewhere is available.

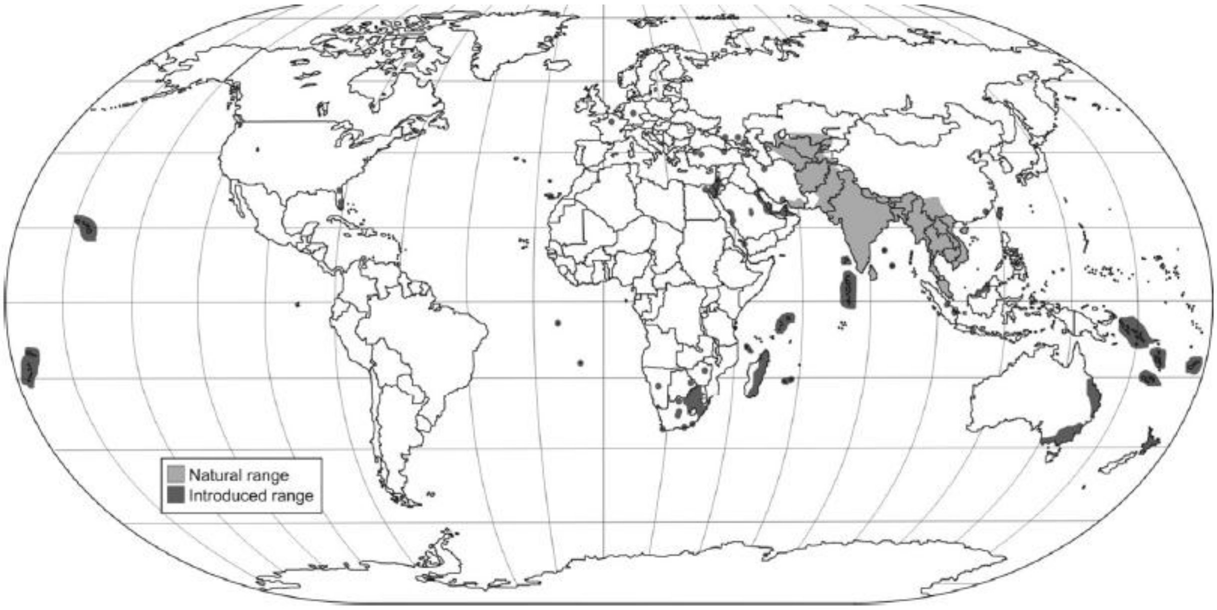

Figure 1: World map showing the distribution of common myna *Acridotheres tristis*. Light grey shaded areas represent the natural range and dark grey shaded areas represent the introduced range. (Source: Peacock *et al*., 2007).

5.1.1 Introduction of mynas to New Zealand and their current distribution

Common mynas were introduced into New Zealand from a stock of birds from India that had naturalised in Australia, by private individuals and a few acclimatisation societies in the early 1870's (Cunningham, 1948). Mynas were liberated at "all centres" including major cities and towns in the South Island, where they eventually disappeared (Cunningham, 1948).

5.1.2 Dynamics of the current distribution of common myna in New Zealand

The common myna, unlike some other introduced birds, continues to show a reduced distribution, especially from the southern end of North Island (Robertson *et al*., 2007). Previously it was common throughout Wairarapa, Wellington and Volcanic Plateau areas, but its population has diminished. Expansion is evident on the East Coast at Poverty Bay, and through to the Bay of Islands (Robertson *et al*., 2007). Wilson (1973) provides some reasons for it being related to changing farming practices, but other reasons are less apparent. This species has not recently been recorded from the South Island (Bull *et al*., 1985; Cunningham, 1948; Robertson *et al*., 2007).

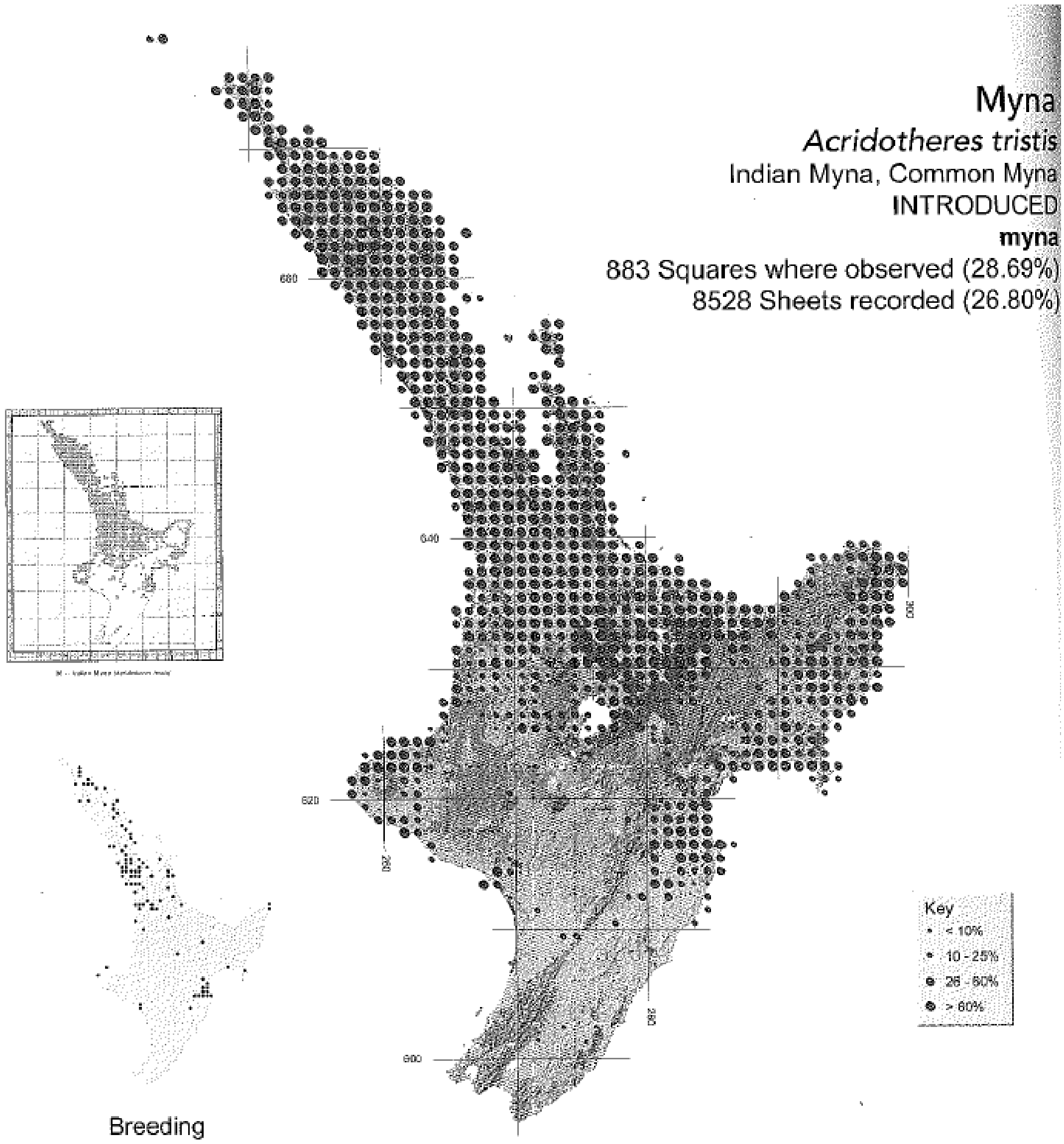

Figure 2: The distribution of common mynas in New Zealand (Source: Robertson *et al.*, 2007).

<u>5.1.3 Preferred habitat types of common mynas</u>

Common myna is said to have evolved in an open woodland habitat in India and is therefore pre-adapted to vertical structures such as trees or buildings in urban or suburban areas (Pell and Tidemann, 1997a). Common mynas are capable of occupying forests, woodlands, farmlands, orchards, urban areas, gardens and parks (Robertson *et al*., 2007). Due to their anthropogenic dependence, human settlements provide ample opportunities for mynas to establish, at least in urban and suburban settings (Cunningham, 1948; Sodhi *et al*., 1999).

5.1.4 Potential for range expansion

Climate matching using CLIMATE software and habitat matching based on Terralink Land Cover database of New Zealand, predicts that common mynas have not completely utilised all the area of the preferred habitat in New Zealand, because the climate in those areas is not suitable (Randall *et al*., 2007). Therefore, given climate change scenarios, ease of introductions from resident populations and trade pathways, range expansion of common mynas in the future could be inevitable.

In the past mynas were released in the South Island of New Zealand (Cunningham, 1948), however perhaps due to the harsh climate or low ambient temperature (temperature strongly affects breeding, section 4.1) these populations did not survive. In the current climate scenario and further warming of the climate due to climate change, there is a possibility of common mynas being able to expand their range in New Zealand.

Common mynas are often transported to New Zealand via trade routes, especially on ships and are also capable of long distance flight over land and seas (Wilson, 1965). Therefore if climate, being an important restricting factor, is eased, it may lead to range expansion by common mynas in New Zealand. This possibility can be closely assessed by climate modelling using the climate data available for myna from around the world.

5.2 Dispersal

Common mynas are capable of long distance flight and have been observed flying over the sea in excess of 50 miles from nearest land (York, D. Marine Dept, 1965 pers. comm. in Wilson, 1965). However, a single study conducted in New Zealand with banded birds determined that 31.4% of juveniles would go past a mile and only 5.7% of adults would fly past a mile from the nest. However, this study was not a large scale experiment and maximum dispersal distances of mynas can therefore not be concluded. Dispersal is an important means of range expansion and therefore needs to be determined before sustained control of mynas can be achieved.

A number of factors such as fledging, winter food shortage, nesting space shortage, etc., may be important in determining dispersal in seasonal climates (Wilson, 1973). A systematic study involving banded birds from a range of habitats in a number of years is required to estimate natural dispersal rate.

5.3 Invasiveness

Common mynas are considered highly invasive and bear pest status in a number of countries and in several regions of New Zealand such as Auckland, Bay of Plenty, Northland, etc (ARC, 2007; EBOP, 2009; NRC, 2009). It is ranked in the same league of well-known invasive organisms as cane-toads and brown tree snake (ISSG, 2006).

In Australia and most of the Pacific islands where common mynas have been introduced they have been considered responsible for decline in the number of threatened bird species (Blanvillain *et al*., 2003; Komdeur, 1996; Pell and Tidemann, 1997a, b; Rowe and Empson, 1996). They are also considered to prey upon lizards (NRC, 2009) and other small vertebrates, however conclusive reports for their impacts, especially in the Pacific, are not available. For a list of location specific impacts of common mynas see Appendix 1.

There are many factors that contribute to the invasiveness of the common myna. A selection of some of the factors is presented below.

5.3.1 Competition

Common mynas compete with other birds at three levels; 1) food, 2) nesting space and 3) territory. In urban areas, common mynas are capable of nesting under metal roofs, gutter entrances, drains funnels, spouting, air vents as well as garden vegetation (Counsilman, 1971). This not only creates public nuisance but further leads to population increase of mynas in cities and provides a source population of mynas emigrating to neighbouring forest reserves. This source population of mynas is greater by many magnitudes (680,000 in Auckland in 1971) than any native birds in forest reserves (Counsilman, 1971). Thus strong competitive pressure from these immigrating birds must be felt by native birds in surrounding bush reserves.

The feeding niche of common mynas overlaps with that of a number of similar sized native birds, such as grey warblers, tuis, etc. (see Table 1, points 3,4). Common mynas are gregarious and opportunistic and therefore capable of easily outcompeting native New Zealand birds as far as uptake of similar food is concerned (Tindall, 1996). Conclusive data on this is however yet to be collected for most countries.

Common mynas in New Zealand are hole-nesters and, in natural areas, nest at a range of heights varying from 1.8 to 25 m, average height about 7 m (Counsilman, 1971). Such variability in nesting range provides mynas with a clear advantage over most native birds that are highly specific to natural cavities (Elliott *et al*., 1996).

Mynas in New Zealand defend much larger territories than in India (Counsilman, 1974a). The average territory size defended by a single pair is 0.83 ha with the largest territory being recorded at 1.38 ha, in an urban setting (Counsilman, 1974a). Territoriality of mynas is yet to be studied in a forested habitat in New Zealand. In urban settings, Counsilman (1971) concluded that there were three major territory requirements 1) suitable hole-nest site, 2) an open habitat, 3) a large area with a variety of land cover. Territories are defended by both male and female birds and a high degree of fighting behaviour is displayed at territory boundaries (Counsilman, 1974a).

Territorial fights may lead to failure of nesting by other birds in myna territories and also displacement of any nests in territorial areas once mynas have established themselves there (Counsilman, 1974a; Tindall, 1996).

5.3.2 Nest Predation

Common mynas have been indirectly found responsible for death or fledging failure of chicks. Mynas were held responsible for the failure of two endemic Mangaia kingfisher chicks to fledge on Mangaia Island in the Cook Islands, as mynas interfered with their feeding (Rowe and Empson, 1996b).

Mynas have also been found to be important egg predators of sooty terns on Ascension Island (Hughes *et al*., 2008). Common mynas were also important egg predators of Wedge-tailed Shearwaters (*Pufinus pacificus*) at Kilauea Point in Hawaii, where, in 1978, all production loss was caused due to egg predation solely by common mynas (Byrd *et al*., 1983). In New Zealand, they are a potential predator of chicks and eggs of saddlebacks on Motukawanui Island and have been noted to use nest boxes on Tiritiri Matangi Island (Lovegrove, 1986).

On a number of occasions mynas have been suspected as egg and chick predators of a number of native birds (see Appendix 1). However, in most cases these effects are not yet quantified and data are insufficient to warrant control measures, but application of the precautionary principle would seem sensible.

5.3.3 Aggression

Common mynas are highly aggressive and show a variety of fighting behaviours and intolerance to neighbour birds. Due to their territorial nature, common mynas evict eggs and chicks of other birds nesting in their vicinity (Byrd *et al*., 1983). They also show considerable aggression towards adults, preventing them from feeding chicks and leading to a reduction in their breeding success (Thibault *et al*., 2002). During peak breeding season, fighting behaviour between neighbouring common myna pairs heightens with pair boundary quarrels (Counsilman, 1971).

Common mynas also show ‘mobbing’ behaviour against black backed gulls, red-billed gulls, cats and humans that come near nests occupied by mynas (Counsilman, 1974a). The high degree of intolerance shown by mynas to other birds nesting in their vicinity may lead to disruption of successful breeding by native birds.

Figure 3 Fighting behaviour display involving four mynas in a park in Sydney, Australia. (Photo courtesy Mark David, accessed on 23 February 2009 from www.mdavid.com.au)

Most reports of effects of mynas are localised studies or observations that do not yield clear-cut quantitative impacts on the native species of concern (see Appendix 1). The single most important analysis of impact of mynas on native birds in New Zealand has shown that presence of mynas does negatively affect native birds. Removal of mynas from Motuora Island led to a significant increase in the native: tui (Prosthemadera novaeseelandiae), fantail (*Rhipidura fuliginosa*), silvereye (*Zosterops lateralis*), welcome swallow (*Hirundo neoxena*) and grey warbler (Gerygone igata) and introduced: chaffinch (*Fringilla coelebs*), blackbird (*Turdus merula*) and starling (*Sturnus vulgarus*) numbers (Tindall *et al*., 2007).

However, the mechanism of the impact of mynas was unclear from their study and hence would be an important question for future studies. It is likely that a combination of the above factors causes the impacts on the native birds. For conservation purposes, however, it would be useful to understand which of the factors is the most important to minimise wastage of resources.

6. Management Recommendations

6.1 Management strategy: To eradicate or to control?

This section concisely covers recommendations for the management of common mynas in New Zealand.

To eradicate or control a pest species? This is a question often faced by conservation workers. Based on the biology and present establishment status of common mynas in New Zealand, it is virtually impossible to eradicate them from the entire country (Counsilman, 1974a). This is mainly because of the large population density (especially in urban areas) and the unavailability of sustainable and highly effective eradication measures.

Nevertheless, eradication of common mynas is possible on small isolated islands. Mynas have been eradicated from the 27 ha Cousin Island in the Seychelles using a combination of techniques (Millett *et al*., 2005). The lessons learned could be applied to Pacific Island Countries and Territories.

Based on the above discussion on the biology and ecology of common mynas, it can be concluded that a variety of potential impacts on native fauna of New Zealand may have been overlooked in the past. Therefore, there is an urgent need to reassess the status of myna as an invasive pest species in New Zealand and control it in high priority nature reserves (e.g. mainland islands such as Trounson Kauri Park) (Saunders and Norton, 2001) and maintain low populations in suburban and urban areas.

Eradication in important wildlife sanctuaries on offshore islands may also be feasible if the population size is small or the island is small and isolated (Millett *et al*., 2005). However, if the risk of re-invasion is very high, eradication may not be practical. Cousin Island in Seychelles from which common mynas were eradicated was not isolated and therefore would be at risk if nearby island get invaded by mynas *(*Millett *et al.*, 2005).

The Allee-effect comes into play when the population size on a particular landmass is so small that inability to find a mate or environmental stochastity leads to extinction. At such a low population threshold, the population growth is retarded. In the case of control on, or eradication from, small islands of ecological importance such as Tiritiri Matangi, Three Kings Islands and the Hen and Chicken Islands, determination of a low population threshold may aid in eradication. The population may be brought down to the low threshold size and then allowed to depreciate naturally. However, reinvasion from the mainland must be considered.

In a mainland island situation of high biodiversity value, sustained control at low-population level must be maintained. Before sustainable control can be achieved, it is important to ascertain the impact of mynas at different population densities on the recipient fauna. The impact could be measured via indicators such as nestboxes taken up by mynas, interference with native bird breeding, reduction in population size of native birds of concern etc.

Following this, different levels of control must be maintained to enable the calculation of a low-threshold population in which minimal impact of mynas is felt. This low threshold level must then be maintained sustainably and stringent monitoring must be applied from which the outcomes are fed back into the management protocol. Furthermore, prioritisation of high importance sites such as the mainland islands and biodiversity hotspots must be conducted to concentrate efforts where they will have the most effect.

6.2 Management options

This section summarises the means available for the management of common myna populations:

<u>6.2.1 Chemical management</u>:

Chemical control is one of the oldest forms of control methods to remove nuisance or pest birds. See Spurr and Eason (1999) for a review of all commercial and non-commercial avicides. Starlicide and alphachloralose are the two main chemical control options tried and tested on mynas with certain success. Following are their main merits and demerits:

Starlicide: DRC-1339 or 3-chloro-p-toluidine hydrochloride is a water soluble oral toxicant registered for use in New Zealand (O'Connor, 1996). Baits can be formulated with dripping on bread squares, with each square containing up to 3mg of the active ingredient (ACVM, 2002) and supplied during the early morning feeds. See ACVM (2002) for details on the preparation of the baits. It can also be provided in glycerine sweetened water during the day (*Pers. comm.*, Bill Simmons). Starlicide is readily absorbed in the bloodstream and completely metabolised by the liver within 3-24 hours (Ramey *et al*., 1994). Death occurs from uremic poisoning and congestion of the major organs (Ramey *et al*., 1994). Death is non-violent, occurring without convulsions or spasms and is usually delayed by 3-4 hours (ACVM, 2002; DeCino *et al*., 1966; Spurr and Eason, 1999). Distress calls that may make other mynas wary of the danger are not emitted by the dying birds (ACVM, 2002).

Pre-feeding must be done to achieve maximum mortality and observations on birds taking the non-toxic pre-feed baits must be made to identify any likely non-target birds (Spurr and Eason, 1999). Starlicide has low toxicity to mammals but has high toxicity to many birds including blackbirds, crows, starlings and American robin (Spurr and Eason, 1999). However, care must be taken if this poison is to be used in native forests as no evaluations of risk to native birds of New Zealand are available. In an urban setting however, it may be safer if baits are administered on the ground, as not many native birds are widespread in the urban settings. Tuis that are present in urban and suburban settings are not ground foraging. Pukekos on the other hand may face some risk (but are a fairly common species).

Alphachloralose: (R)-1,2-0-(2,2,2-trichloroethylidene)-α-D-glucofuranose is an oral narcotic used mostly to immobilise birds to make them easier to catch (Nelson, 1994; Thearle, 1969). Pest species can then be killed humanely and non-pest species can be revived and released (Thearle, 1969). In sufficient quantities alpha-chloralose can be toxic and has been widely used on starlings, house sparrows, and rock pigeons (Ridpath *et al*., 1961).

It is fast acting with first signs of narcosis occurring after 10 minutes, followed by mild convulsions and immobilization (Thearle, 1969). Affected birds do not emit distress calls that may warn other birds (Thearle, 1969), but the convulsions may alert conspecifics. Alpha-chloralose is less toxic to mammals but there is risk of primary poisoning to non-target birds (Schafer, 1991). Secondary poisoning to scavengers or predatory birds may also occur as it is slowly metabolised (Schafer, 1991). It is also very labour intensive as the stupefied birds have to be collected before they wake up (Spurr and Eason, 1999).

6.2.2 Trapping:

A variety of traps have been designed for trapping mynas. Following is a critical assessment of the popular myna trapping methods in their order of success.

Decoy-traps: Any form of wire-netting trap that contains one or two decoy mynas. The decoy birds are usually in a separate chamber and are provided food and water (Sharp and Saunders, 2004). The decoy birds serve to attract foraging mynas towards the trap and this type of trap has been repeatedly found to be most successful in trapping mynas in New Zealand (Tindall, 1996; Wilson, 1973). Decoy birds can be used in most trap types. The traps have to be constantly monitored and any caught birds have to be removed at night. The traps have to be shaded and furnished with water, food and preferably a perch.

Walk-in/Funnel entry traps: A variety of designs are available for the funnel entry or walk-in traps. The trap entrance is in the form of a funnel, through which the birds enter the trap by crouching, but cannot exit once they are standing inside the trap. The traps have to be periodically monitored and any caught birds have to be removed. The traps need to be furnished with shade, water, food and preferably a perch for humane treatment of trapped birds. Cylindrical (Tindall, 1996), 'box' trap (Tindall, 1996), Tidemann trap (Pell and Tidemann, 1997a), etc., are all modifications of funnel entry or trap-door traps.

Noose-traps: A bunch of nylon nooses are nailed to the entrance of a nestbox once it has been established that it is occupied by mynas. Both male and female can be captured using this method. However, it is labour intensive and monitoring is required beforehand to identify myna nests.

Mist-nets: Mist nets are fine polyester or nylon nets which are suspended between two upright poles, requiring continual monitoring and expert handling of caught birds (Sharp and Saunders, 2004). Since mynas are very wary birds, these traps showed least success in Wilson's (1973) study.

6.2.3 Shooting:
Shooting by competent marksmen has often been quite useful to remove small populations of isolated birds (Millett *et al*., 2005). However, a gun with a silencer must be used and shooting must be carried out preferably during night so that the birds do not become wary of the shooters.

6.3 Combinations of the management options in different scenarios
Since mynas are wary birds, it is advised to use a combination of more than one technique to target them (Millett *et al.*, 2005). The following scenarios are examples of how different methods may be suited for different habitats where myna control may be essential.

6.3.1 Urban habitat:
Starlicide (DRC-1339) on bread cubes should be used in urban situations as it has high rates of mortality and is sufficient for an initial knockdown of large populations (Millett *et al.*, 2005). It was found to be very effective on Seychelles Islands in controlling mynas (Millett *et al*., 2005). Ground dispersal of bread baits may be useful as most native birds in an urban setting are not ground foraging. Also, most native birds in an urban setting do not feed on artificial food sources such as bread. Pre-feeding from 3 days to up to a month must be conducted. Since mynas nest around human habitations (see 5.3.1) active removal of potential nesting sites must be undertaken preferably as a project involving local communities. Spreading awareness and community education may play an important role in such a project.

6.3.2 Native forests:
Edges of the native forests must be targeted first because of their role in weed-dispersal. Since the risk of non-target effects may be high in this habitat, use of Starlicide is not advised (unless it can be proven that non-target impacts will be negligible). Decoy traps, in open habitat should be used and alpha-chloralose baits in the interior of the forests in winters may be useful. Any non-target birds can be collected and kept warm until revived.

In a native forest, more labour intensive and consistent effort would be required to attain an initial knockdown to a low population. Shooting may also be done in native forests by experienced marksmen. Noose traps may also be utilised if it is known that a certain nest box is inhabited by mynas.

6.4 Monitoring
Rigorous monitoring and surveillance is an important aspect of any management operation. In the control of myna population monitoring would be extremely important. All captured mynas must be sexed using morphometric analysis (Counsilman *et al*., 1994) and counted. As much location and biology detail as possible, including gut content, must be ascertained before disposing of the carcass. Gene based methods may be developed for sexing and demographic analysis of a particular population.

7. Research Recommendations

Very little work has been done in the Pacific and, despite the work done on the biology of mynas in New Zealand, a volume of important ecological information is missing that would hinder any management operations. Firstly, apart from the traps used by Wilson (1973), no method efficiency comparisons are available for the control options of mynas in New Zealand. A number of other short-term and long-term research needs arise from this report.

7.1 Introduction pathways:
Mynas are flighted, however they have limited home ranges. Nevertheless the maximum extent of dispersal via flight and the rate of natural range expansion (due to increasing population) for mynas in New Zealand are unknown. It would be critical to know these details before a large scale management operation can be designed.

7.2 Impact assessment:
As discussed above, assessment of the impact of mynas on native fauna would be elemental in sustainably controlling mynas to achieve the desired biodiversity outcomes. Of further importance may be the impact of mynas on individual species that appear most affected, for example the tui (Tindall, 1996). An hypothesis such as 'Limitation of tui productivity caused by mortality due to mynas' may be tested and tui productivity may be used as an index to ascertain the impact of mynas at different population levels.

7.3 Interspecies interactions:
Very little is known about the interactions of common mynas with other introduced species. Therefore this should be considered if mynas are targeted in a multiple introduced species area. The removal of one invasive species often leads to the ecological release of another, apparently less harmful invasive.

Mynas interact with starlings, blackbirds etc. Therefore, the cascading effects of myna control on those introduced birds with similar niches, such as starlings and blackbirds need to be pre-examined before single species targeted control is undertaken. It may pay in the long-term to attempt multi-species control in important sites.

Also, in other control programmes in places where mynas are present, their populations should also be monitored. On Ascension Island in the South Atlantic, control of cats lead to an increase in the population of common mynas which in turn lead to 25% loss of sooty tern eggs (Hughes *et al*., 2008). Myna predation of sooty tern eggs on the island was greater than that caused by rats.

7.4 Further research on the ecology of mynas:
Tindall (1996) concluded that, excepting a radical breakthrough in biological control, continued research into the ecology and impacts of mynas may provide the only means for development of innovative control techniques and long-term resolution. Therefore, research and management must go hand-in-hand for the management of this invasive pest species.

7.5 Review of earlier research
When a species naturalises in a new habitat, its ecology can be different from the population in its native area. The ways in which common mynas adapt to a new environment need attention.

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Common mynas (*Acridotheres tristis*) showing preference
for pawpaw (*Carica papaya*) over fresh coconut and boiled white rice,
Mangaia, Cook Islands. (Photo: Bill Nagle)

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APPENDIX 1: Some location-specific impacts of common mynas on native fauna and flora (modified from ISSG, 2006)

Australia

Agricultural: Common Indian mynas (*Acridotheres tristis*) cause some depredation on fruit, especially figs (Frith 1979)

Mangaia Is. (Cook Islands)

Competition: Mynas negatively effect native biodiversity by competing for nesting holes, preying on chicks and eggs and evicting small mammals. The myna poses a particular threat to Mangaia's endemic vulnerable Mangaia kingfisher (see *Todiramphus ruficollaris* in the IUCN Red List of Threatened Species). Anecdotal evidence indicates that the kingfisher cannot breed successfully outside the small areas of *Barringtonia asiatica* forest on Mangaia because of interference from the myna.

Fiji

Competition: Mynas are great adaptors to local food sources, which they can exploit very effectively to their advantage. In Fiji, the seashore along the main street in Suva (the capital) attracts hundreds of mynas at low tide, that proceed to feast on worms, molluscs, crustaceans and other seafood that has been stranded on the mud flats (Stoner 1923). Presumably this limits potential sources of food for native seabirds.

Disease transmission: Mynas in Fiji have been identified as carrying owl flies, biting lice, thread worms (of a species of *Oxyspirrura*) and round worm (Stoner 1923). Presumably, populations of the bird may provide reservoirs of a disease that affects native birds, while themselves remaining largely unaffected.

Human nuisance: Described as "thrifty" and "pugnacious" the myna has the annoying habit of building nests in and around human habitations which may cause house keeping problems, for example when they construct nests in spouting and drain pipes.

Predation: Common Indian mynas (*Acridotheres tristis*) have been reported to predate on the eggs and young of terns (*Sterna* spp.) and noddies (*Anous* spp.) as recorded by Pernetta and Watling (1978). They also recorded agonistic behaviour by naturalised red-vented bulbuls (*Pycnonotus cafer*) with the common myna (amongst other species, including jungle myna (*Acridotheres fuscus*). In a form of role-reversal, the two mynas were themselves observed initiating attacks on bulbuls.

Hiva Oa Is. (French Polynesia (Polynésie Française))

Other: It is possible that common mynas may have contributed to the decline of the red-moustached fruit dove and the Marquesas warbler by stealing their nests. Cave swiftlets (*Collocalia* spp.), on whose eggs common mynas are known to prey, are rare or absent (Holyoak and Thibault 1984, Seitre and Seitre 1992).

French Polynesia (Polynésie Française)

Interaction with other invasive species: *Acridotheres tristis* is suspected of contributing to the spread of invasive alien plants by consuming their fruit.

Predation: *Acridotheres tristis* is able of consuming the eggs or young native birds such as the Tahiti swiftlet (*Collocalia leucocephalus*) (Holyoak and Thibault 1984, Seitre and Seitre 1992).

Threat to endangered species: *Acridotheres tristis* is suspected of having contributed to the exclusion of certain species that are endemic to the Marquesas such as *Acrocephalus caffer mendanae* or *Ptilinopus dupetitthouarsii*. It represents a major threat to the Tahiti monarch, a species classified as Critically Endangered by IUCN (see *Pomarea nigra* in the IUCN Red List of Threatened Species) (Blanvillain *et al*., 2003).

Moorea Is. (French Polynesia (Polynésie Française))

Predation: Cave swiftlets (*Collocalia* spp.), on whose eggs common mynas are known to prey, are rare or absent (Holyoak and Thibault 1984, Seitre and Seitre 1992).

Reduction in native biodiversity: Mynas may have contributed to the decline of the long-billed reed warbler (Holyoak and Thibault 1984)

Tahiti Is. (French Polynesia (Polynésie Française))
Agricultural: In Tahiti, mynas eat cultivated fruits (Holyoak 1974).
Predation: Cave swiftlets (*Collocalia* spp.), on whose eggs common mynas are known to prey, are rare or absent (Holyoak and Thibault 1984, Seitre and Seitre 1992).

Tel Aviv (Israel)
Competition: Mynas were observed taking over an active nest of a Syrian woodpecker (*Dendrocopus syriacus*).
Human nuisance: One roosting site included around 200 mynas, as well as other bird species, situated in a botanical garden over a public footpath (causing fouling problems).
Unknown: Since mynas are a relatively new invasive species to the region and most of the population is in man-made habitat, it is too early to evaluate actual or future impacts.

Mauritius
Competition: In Mauritius, where they are now the most adundant bird species, common mynas compete successfully for nesting sites with the endangered and endemic Mauritius or echo parakeet (see *Psittacula eques* in IUCN Red List of Threatened Species) (Long 1981, Lever 1987).

Grand Terre Is. (New Caledonia) (New Caledonia (Nouvelle Calédonie))
Competition: *Acridotheres tristis* is believed to compete with local bird species for food and nesting sites (Pascal *et al*., 2006).
Interaction with other invasive species: *Acridotheres tristis* probably played a key role in the massive extension of *Lantana camara* (Virot, 1956 in Gargominy *et al*., 1996)

New Zealand
Competition: In New Zealand mynas prey on the eggs and nestlings of feral pigeons, silver and southern black-backed or kelp gulls, as well as those of the small native and introduced passerines (Thomson 1922, Oliver 1955, Wodzicki 1965).

Reunion (La Réunion)
Economic/Livelihoods: Mynas cause damage to fruits and affect production.
Interaction with other invasive species: Concerns have been raised on the role of mynas in the dissemination of exotic weeds.

Reunion (La Réunion)
Interaction with other invasive species: *Acridotheres tristis* is suspected of contributing to the spread of invasive alien plants by consuming their fruit.

Ascension Is. (Saint Helena)
Predation: *Acridotheres tristis* predate extensively on sooty tern eggs (*Sterna fuscuta*) (Hughes, 2004 in Varnham, 2006), there are reports that probably they cause more predation on sooty tern eggs than rats.

Saint Helena
Competition: *Acridotheres tristis* competes with the 'Critically Endangered (CR)' endemic wirebird (see *Charadrius sanctaehelenae* in IUCN Red List of Threatened Species) for invertebrate prey (McCulloch and Norris, undated in Varnham, 2006).
Interaction with other invasive species: *Acridotheres tristis* depredates fruit trees and other crops. It is a major dispersal agent for invasive exotic plant species such as *Opuntia stricta* and *Lantana camara*. *A. tristis* is implicated in the spread of the invasive shrub wild currant (Ashmole and Ashmole, 2000 in Varnham, 2006) and in the spread of non-native Bermuda cedar (Rowlands *et al*., 1998 in Varnham, 2006).
Predation: *Acridotheres tristis* may raid nests of the 'Critically Endangered (CR)' endemic wirebird (see *Charadrius sanctaehelenae* in IUCN Red List of Threatened Species) and eat hatchlings and

eggs (known to predate nests of other small birds) (McCulloch and Norris, undated in Varnham, 2006).

Seychelles

Threat to endangered species: Newton (1867) suggested that competition with mynas may have contributed to the decline of the Seychelles magpie robin (see *Copsychus sechellarum* in IUCN Red List of Threatened Species).

Singapore

Fouling: Large communal roosts of mynas in urban environments cause problems; the noisy cheeky and intelligent bird increases noise pollution and also fouls the environment by depositing unhygienic droppings and creating other litter (Yap *et al.*. 20002, in Lim Sodhi Brook and Soh 2003).

Reduction in native biodiversity: The decline of the native hole-nesting oriental magpie robin (*Copsychus saularis*) in Singapore has been hypothesised to be linked to the presence of exotic mynas (Huong & Sodhi 1997, in Lim Sodhi Brook and Soh 2003).

Hawaii (Hawai'i) Is. (United States (USA))

Interaction with other invasive species: The common myna has aided the spread of lantana (*Lantana camara*) seeds - which is an invasive plant threatening the sustainability of native Hawaiian flora.

Hawaiian Islands (United States (USA))

Interaction with other invasive species: Mynas indirectly affect the environment, largely through the dispersal of seeds. In 1858 the ornamental plant *Lantana camara* was introduced from Mexico (where it is harmless) to gardens in the Hawai'ian Islands, where before long, common mynas were eating the berries (which were ignored by native species) to such an extent that correlative fluctuations were noticed in the abundance of fruits and mynas, the latter spreading the seeds (the germination of which is said to be increased by their passage through the bird) until rank growths of lantana became an agricultural nuisance (notes from Lever 1987: 497–498).

Predation: Byrd (1979) considered that common mynas may be significant predators of the eggs of wedge-tailed shearwaters (see *Puffinus pacificus* in IUCN Red List of Threatened Species) in the Hawai'ian Islands, where in his study on Kauai some 23% of shearwater eggs were destroyed (notes from Lever 1987: 497–498).