



Introduction, spread,
impact and control of the
common myna
(*Acridotheres tristis*)

by

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Candidate's Declaration

This thesis contains no material that has been accepted for the award of any other degree or diploma in any university. The research, analysis and writing in the thesis are substantially (>90%) my own work. To the best of my knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

Kate Grarock

Date:

Acknowledgements

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Abstract

The common myna (*Acridotheres tristis*) has been introduced throughout the world primarily to control insect pests in agriculture. However, the common myna has now been listed in the world's top 100 worst invaders. There is global concern that the common myna may negatively impact other species through territorial exclusion and cavity-nesting competition. As such, there is growing demand for management strategies to control the species. Despite this concern, there is limited scientific evidence regarding the impact of the common myna. Some research even suggests the impact of this species is over stated or nonexistent. Therefore, it is imperative that the population dynamics and potential impact of this species are understood. This thesis comprises five research articles that investigate the introduction, spread, impact and control of the common myna.

To examine the introduction and spread of the common myna, a composite 41-year data set was used to reconstruct the species invasion sequence. The impact of the common myna on native bird abundance was then assessed, using long-term data both pre and post invasion. A negative relationship between the establishment of the common myna, and the long-term abundance of three cavity-nesting species and eight small bird species, was observed. This finding has never previously been demonstrated at the population level.

Using 1071 transect bird surveys, the impact of the common myna in conjunction with habitat modification was then investigated. This study indicated that common myna abundance is strongly influenced by habitat. However, negative associations between common myna abundance and some bird species were also observed. To investigate cavity-nesting competition, 225 nest boxes were established and monitored over three breeding seasons. This study provides the strongest evidence to date for a negative impact of the common myna on native birds through cavity-nesting competition. Finally, the impact of a community-led culling program of the common myna was assessed using transect surveys and a population model. Reductions in common myna abundance were related to high intensity culling across small-scale areas. However, the results indicate that too few individuals are being removed to have a broad scale influence. The elements for a successful control program and methods to increase the effectiveness of culling programs are discussed.

This thesis provides a comprehensive investigation into the ecology of the common myna and adds significant new knowledge on the invasion sequence, species impact (type and severity) and population dynamics of the common myna. An overarching finding of this thesis is the significant impact of habitat on species abundance. Therefore, to disentangle the impacts on native species, analysis must include both habitat variables and introduced species impact. Habitat modification can also influence the severity of introduced species impact and therefore potential management responses. Habitat restoration is recommended as an alternative method for common myna control that would also aid native species recovery.

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Chapter 1

Introduction

1.1 Introduction

1.1.1 Introduced species

Introduced species can have substantial impacts on human health, on economies, and on biodiversity (Gurevitch *et al.* 2011). They can affect ecosystems independently, or have a compounding affect in conjunction with human habitat modification (Didham *et al.* 2005; Gurevitch and Padilla 2004; MacDougall and Turkington 2005). These impacts can lead to changes in population dynamics, altered community structure, and altered ecosystem services (Crooks 2002; Manchester and Bullock 2000; Pimentel *et al.* 2005; Vitousek *et al.* 1987; Wilcove *et al.* 1998).

Demonstrating the impact of an introduced species is a complex task, especially when it occurs through competition (Cooper *et al.* 2007; Didham *et al.* 2005; MacDougall and Turkington 2005). Competition from introduced species can often have a slow and gradual influence on the abundance of native species, and frequently occurs in combination with other environmental impacts, such as human-habitat modification (Cooper *et al.* 2007; Didham *et al.* 2005; MacDougall and Turkington 2005). As a result, negative impacts on native species through competition are poorly documented.

To successfully manage introduced species, it is essential to understand the type and level of impact they cause and then (if determined) how to reduce their impact (Bradshaw *et al.* 2007; Davis *et al.* 2011; Parker *et al.* 1999; Shine and Doody 2010; Simberloff 2003). Due to limited resources, management prioritisation should be given to introduced species that have the greatest undesirable impact (Davis *et al.* 2011; Simberloff 2003).

Management of introduced species has traditionally focused on attempts to eradicate them (Newton 1998). However, eradication is often only effective for recently arrived, newly established or species with restricted distributions (e.g. small islands) (Hulme 2006). Many widespread eradication or reduction measures have failed leading to a waste of resources (Caughley 1977; Davis *et al.* 2011; Feare 1991; Newton 1998; Shine and Doody 2010; Ward *et al.* 1979). Due to the difficulties associated with introduced species eradication, many programs have now shifted toward impact reduction measures, as they tend to be a more economical and effective way of impact mitigation (Melero *et al.* 2010; Newton 1998; Shine and Doody 2010). Control strategies should aim to reduce species abundance to below a threshold where their 'damage' is minimised (Braysher 1993; Eiswerth and Johnson 2002). Therefore, to successfully control species abundance their biology and population dynamics need to be understood (Newton 1998). An effective method for population reduction also needs to be available (Louette *et al.* 2013; Melero *et al.* 2010; Newton 1998).

This thesis explores themes relating to the effective management of introduced species. The common myna (*Acridotheres tristis*) is used as a case study to investigate the invasion sequence, species impact (type and severity) and population dynamics of culled species.

1.1.2 Common myna

1.1.2.1 Taxonomy and appearance

The common myna is a member of the Starling and Myna family (*Sturnidae*) (Feare and Craig 1998). The species is a stocky bird measuring 23 to 25 cm in length (Feare and Craig 1998; Wilson 1973). Adult birds have black feathers on the head and neck and brown feathers on the body (Figure 1.1) (Pizzey and Knight 2007). When in flight, the species has distinctive white wing patches. The legs, feet, beak and skin around the eye are yellow (Feare and Craig 1998; Pizzey and Knight 2007). Both sexes look similar, with males being slightly larger (Counsilman 1971). However, in the breeding season, females can develop a bald brood patch on their lower abdomen (Wilson 1973). Juveniles tend to be duller in appearance than adult birds, with a dark brown head and neck and pale yellow skin around the eye (Pizzey and Knight 2007).



Figure 1.1: The common myna (*Acridotheres tristis*).

1.1.2.2 Foraging

The common myna is a highly adaptable, generalist omnivore (Counsilman 1974b; Griffin 2008; Long 1981). The species is sedentary, foraging within 1 to 3 km from a communal roost (Counsilman 1974b; Tracey *et al.* 2007). The common myna has been observed eating insects, fruit, berries, grains, seeds, food scraps, eggs, nectar, carrion, geckos, frogs, young snakes, fledglings and even rubber bands (Dhami and Nagle 2009; Overs 1997). However, nestlings (less than ten days old) are exclusively fed invertebrates (primarily insects) (Counsilman 1971; Sengupta 1976).

1.1.2.3 Breeding

The common myna forms lifelong, monogamous breeding pairs (Counsilman 1974a; Wilson 1973). However, if one individual from the monogamous pair dies, it will rapidly be replaced (Wilson 1973). The species aggressively defends the same territory each nesting season, especially from neighbouring common myna pairs (Figure 1.2) (Ambrose 1982; Counsilman 1971; Wilson 1973).



Figure 1.2: The common myna (*Acridotheres tristis*) aggressively defending their territory from a neighbouring pair.

In Australia, the common myna breeds from October to March with peak nesting usually occurring in November (Harper *et al.* 2005; Pell and Tidemann 1997a). The species is primarily a cavity-nesting species throughout its introduced range (Figure 1.3). They lay between two to seven eggs per clutch and up to three clutches per season (Counsilman 1974a; Dhami and Nagle 2009; Feare and Craig 1998). The average clutch size in Canberra, Australia is 3.8 ± 1.3 eggs, while the number of chicks fledged per clutch is 2.0 ± 1.5 (Pell and Tidemann 1997a). Nesting success rates appear to vary, ranging from 14 to 61% (Pell and Tidemann 1997a). Starvation is believed to be the major cause of nestling mortality (Pell and Tidemann 1997a; Sengupta 1976; Wilson 1973).



Figure 1.3: The common myna (*Acridotheres tristis*) outside a nest box that it is using as a cavity-nest site.

The common myna has been observed using a broad range of nesting sites including natural tree cavities and human made structures (Overs 1997). Generally, the common myna will nest in any cavity that has an entrance diameter greater than 45 mm (Moeed and Dawson 1979). Nest building takes an average of seven days from commencement to egg laying (Counsilman 1974a). The species builds a bowl-shaped nest out of twigs (Counsilman 1974a; Harper *et al.* 2005) and green leaves are normally added in the final stages (Wilson 1973) (Figure 1.4). The common myna is a persistent nester and will rebuild a nest if it is disturbed during the breeding season (Harper *et al.* 2005).

Once the eggs hatch the chicks spend approximately 25 to 27 days in the nest before fledging (Counsilman 1974a; Wilson 1973). Adult birds continue to feed fledglings for two to three weeks before chasing them out of the territory (Counsilman 1974a; Pell and Tidemann 1997a).



Figure 1.4: Common myna (*Acridotheres tristis*) bowl shaped nest with green leaves lining the nest.

1.1.2.4 Habitat

The common myna thrives in human-modified environments, reaching high densities of more than 200 birds per km in cities and towns (Counsilman 1971; Dhama and Nagle 2009; Hone 1978; Long 1981). However, the species has been observed living in high numbers away from human disturbance in New Zealand (Bull 1985) and is also found along roadsides, in coastal mangroves, and in open forest habitats (Feare and Craig 1998). The common myna tends to avoid dense forest but landscape fragmentation can lead to increases in their abundance (Dhama and Nagle 2009; Lowe *et al.* 2011; Pell and Tidemann 1997a; Tracey *et al.* 2007). The species has also been observed to be more prevalent in reserve edges than in the reserve interior or dense woodland (Pell and Tidemann 1997a).

1.1.2.5 Movement

The common myna often defends a territory around its nest site. However, territory size can vary considerably. In Hawaii and India, the species has been observed to defend only the nest site or a small area around the nest site (Eddinger 1967; Lamba 1963; Sengupta 1968). Conversely, territories tend to be larger in New Zealand and include the nest site and foraging area. For example, in Auckland average territory size was 0.83 ha (Counsilman 1974b) and in Hawke's Bay territories were up to 2.0 ha in size (Wilson 1973).

In a radio telemetry study in Singapore, the common myna was observed travelling an average total distance of 3 km a day. These movements occurred within a home range of 10 ha (Kang 1989).

The common myna has been observed dispersing along highways in Australia and in South Africa (Overs 1997; Peacock *et al.* 2007). There are reports that the species is capable of long distance flight (Wilson 1973). This indicates that the species is capable of spreading to new areas, potentially having negative impacts in these new environments.

1.1.2.6 Roosting

The common myna is a communal species that groups together in the evening to form overnight roosts of up to 1000 individuals (Counsilman 1974b; Sengupta 1973; Yap *et al.* 2002). Roosts are often formed in trees and dense vegetation (e.g. hedges) or on human-made structures (e.g. buildings or bridges) (Counsilman 1974b; Pizzey and Knight 2007; Sengupta 1968; Slocum 1995).

Roost sites tend to be 1 to 3 km apart and this may represent the maximum distance birds will travel for foraging (Counsilman 1974b; Sengupta 1973). In Canberra, Australia, common myna roosts are located approximately 100 to 700 m from breeding areas, with roosts spaced approximately 1.3 and 1.8 km apart (Pell and Tidemann 1997a).

The common myna often forms pre-roost gatherings in open areas surrounding a roost (Mahabal and Vaidya 1989; Wood 1995). Birds start arriving approximately 80 minutes before sunset and will forage and interact with other individuals (Counsilman 1974b; Wood 1995). Approximately 30 minutes before sunset, birds start to enter the roost while calling continuously. As more birds arrive, the noise from calling birds can be very loud. These vocalisations may advertise the location of the roost to individuals as the roost may change throughout the year (Counsilman 1974b; Zahavi 1971). Birds will continue to arrive at the roost up to ten minutes after sunset and once it becomes dark vocalisations cease (Counsilman 1974b; Mahabal *et al.* 1990; Slocum 1995; Wood 1995).

In the morning, vocalisations begin again as birds start to leave the roost around civil twilight (Counsilman 1974b). During the nesting season, brooding females stay on their nest overnight and do not return to the communal roost (Counsilman 1974a; Counsilman 1974b; Sengupta 1968; Wilson 1973).

1.1.2.7 *Distribution*

The common myna originates from India and central and southern Asia (Feare and Craig 1998; Long 1981). The species has become established on all continents except Antarctica (Feare and Craig 1998). Introductions have been through a range of pathways including acclimatisation societies, natural migration (especially along roadways), escape from the pet trade, and via ship movements (Feare and Craig 1998). The common myna also was introduced to control insect pests in agriculture, but it is now regarded as an agricultural pest in some countries (Feare and Craig 1998; Lever 1987; Long 1981; Tracey *et al.* 2007).

The common myna was first brought to Melbourne, Australia in 1862 to control insects in market gardens (Hone 1978; Pizzey and Knight 2007). The species quickly established and this population became a source for other introductions within Australia (Hone 1978). The common myna is now well established in many cities and towns along the east coast of Australia (Pizzey and Knight 2007).

Climatic modelling of the species' potential distribution predicted suitable habitat along the east coast of Australia from north of Cairns through to South Australia (Martin 1996). Other areas predicted to be suitable for the common myna include the gulf peninsulas of South Australia and the south-western corner of Western Australia. Common myna range expansion is believed to be limited to warmer regions above 40 degrees south (Martin 1996).

1.1.2.8 *Impact*

Originally, the common myna was described as a 'useful species' due to its strong preference for eating insects (Sengupta 1968). However, the common myna is now listed as one of the world's 100 worst invaders (Lowe *et al.* 2000). Across the globe there are many anecdotal reports detailing the negative impact of the common myna (Blanvillain *et al.* 2003;

Dhami and Nagle 2009; Feare and Craig 1998; Grant 1982). The common myna was voted as the most hated pest in Australia, in the ABC *wild watch quest for pests* in 2005 (ABC 2011). A main factor in the unpopularity of the common myna is the perception that they negatively impact native birds and mammals. As a result, there are a growing number of community groups that are attempting to control the species (CIMAG 2013; Lowe *et al.* 2011).

There is concern that the common myna has a negative effect on cavity-nesting species through competition for nest sites, and reducing native species breeding success (Blanvillain *et al.* 2003; Byrd 1979; Counsilman 1974a; Dhami and Nagle 2009; Feare and Craig 1998; Grant 1982; Harper *et al.* 2005; Pell and Tidemann 1997a; Pell and Tidemann 1997b; van Rensburg *et al.* 2009; Watson *et al.* 1992). The common myna has been observed dominating natural nesting cavities, evicting native birds, killing the chicks and destroying eggs (Byrd 1979; Davey 1991; Feare and Craig 1998; Harper *et al.* 2005; Jones 1996; Komdeur 1996; Pell and Tidemann 1997b; Watson *et al.* 1992). The species also can build more than one nest that may deter other cavity-nesting species (Harper *et al.* 2005; Pell and Tidemann 1997b). Bomford (2008) concluded that the common myna poses a ‘very serious’ threat to native Australian birds, and a ‘serious’ threat to structures and buildings.

The common myna is described as a territorial species actively defending an area of 1 to 3 ha from both intraspecific and interspecific bird species (Counsilman 1971; Tindall *et al.* 2007; Wilson 1973) (see Dhami and Nagle (2009) for a review) (Figure 1.2). One study on the reduction in common myna numbers from a small New Zealand island found significant increases in five native bird species (Tindall *et al.* 2007). However, mechanisms of the common myna impact were unclear and the island had undergone rat eradication two years prior to the study.

The common myna can spread the noxious weed *Lantana camara* in Hawaii (Pimentel *et al.* 2000), leading to an altered vegetation structure. The common myna can damage fruit crops and be a public nuisance through loud and persistent vocalisations, building of nests in public structures and soiling public areas (Martin 1996; Tracey *et al.* 2007; Yap *et al.* 2002).

Despite the above observations, to the best of my knowledge, there is no scientific evidence that the common myna is responsible for reductions in the long-term abundance of native species. For example, in Hawaii where common myna predation is responsible for a significant reduction in wedge-tailed shearwater (*Puffinus pacificus*) eggs, no negative impact on the number of wedge-tailed shearwaters has been found (Byrd 1979; Dhami and Nagle 2009). Many studies are limited to observations of common myna having negative interactions with native species and then statements about how this *may* lead to changes in native species abundance. For example, Pell and Tidemann (1997b) found the common myna won more than 80% of interspecific aggressive encounters with native parrots during the breeding season, *potentially* reducing the breeding successes of these native birds. Harper *et al.* (2005) found the

common myna dominated nest boxes in Melbourne, Australia, *possibly* limiting the availability of nesting sites for native species.

Some research suggests the impact of the common myna is overstated or nonexistent (Crisp and Lill 2006; Haythorpe *et al.* 2012; Lowe *et al.* 2011; Parsons *et al.* 2006; Wood 1996). In Sydney, Lowe *et al.* (2011) found no evidence that the common myna initiated more aggressive encounters than other bird species. Lowe *et al.* (2011) suggests the common myna may only aggressively defend specific resources such as nest-cavities and areas in their immediate vicinity, rather than excluding birds from a broad area. Lowe *et al.* (2011) also found no evidence for cavity-nesting competition, with the common myna showing a preference for nesting in highly modified habitats and artificial nest cavities. Several studies have also found that the common myna is unlikely to compete with other bird species for food resources (Crisp and Lill 2006; Haythorpe *et al.* 2012; Lowe *et al.* 2011). In resource rich urban environments, food resources are unlikely to be limited, especially for a ground feeding omnivore such as the common myna (Haythorpe *et al.* 2012; Lowe *et al.* 2011).

Overall, much of the potential impact of the common myna has not yet been empirically examined. Linking observed negative interactions between the common myna and native species, to reductions in species abundance, is critical to inform management. The common myna has already invaded many regions across the globe and will continue to spread to new areas (Feare and Craig 1998). Therefore, it is timely that this thesis investigates the introduction, spread, impact and control of the common myna to inform the understanding and management of this species.

1.2 Context and structure

The following section provides a brief overview of the chapters in the thesis. The body of work is presented as a compilation of separate papers published as journal articles. As such, it follows The Australian National University's annotated Thesis by Compilation Guideline of 10 May 2013, available on the following webpage:

https://policies.anu.edu.au/ppl/document/ANUP_003405

1.2.1 Chapter 2 – The invasion process - Grarock, et al. (2013) Journal of Environmental Management

Research indicates that invasion is a multi-step process, where each stage is contingent on the stage that precedes it. Numerous hypotheses have been formulated on factors that influence each stage of the invasion process. But how well does this theory match what occurs in the natural world?

In Chapter 2, a general conceptual model for the invasion process, based on invasion theory, was developed. Using a composite 41-year data set, the invasion sequence of the

common myna was recreated to investigate the similarities between invasion theory and this observed invasion. Reconstructing the invasion sequence of the common myna is the first step towards understanding the species invasion dynamic and enhancing management of this species.

The length and duration of the invasion sequence for the common myna correspond closely with what invasion process theory would predict. This finding indicated that a conceptual model, coupled with basic species, environment and event information, could be a useful tool to enhance the understanding and management of invasions.

1.2.2 Chapter 3 – Is it benign or is it a pariah? - Grarock, *et al.* (2012)

PLoS ONE

Empirical evidence of the impact of an introduced species can be difficult to obtain. Long-term data, pre and post, common myna invasion was used to quantify the impact of the common myna on native bird abundance.

A negative relationship was observed between the establishment of the common myna and the long-term abundance of three cavity-nesting species and eight small bird species. This finding had not previously been demonstrated at the population level. However, the prioritisation of the common myna for management over other species still remains a contentious issue.

1.2.3 Chapter 4 – Drivers and passengers of change - Grarock, *et al.* (2014) *Austral Ecology*

Habitat modification and invasive species are significant drivers of biodiversity decline. However, distinguishing between the impacts of these two drivers on native species can be difficult. For example, habitat modification may ‘drive’ native species decline, while an invasive species may be a ‘passenger’, taking advantage of the new environment. This scenario has been described as the driver-passenger model.

In Chapter 4, the impact of the common myna on native species, in combination with habitat variation, was examined. It was hypothesised that the common myna is both a passenger of habitat change and a driver of some bird species decline.

Common myna abundance was almost three times higher in urban areas than nature reserves and declined rapidly as tree density in nature reserves increased. This finding indicated that the common myna is primarily a passenger of habitat change. However, negative associations between common myna abundance and some bird species also were observed.

It is important to simultaneously investigate both invasive species impact and habitat modification to disentangle their impacts on native species. Understanding the drivers of native species decline will help inform impact mitigation and direct further research.

1.2.4 Chapter 5 – Influence of habitat on the impact of introduced species - Grarock, *et al.* (2013) *Environmental Management*

Due to the strong influence of habitat on species abundance, Chapter 5 investigated if human-induced habitat modification influenced cavity-nesting competition, between the common myna and native species.

Through the establishment of 225 nest boxes, the relationship between tree density and the abundance and nesting success of the common myna, crimson rosella (*Platycercus elegans*), and eastern rosella (*Platycercus eximius*) was examined.

Tree density significantly influenced the abundance and cavity-nesting of all three species. Despite this strong influence, at low tree density sites, a significant negative relationship was observed between common myna nest box occupancy and the abundance of the crimson rosella and eastern rosella. There also was a negative relationship between common myna nest box occupancy and crimson rosella abundance at high tree density sites. The relationship appeared to be more severe at high tree density sites. Therefore, management of the common myna may be more effective in areas that represent ‘high quality’ habitat for native species. This study also provided the strongest evidence to date for the negative impact of the common myna on native bird *abundance* through cavity-nesting competition.

1.2.5 Chapter 6 – Effective control of the common myna - Grarock, *et al.* (2013) *Biological Invasions*

Chapter 6 assessed the effectiveness of community-led culling of the common myna in Canberra, Australia. A basic population model was utilised to enhance the understanding of common myna population dynamics and the potential influence of various culling regimes.

Over a fine scale; a significant negative relationship was found between common myna abundance and culling. However, no significant relationship was observed between common myna abundance and culling across four broad regions in Canberra. A population model indicated that culling at a rate of 25 birds per km² would reduce the population size regardless of initial density. However, regional culling was less than 15 birds per km². These results suggested that currently too few individuals are being removed from the Canberra population to effectively reduce population size. Natural reproduction, survival and/or immigration are able to replace the culled individuals.

This research highlighted the value of undertaking population modelling to assess if control measures are capable of achieving desired outcomes. This knowledge also will help drive innovation of new or complementary control measures.

1.2.6 Chapter 7 – Conclusion

Chapter 7 discusses the impact of the common myna on other bird species and potential management options for the control of this introduced species. An overarching finding of this thesis was the significant impact of habitat on species abundance. It is important to including both introduced species impact and habitat variables into analysis to disentangle the different impacts on native species. Similarly, habitat can influence the severity of introduced species impact and therefore potential management responses. Chapter 7 suggests that habitat restoration through tree planting may be an alternative method for common myna control.

1.3 Thesis summary

This thesis comprises five research articles that combine to provide a detailed investigation of the ecology of the common myna. This research adds significant new knowledge on the invasion sequence, species impact (type and severity) and population dynamics of the common myna. These findings are timely due to the growing concern about the impact of the common myna and attempts to control this introduced bird species.

1.4 Publication summary, candidate contribution and co-author acknowledgement

The material presented in this thesis is an accurate representation of research conducted during my candidature for the degree of Doctor of Philosophy between February 2008 and August 2013. This material is presented as contributions to the published scientific literature. These contributions are listed below in order of their appearance in this thesis:

- (i) Grarock, K, Lindenmayer DB, Wood JT, Tidemann CR (2013) Using invasion process theory to enhance the understanding and management of introduced species. A case study reconstructing the invasion sequence of the common myna (*Acridotheres tristis*). *Journal of Environmental Management*, 129(11): 398-409, doi:10.1016/j.jenvman.2013.08.005 (Appendix 1).
- (ii) Grarock, K, Tidemann CR, Wood JT, Lindenmayer DB (2012) Is it benign or is it a pariah? Empirical evidence for the impact of the common myna (*Acridotheres tristis*) on Australian birds. *PLoS ONE* 7(7): e40622. doi:10.1371/journal.pone.0040622 (Appendix 2).
- (iii) Grarock, K, Tidemann CR, Wood JT, Lindenmayer DB (2014) Are invasive species drivers of native species decline or passengers of habitat modification? A case study of the impact of the common myna (*Acridotheres tristis*) on Australian bird species. *Austral Ecology*, 39(1): 106-114, doi:10.1111/aec.12049 (Appendix 3).

- (iv) Grarock, K, Lindenmayer DB, Wood JT, Tidemann CR (2013) Does human-induced habitat modification influence the impact of introduced species? A case study on cavity-nesting by the introduced common myna (*Acridotheres tristis*) and two Australian native parrots. *Environmental Management*, 52(4): 958-970, doi:10.1007/s00267-013-0088-7 (Appendix 4).
- (v) Grarock, K, Tidemann CR, Wood JT, Lindenmayer DB (2013) Understanding basic species population dynamics for effective culling: A case study on community-led culling of the common myna (*Acridotheres tristis*). *Biological Invasions*, Online First: 5 November, doi:10.1007/s10530-013-0580-2 (Appendix 5).

The research, analysis and writing in the above publications was substantially (>90%) my own work. I am also the corresponding author for each publication.

Kate Grarock

Date:

Co-author acknowledgement:

Christopher R. Tidemann

Date:

Jeff T. Wood

Date:

David B. Lindenmayer

Date:

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