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The introduction and distribution history of the common myna (*Acridotheres tristis*) in New Zealand

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ABSTRACT

Throughout history, human movements have been a mechanism by which species are introduced to new environments. Although these introductions may sometimes be unintended, they have often occurred through organised effort and led to successful establishment outside a species' native range. The common myna (*Acridotheres tristis*) is an invasive bird species that has successfully established globally, including on New Zealand's North Island. To better understand the establishment of this invasive species, historical records of the myna's introduction and subsequent distribution were compiled and analysed. We determine that mynas were introduced into New Zealand repeatedly between the 1860s and 1880s, originating from stock acclimatised in Australia with strong links to Melbourne. Additionally, we track the changing distribution of the myna across New Zealand, allowing us to create a detailed timeline. Our findings are discussed in the context of the motivations behind myna introduction, and public response to their introduction and spread.

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Introduction

The introduction of species to habitats outside their native range has led to significant ecological changes throughout history. Depending on the species, introductions have been justified for reasons such as economic benefit and resource stability, aesthetic purposes, companionship, or targeted attempts at environmental modification (Vitousek et al. 1997; Keller et al. 2011). Some introduced species succeed and become naturalised in their new habitats and can even become invasive – causing harm to the environment, economy, or human health (Mack et al. 2000; Pyšek and Richardson 2010). Studying the establishment history of invasive species can inform approaches to mitigate their spread, for example by identifying and monitoring areas at highest risk of invasion, and is

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important in predicting or preventing future invasions (Mooney and Cleland 2001; Duncan et al. 2006; McGeoch et al. 2016).

The common myna (*Acridotheres tristis*; also termed Indian myna) is a medium-sized passerine bird in the Sturnidae (starling) family. It is native to southern Asia and has successfully established well outside its native range, earning it a place on the IUCN Top 100 Invasive Species List (Lowe et al. 2000). Mynas were deliberately introduced to control agricultural insect pests in many countries, including Australia and New Zealand, self-introduced to many others, and are now present in every continent except Antarctica (Long 1981; Baker and Moeed 1987; Ehlers Smith et al. 2020; Invasive Species Compendium 2022).

The incompleteness of the data used in overviews of myna introduction to New Zealand has been identified by multiple authors (Wellwood 1968; Sowman 1981; Moulton et al. 2012). These overviews are typically based on Thomson (1922), a report that attempts to explain the myna's introduction to New Zealand by providing information on a few selected introduction events, and retelling anecdotes of early myna distribution. The report also speculates that some recorded introductions of the noisy miner (*Manorina melanocephala*), a native Australian bird in the Meliphagidae (honeyeater) family, are instead Indian (i.e. common) myna introductions. Further, importation records of 'Australian' mynas (e.g. Acclimatisation Society 1878) create some ambiguity about whether these were common myna or noisy miner introductions. One often repeated, yet ambiguous statement from Thomson (1922) is that mynas were introduced to the 'centres' of New Zealand (Cunningham 1948; Oliver 1955; Baker and Moeed 1987; Grarock et al. 2012).

In contrast with the insubstantial literature investigating myna introduction, accurate and detailed data on myna distribution across New Zealand have been collected across several periods since their introduction (Thomson 1922; Stidolph 1940; Cunningham 1948, 1951, 1954; Bull et al. 1985; Heather and Robertson 1996; Heather et al. 2005; Robertson et al. 2007), with the most substantial long-term summary found in Heather et al. (2015). Although the distribution of mynas has been tracked with much more accuracy and detail than their introduction has, there is little published literature on myna distribution prior to 1940. Given that much of the information around myna introduction is based on Thomson's unclear and speculative 1922 book section, and that the post-introduction distribution data lack some temporal synthesis, a detailed history of mynas in New Zealand is missing from the literature. Here, we leverage the modern availability of searchable online databases, alongside existing archives and distribution maps, to document a more detailed and complete timeline of myna introduction and establishment in New Zealand. Our results are considered in the context of drivers of myna introduction, the public response, and the ecological impact of this introduction and spread.

Methods

To determine the introduction history and establishment of common mynas in New Zealand, we combined information from secondary literature in the form of journal articles, books, and histories of acclimatisation societies with archival primary literature, including newspaper reports. Starting from a list of secondary sources collected using an

initial exploratory Google Scholar search, additional relevant material was identified by searching through sources cited by or citing these works. We found further secondary sources that documented common myna introductions by searching Google Scholar alongside books and theses in the University of Auckland library catalogue using a combination of keywords and phrases; 'myna', '*Acridotheres tristis*', 'introduction', 'acclimatisation', 'New Zealand'.

A review of this literature helped inform the search for primary literature, most of which we conducted using the PapersPast digital archive (https://paperspast.natlib.govt.nz), which contains a wide range of newspapers, magazines, and journals published in New Zealand in the 19th and 20th centuries. PapersPast was searched using a similar set of keywords as used when searching for secondary sources (e.g. 'myna', 'introduction', 'introduced', 'acclimatisation'), as well as variations of the species common name (e.g. 'myna', 'minah', 'mina', 'mynah', 'maina') to capture the historical use of a variety of spellings for the species. This search revealed a wide range of relevant newspaper articles from diverse sources, including letters to the editor, import lists, records and reports from acclimatisation societies, editorials, and articles. In general, acclimatisation societies' records provided the most detailed and specific information for myna introductions.

As locations and dates of interest for the introduction of mynas became apparent, we contacted museums, Fish and Game New Zealand (the successors of the New Zealand Acclimatisation Societies), and public libraries across a number of districts aiming to gather relevant information which was not accessible in PapersPast or secondary literature. Records from Auckland Public Library and Archives New Zealand, Wellington were examined in person and documents scanned where relevant. The majority of relevant non-digitised records were acclimatisation society records from various districts, with introduction information typically found in societies' annual reports and/or cash books from the years surrounding myna introduction (1860s–80s). In some districts, original acclimatisation society records were not available from this period, such as in Hawke's Bay where early records were reportedly destroyed by the 1931 earthquake (Wellwood 1968), although in some cases this information had been published in newspapers and was therefore accessible through PapersPast.

Data analysis was completed using the qualitative analysis software package NVivo (initially NVivo 12, released March 2018, then updated to NVivo, released in March 2020, QSR International Pty Ltd), allowing for simple data organisation, comparison, and analysis. Document scans of relevant literature and primary resources were entered into NVivo. The coding function in NVivo was then used to categorise sections of each document into hierarchical categories (Supplementary Table S1) to sort and identify similarities and themes between files. This process allowed for initial introduction data to be separated from later distribution data across each district of New Zealand, and allowed introduction and distribution to be more easily tracked across time and space.

NVivo analysis enabled us to create a myna introduction timeline with a qualitative indication of the certainty around the dates and number of individuals introduced. Research revealed inconsistencies in the number and timing of recorded myna introductions. Uncertainty regarding an event was quantified primarily by assessing the number of unique primary sources referencing the same details of an event, while also

considering the number of unique references of an event in secondary sources, the length and quality of the information provided in primary/secondary sources, as well as any conflicting information. Some primary sources of information created uncertainty in the introductions they reported due to the frequency at which mynas were referred to as 'Australian'. This reduces the certainty that a report is referring to *Acridotheres tristis* and introduces the possibility that it is instead referring to the native Australian *Manorina melanocephala*, also known to have been introduced to New Zealand (Thomson 1922).

Results

Myna introduction

Through our systematic search of primary and secondary literature, we collected 15 journal articles, 13 books, 120 newspaper articles, 5 sets of documents, and one online database based on their relevance to the introduction or distribution of mynas in New Zealand. The primary literature spans from 1868 to 2022 (iNaturalist data accessed on 18/02/2022; www.inaturalist.org) while the secondary literature spans 1897–2022.

The earliest reliable record of myna introduction to New Zealand is the import of two birds to Nelson in 1868 (Supplementary Table S2). From this initial introduction until the end of 1875, the data show most myna introductions occurring in South Island towns. After 1875, the records show the majority of myna introductions occurred in North Island towns and localities, including several instances of birds sourced from within New Zealand. After 1878, no definitive records were found of mynas being imported from overseas (Figure 1; Supplementary Table S2). The final recorded myna introduction is an unknown number of birds sent in 1882 or 1883 from the Hawke's Bay Acclimatisation Society to the Poverty Bay Acclimatisation Society in Gisborne. In the early 1920s, there were rumours that some people supported the introduction of mynas into the Waikato district, however there is no evidence for this materialising (Supplementary Information).

Myna distribution

A detailed timeline of New Zealand myna distribution was created by synthesising information from many sources across a range of time periods. The timeline resulting from this synthesis is ordered by district and time period (Supplementary Information). We have recorded uncertainty to reflect distribution claims with contradictory or insufficient evidence.

After the initial introduction of mynas to several North and South Island population centres (New Plymouth, Gisborne, Napier, Hastings, Whanganui, Wellington, Nelson, Christchurch, and Dunedin; Figure 2), a number of changes occurred in their distribution. Following a decade or so of stability, the small populations existing in South Island town centres – Nelson, Christchurch, and Dunedin – began to reduce in number and disappeared from the South Island altogether by 1900. One notable exception is a small population that remained established in Richmond (near Nelson) until around the 1960s (Stidolph 1929; Falla et al. 1979; Sowman 1981).

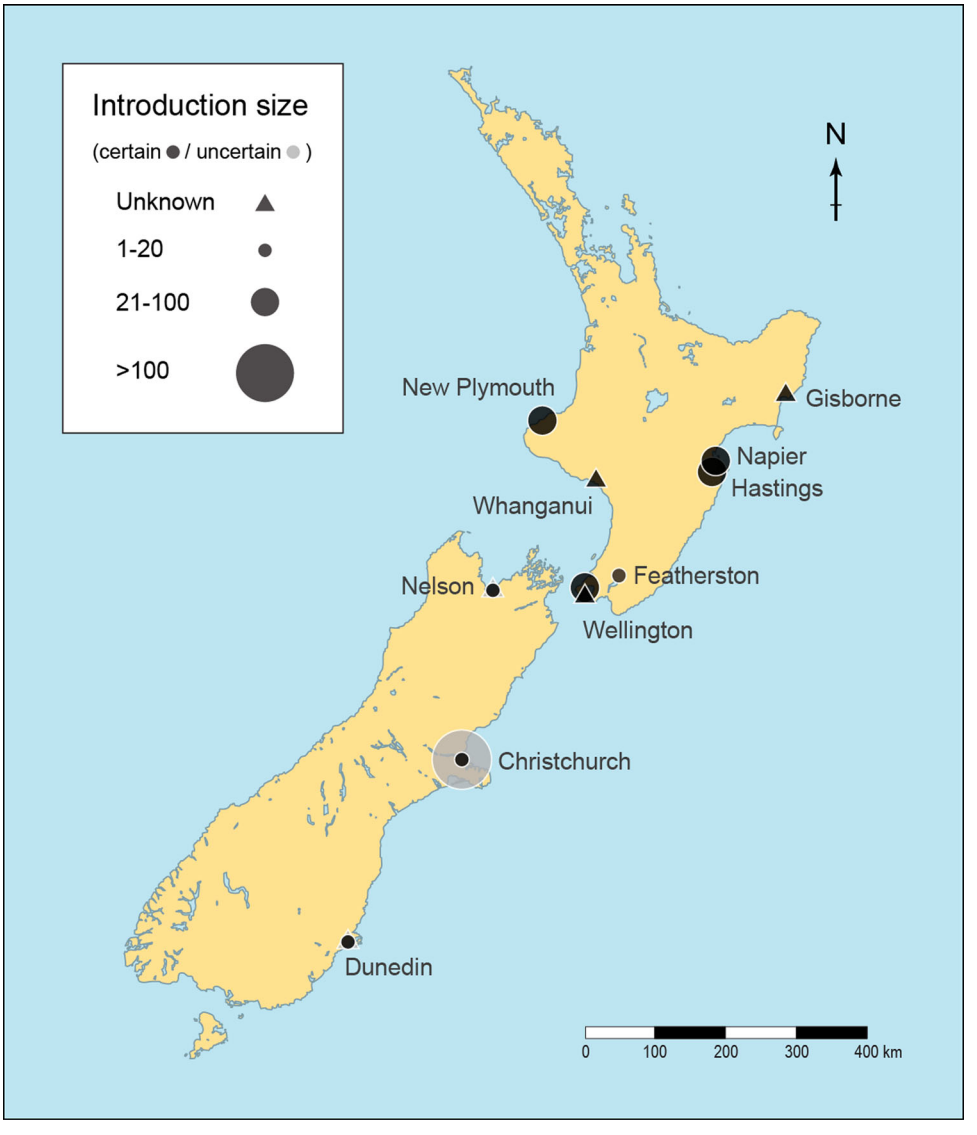

Figure 1. Introduction of mynas to New Zealand centres (1868–1883). Each point represents the sum of introductions to that location. 'Uncertain' introductions indicate those where records are unclear and may refer to the introduction of another species.

In the North Island, mynas quickly increased in number as they established across much of the cleared land in the districts they had been introduced to. By the 1910s, mynas were firmly established in the districts of Gisborne, Manawatu-Wanganui, Hawke's Bay, and Taranaki. By this time, mynas in the Wellington district began to reduce in number, becoming uncommon by 1922. This contraction of mynas' southern territorial boundary continued to move north until it reached the current locations by at least 1979, with some fluctuations since, but few mynas established below Whanganui on the West Coast, or below Hastings on the East Coast. In the last decade (2011–2021), counts of mynas have remained relatively stable across all North Island districts,

except for in the Wellington district where there has been a dramatic increase, possibly indicating a change in the myna's southern boundary (Hayman et al. 2021).

The northward territorial range expansion of mynas began in earnest in the 1920s, with sightings in 1922 and 1923 in Morrinsville and Te Mawhai marking their journey into Waikato. A Papakura sighting in 1940 and an Opotiki sighting in 1942 marked the beginning of their self-introduction into the Auckland and Bay of Plenty districts, respectively, and by the end of the 1960s, they had established up to the tip of the North Island (Falla et al. 1979; Figure 2).

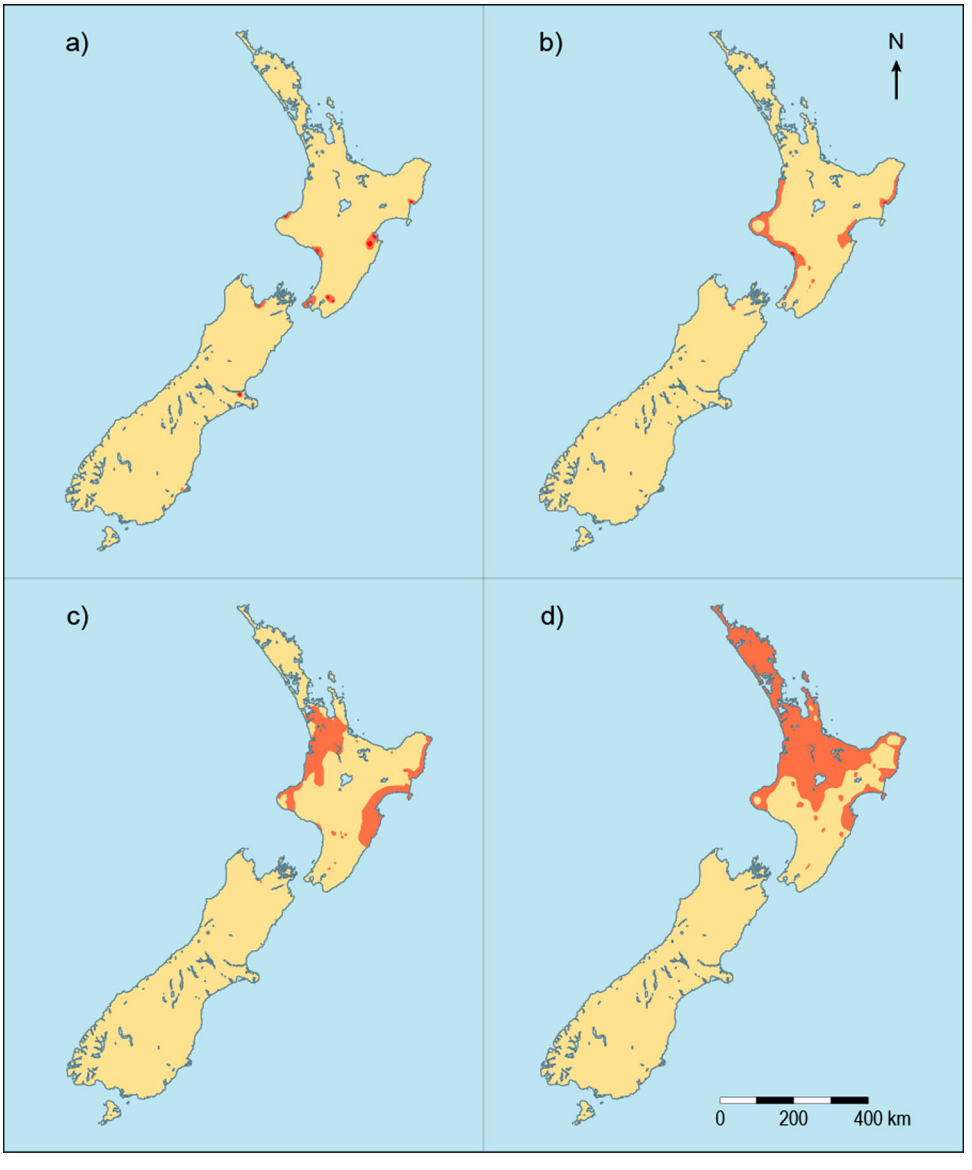

Figure 2. Myna distribution across New Zealand during four time periods, clockwise from top left; **A**, 1870s–80s, **B**, 1900s–10s, **C**, 1930s–40s, **D**, 1960s–2010s. See further detail of myna distribution over time in the Supplementary Information.

Discussion

Introduction and distribution

Our analysis of the available archival resources reveals some patterns in the introduction of the common myna into New Zealand. The introduction of mynas appears, from the available records, to have been largely overseen by regional acclimatisation societies with some input from private individuals – this is consistent with existing literature (Thomson 1922; Higgins et al. 2006). One pattern identified in the introduction data was that most introductions to the South Island occurred in 1875 or earlier, whereas most North Island myna introductions occurred after 1875. This may be due to differences in the towns or acclimatisation societies, with towns such as Nelson, Christchurch, and Dunedin being well-established compared to some introduction locations in the North Island. Mynas described as 'Indian' also tended to be imported in smaller batches (2–70) than mynas described as 'Australian' (8–184). This pattern makes the interpretation of mynas described as 'Australian' particularly significant, as including these imports to the total figures of myna introduction doubles how many birds are counted.

While most introduction reports did not specify the country or town of origin (other than the common use of the ambiguous 'Australian myna'), when it is specified, it is always listed as Melbourne or its state, Victoria (Supplementary Table S2). There is no evidence for mynas being imported directly from their native range in India to New Zealand, however the possibility of this had been discussed on at least one occasion (The Acclimatisation Society 1868; Supplementary Table S2). The absence of any other listed origin emphasises the importance of Victoria (and specifically Melbourne) as a source for New Zealand mynas. This adds more detailed information to that presented in existing literature, which typically names 'Australia' as the immediate origin of the New Zealand myna population (Thomson 1922; Stidolph 1940; Baker and Moeed 1979).

Another key finding in our research has been uncovering evidence for mynas being widely sent within New Zealand, from Wellington to the Wairarapa, from Wellington and Nelson to New Plymouth, and from Hawke's Bay to Gisborne (Supplementary Table S2). Intentional internal distribution has not been mentioned in key literature on New Zealand myna and has only been considered speculatively in casual discussions of their introduction (Anonymous 1907; Thomson 1922; Cunningham 1948; Baker and Moeed 1979). Distinguishing between international and domestic myna imports is important, firstly, because it allows for the exploration of the historical contexts underlying different import strategies, and secondly, it gives context to further study, for example, understanding the reason for genetic connectivity between distant populations, and exploring the genetic basis of adaptation in the species.

Our distribution timeline has highlighted some features of the spread of mynas across New Zealand over four evenly spaced time periods (Figure 2). The most clearly visible trend is the northward migration and southern contraction of the myna populations. Our data, along with previous reports, show this movement taking place from introduction until the population boundaries became more or less established at their current position in the mid-1960s (Figure 2; Heather et al. 2015). New Zealand covers a broad latitudinal range, with its climate ranging from warm subtropical in the northern North Island to cool temperate in the southern South Island. The mynas' range

movement therefore reflects their global ecological preference for less extreme habitat seasonality (Magory Cohen et al. 2019). Further, the reliance of mynas on anthropogenic environments is reinforced with both historical and current data revealing sightings in almost exclusively urban or farmed environments in New Zealand (Drummond 1909; Stidolph 1940; Bull et al. 1985; Robertson et al. 2007; Spurr 2012). This behaviour is echoed when looking at overall distribution through time; the main areas without myna coverage in the North Island have consistently been the areas with the least human activity, typically dense native bush (Figure 2). This is also consistent with global literature that describes the myna as most successful in human-modified environments (Cunningham 1948; Cramp and Perrins 1994; Heather and Robertson 1996; Higgins et al. 2006; Magory Cohen et al. 2019). The overall pattern of northward migration and southern contraction reflects descriptions in the literature; however, the recent records of myna in the Wellington district signal a potential range expansion to the south.

Although the overall temporal trends in distribution are aligned with the extant literature, exploring outliers in distribution since the introduction of mynas to New Zealand illustrates the adaptability of mynas in the anthropogenic environment. While maps of distribution (e.g. Bull et al. 1985) have often sidelined South Island myna sightings, the small remnant population surviving in Richmond, near Nelson, until about the 1960s serves as an interesting outlier highlighting how locally resilient myna populations may persist outside of a generally accepted distribution (Cunningham 1948; Sowman 1981). This resilience can also be seen in reports of remnant populations of myna surviving below the generalised southern limit through the exploitation of concentrated resources available at specific sites such as landfills (Heather and Robertson 1996). The non-migratory nature of mynas compared with their sporadic appearance in the South Island suggests mynas are capable of travelling over longer distances independent of human efforts (e.g. as aviary escapees or accidental maritime stowaways). This raises the interesting possibility of early myna introductions in parts of New Zealand occurring independently from direct human intervention.

Limitations

Studying historical species introductions comes with an inherent level of uncertainty, which is only magnified when relying on incomplete historical data. Four key issues are important to highlight. First, many reports of introduction record imported mynas as 'Australian', which presents ambiguity as to whether these imports represent common myna (*Acridotheres tristis*) or noisy miner (*Manorina melanocephala*) introductions. There is good evidence that noisy miners were introduced to both Wellington and Otago (Wellington Acclimatisation Society 1884; Otago Acclimatisation Society 1885; Thomson 1922). Additionally, in one Wellington report, an importer promotes the 'Australian minah, indigenous to Victoria, New South Wales, and Tasmania' (Acclimatisation Society 1878). No populations of noisy miner appear to have become established after many of these 'Australian myna' introductions, or alternatively, any introduction would have been short-lived (Thomson 1922). Given there is tentative evidence that some myna introductions were actually noisy miners, we have classified several introductions of birds described as 'Australian myna' as uncertain.

A second limitation within our study is that acclimatisation society records from many New Zealand districts during the time period of myna introduction are missing, and private introductions are only known about through surviving newspaper reports (Sowman 1981). This means that most of our historical research relies on newspaper accounts impacted by the inaccuracy and conflicting data inherent in secondary sources, as well as information from sources with varying levels of expertise (Hill 1879; Anonymous 1907). These types of data are also affected by biases relating to which groups and stories are more likely to be published. The values and interests of an introducer or a newspaper editor, as well as the ability for an introduction to be reported, are just a few factors contributing to the uncertainty regarding the true number of introductions of myna into New Zealand, either privately or through a society.

Third, despite the large amount of coverage of digitally archived newspapers held on PapersPast, the Optical Character Recognition (OCR) technology used to make the database searchable is far from perfect, meaning that search terms only reveal results where the OCR identified these words in the text. As the PapersPast archives continue to grow and as OCR technologies improve, this database's inherent limitations will be minimised.

Finally, the application of the introduction data is limited by the variable recording of different types of myna movement. Pipek et al. (2015) highlight issues that can arise when authors misunderstand and misuse introduction data, such as differences between domestic and international bird importation, or between introductions and releases. We have differentiated between international and domestic imports, and imports of uncertain origin, in an attempt to prevent this misunderstanding.

Broader historical context

Our research into the history of myna in New Zealand has uncovered a number of people voicing strong opinions about the species and its introduction. The strength of these opinions is exemplary of how interconnected the common myna is with human activity, and how well it succeeds in human-managed environments. Acclimatisation societies formed in New Zealand in the 1860s and 1870s with the goal of introducing and establishing any foreign species considered in some way 'useful', including introducing insectivorous birds (Wellington 1871; Otago Acclimatisation Society 1885; McDowall 1994). During this period, farmers and gardeners across the country were suffering significant crop damage from insects and were making calls for the introduction and acclimatisation of foreign insectivorous birds (Insects and Birds 1861; The New-Zealander 1864; On insects injurious to agriculture 1865; The Acclimatisation Society 1867). Mynas were only one of many insectivorous bird species to be introduced to New Zealand (The Evening Herald 1870; Otago Acclimatisation Society 1885).

Once mynas became established, members of the public were quick to raise alarm about the bird's undesirable behaviours, including reports about dietary flexibility (consuming not only insects but also fruit and grain), aggressive behaviour, and spreading weeds and disease (Local and general 1884; A national curse 1898; Drummond 1912; Nightingales for New Zealand 1927). The myna's usefulness was defended particularly strongly around the time of its introduction, with supporters of introduction justifying

the cost incurred through its fruit and grain-eating by its value in controlling insects (Acclimatisation 1877; Talk of the week 1877; 'The small bird nuisance' in Parliament 1886). Whilst some concern was raised about the impact of mynas' aggressive behaviour on introduced and native bird species, their impact on other animals was mainly considered in terms of agricultural impact, which was central to debates around management that continued well into the twentieth century (A. & P. Society 1932; Cunningham 1951).

The unsuccessful outcome of the myna's introduction (in contrast with its intended effect) was seen by some as representative of a disparity between the out-of-touch urban members of acclimatisation societies whose introductions end up harming the rural settler (Stratford and Ngaire 1882; Tikorangi 1889). Imports of mynas from Victoria to New Zealand continued through the 1870s, despite the 1867 Victorian legislation protecting 'all birds' being amended in 1871 to specifically remove protection from mynas (An Act to Protect Game 1867; An Act to amend an Act intituled 'An Act to Protect Game' 1871). This seeming discord of opinion between and within interested parties (farmers, home gardeners, acclimatisation society members, and parliamentarians) is juxtaposed by the many linkages between acclimatisation societies and members of the community demonstrated by the rapid domestic distribution of mynas in several locations in the North Island (Supplementary Information).

Conclusion

The findings from the distribution data are relevant to control efforts through the opportunities it creates to complement and inform further research. Using the distribution findings to follow the species' nearly century-long journey to establish itself within its current boundaries may enable further understanding of the ecological constraints that are currently limiting the species' distribution, and how habitat suitability may change with climate change (Hellmann et al. 2008). Similarly, the variable conditions under which smaller populations of mynas were able to hold on in locations further south than their current boundary could also be investigated to discover what conditions discourage the establishment of mynas. Knowledge of the historical connectivity between current-day myna populations is also likely to inform research into the genomic basis of rapid adaptation in the species (North et al. 2021). Overall, using historical data to better understand how invasive populations are founded and how they spread will be useful in the effective management of other local and global invasive species.

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