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How the Yellowhammer became a Kiwi: the history of an alien bird invasion revealed

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Abstract

New Zealand harbours a considerable number of alien plants and animals, and is often used as a model region for studies on factors determining the outcome of introductions. Alien birds have been a particular focus of research attention, especially to understand the effect of propagule pressure, as records exist for the numbers of birds introduced to New Zealand. However, studies have relied on compilations of bird numbers, rather than on primary data. Here, we present a case study of the alien yellowhammer (*Emberiza citrinella*) introduced from the UK to New Zealand, to demonstrate how recourse to the primary literature highlights significant data gaps and misinterpretations in these compilations. We show that the history of the introduction, establishment and spread of the yellowhammer in New Zealand can be reconstructed with surprising precision, including details of the ships importing yellowhammers, their survival rates on board, the numbers and locations of release, and the development of public perception of the species. We demonstrate that not all birds imported were released, as some died or were re-transported to Australia, and that some birds thought to be introductions were in fact translocations of individuals captured in one region of New Zealand for liberation in another. Our study confirms the potential of precise historical reconstructions that, if done for all species, would address criticisms of historical data in the evidence base for the effect of propagule pressure on establishment success for alien populations.

Keywords
Bird invasion, establishment, introduction, invasion history, native range, New Zealand, propagule pressure, release, shipping

Introduction

Propagule pressure is widely accepted as one of the key factors determining the outcome of biological invasions (Lockwood et al. 2005, 2009; Duggan et al. 2006; Simberloff 2009; Blackburn et al. 2011b). If the numbers introduced are large enough, they have the potential to overcome the biological constraints of the invading species, and the intrinsic resistance of biological communities to the establishment of alien species (D'Antonio et al. 2001; Von Holle and Simberloff 2005). For these reasons, it has been suggested that propagule pressure should be used as a null model for studies of biological invasions that attempt to infer processes from patterns (Colautti et al. 2006). Unlike for plants, where metrics derived from the intensity of human activities (e.g. Daehler 2006; Křivánek et al. 2006; Chytrý et al. 2008) are usually used as proxies for propagule pressure (e.g. Wonham et al. 2013), analyses of bird invasions are often based on direct data on numbers derived from historical records of introductions (Blackburn et al. 2009). Nevertheless, the quality of data on bird propagule pressure is increasingly being questioned in the literature (Moulton et al. 2011, 2012a, b; Santos 2012), and this criticism has even been used to question the importance of propagule pressure as a key driver of establishment success.

The introduction of alien birds to New Zealand has been one of the key model systems for studying the effects of propagule pressure in historical data (e.g. Dawson 1984; Veltman et al. 1996; Duncan 1997; Green 1997; Sol and Lefebvre 2000; Cassey 2001; Duncan and Blackburn 2002; Brook 2004; Møller and Cassey 2004; Duncan et al. 2006; Blackburn et al. 2011a; Moulton et al. 2011). Bird introductions there started in the middle of the nineteenth century, under the auspices of a range of Acclimatisation Societies (Figure 1) founded with the express aim of naturalising alien species (McDowall 1994). New Zealand is an isolated archipelago, some 2,000 km from the nearest major landmass (Australia), and so introduced species had to be shipped there. Records from shipping and the Acclimatisation Societies mean that information on what was imported is relatively well delineated, compared to the situation in most continental areas. Nevertheless, the data on the importation and release of birds to New Zealand on which analyses of the effect of propagule pressure are based are not perfect, suffering from a variety of errors and problems of interpretation.

First, as pointed out by Moulton et al. (2012a), studies on the role of propagule pressure in bird introductions to New Zealand are mostly based, directly (e.g. Veltman et al. 1996; Blackburn et al. 2011a) or indirectly (e.g. Green 1997) through secondary sources (Long 1981; Lever 2005), on an influential book by the New Zealand

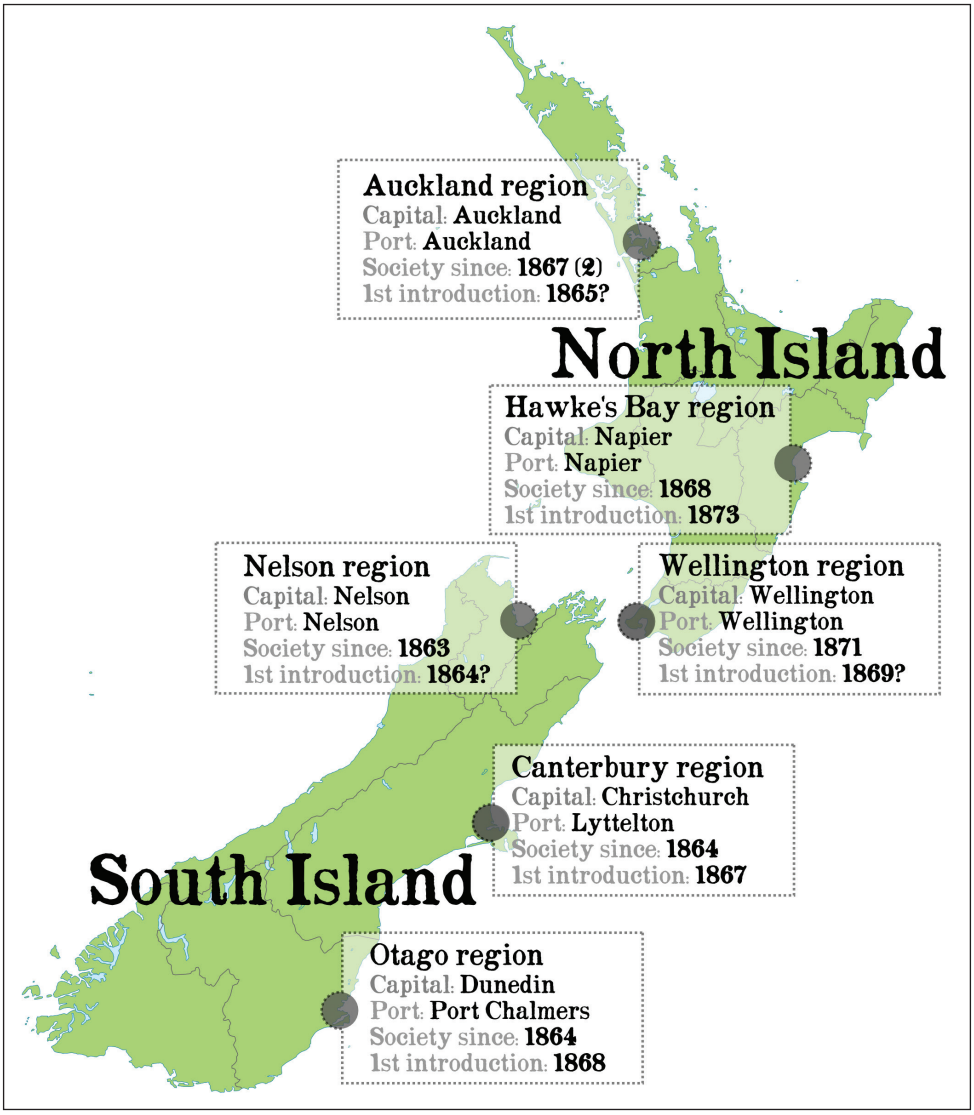

Figure 1. A map of New Zealand identifying the locations of the principal Regional Acclimatisation Societies.

naturalist George Malcolm Thomson. Thomson (1922) provides an extensive compilation of records of attempts to acclimatise species to New Zealand. Unfortunately, despite the volume of data it contains, the book suffers from significant information gaps. Thomson primarily based his research on the reports of the Acclimatisation Societies. These reports were sometimes poorly kept, and sometimes incorrectly interpreted by Thomson (1922). For example, a significant shipment of birds reached the Canterbury Acclimatisation Society in 1875, but in that year the Society did not pub-

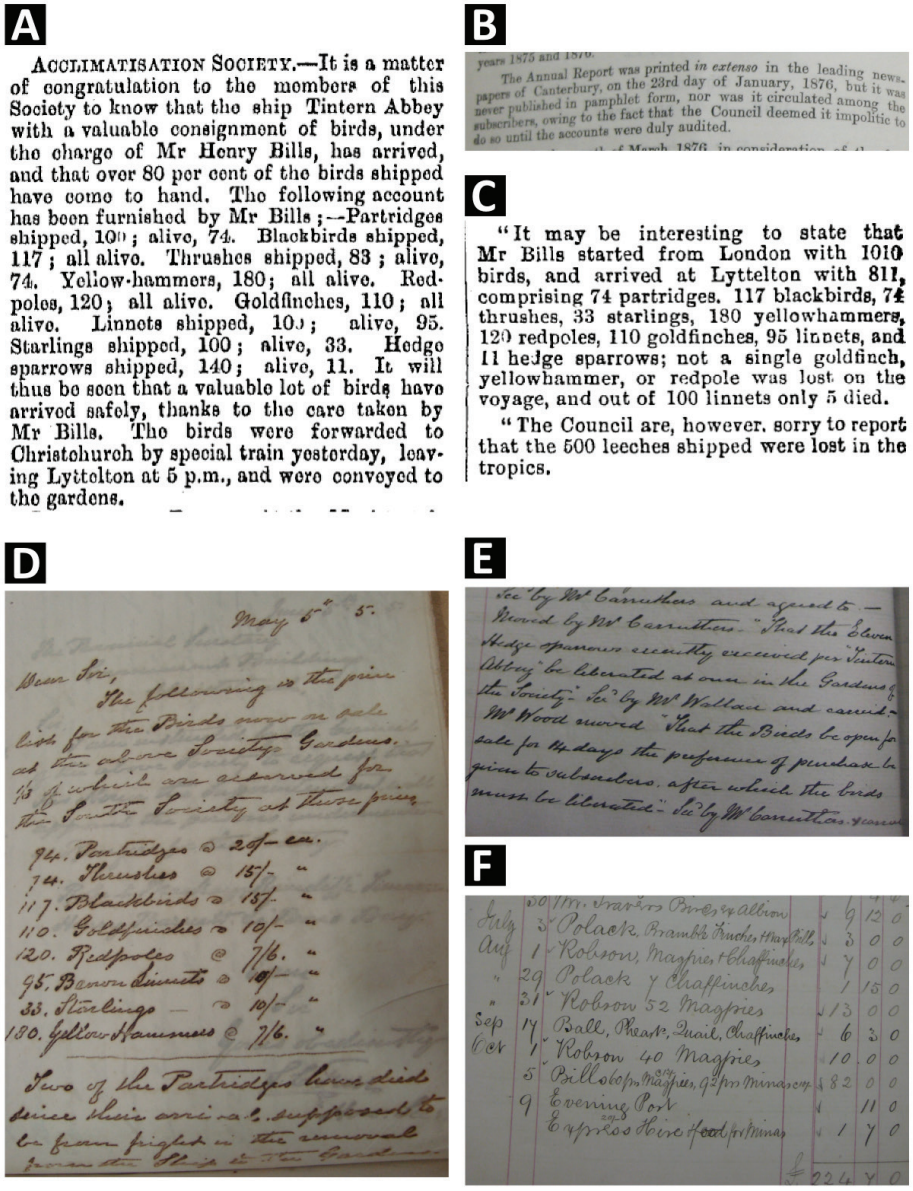

Figure 2. Examples of resources (extracts) used, five of which concern the shipment of birds on the Tintern Abbey. **A** Article about the arrival of the ship (Star 5 May 1875, Page 2) **B** the Twelfth and Thirteenth Annual Reports of the Canterbury Acclimatisation Society (Archives New Zealand, Christchurch Regional Office, CH1002/37/b) **C** The preliminary annual report published in a newspaper (Press 21 January 1876, Page 2) **D** letter of the Canterbury Acclimatisation Society confirming numbers **E** Minutes of the Canterbury Acclimatisation Society (Archives New Zealand, Christchurch Regional Office, CH1002/1/a) **F** Cashbook of the Wellington Acclimatisation Society (ref. number MSX-6860). Reprinted with the permission of the Christchurch Regional Office of Archives New Zealand (**B, E**), Christchurch City Libraries (**D**) and the National Library of New Zealand in Wellington (**F**).

lish its annual report in pamphlet form due to problems in accounts that had to be audited (Canterbury Acclimatisation Society 1877). The full text of the annual report was published only in a newspaper (Press 21 January 1876, Page 2), and information on the shipment is therefore not included in Thomson's book.

Second, the further in time from the date of publication of the original source of data on bird introduction, the higher the probability that those data will be interpreted erroneously. For example, Lever (2005) incorrectly interpreted the (already incomplete) data in Williams (1969) about introduction events in Canterbury, assuming that a request in 1873 by the Canterbury Acclimatisation Society for 108 yellowhammers (Star 23 March 1872, Page 2) was met. In reality, only 34 birds reached Canterbury in this shipment (Star 3 March 1873, Page 2).

Third, some of the birds released in New Zealand were actually born there, being captured in one part of the country and sold to another. These individuals were therefore not introduced, but rather translocated. For example, Thomson (1922) states that 32 yellowhammers were released on Stewart Island, and subsequent authors (e.g. Moulton et al. 2012a) count them as an introduction to New Zealand. These birds were, however, caught in Otago (Otago Daily Times 13 May 1879, Page 3). Translocations were even more prevalent in skylarks (*Alauda arvensis*). Williams (1969) says that 300 skylarks were distributed in South Canterbury in 1875, but these 300 birds were ordered from Nelson (Timaru Herald 29 October 1875, Page 4); furthermore only 165 of them survived (Timaru Herald 12 November 1875, Page 3)!

Fourth, some of the birds reported to have been introduced to New Zealand actually never made it into the wild: some died (e.g. Auckland Acclimatisation Society 1868; Daily Southern Cross 4 April 1871, Page 3), while others were re-transported to Australia (Press 27 March 1880, Page 3). Not surprisingly, given these complications, there is variation in the numbers of introduced individuals reported by individual authors (see Moulton et al. 2011); some works apparently underestimate the numbers (e.g. Thomson 1922; Lever 2005; Blackburn et al. 2011a), whilst others overestimate them for certain regions (Veltman et al. 1996; Duncan 1997). However, this of course raises the question of what was the actual number of birds introduced, and how much more accurate an estimate of this number can we get by mining historical sources?

Here, we explore data on historical introductions of the yellowhammer (*Emberiza citrinella*) to New Zealand, to show how much we can improve the knowledge of introductions if more sources, such as newspaper clippings and documents kept by Acclimatisation Societies (cashbooks, letters and minutes; Figure 2), are systematically explored. We aim to demonstrate how imprecise information can be propagated from one source to another, but that by going back to the primary sources of information (and avoiding "second-hand" resources), many uncertainties and inconsistencies that stem from using incomplete compilations can be eliminated (see also Moulton et al. 2011, 2012a; Haemig 2014). Finally, by correcting some erroneous data and pointing to misinterpretations in other treatments, we provide the most accurate information to date on yellowhammer introductions to New Zealand.

Methods

Newspapers

Newspapers from the 1840s onwards have been digitised by National library of New Zealand and made available online without any restriction through Papers Past (paperspast.natlib.govt.nz); this was launched in 2001, with 250,000 pages from historic New Zealand newspapers. New titles have been added regularly since then, and the whole site was re-launched in 2007 with a new interface that added full text search for a third of the collection. The whole collection was made searchable by mid-2009, allowing every short note referring to our focal species to be located. Newspapers have previously been used as data sources in ecological studies (Lamb 1964; Sowman 1981), but for obvious reasons, digitisation provides a major boost to their utility.

We searched Papers Past with search strings that included 'yellowhammer' in singular and plural, with/without a space between 'yellow' and 'hammer', and allowing for all sorts of possible typographical errors, which have been introduced to the text through the optical character recognition software used in digitisation (e.g. o or c instead of e, U instead of ll, b or li instead of h, v instead of y, rn instead of m, etc.). We also searched Papers Past for yel*mer*, as * represents any group of characters, again allowing for the aforementioned typographical errors.

After identification of ships bringing yellowhammers, and years of introduction, more directed keyword searches were used in order to understand the pathways by which the birds arrived (examples include: name of the ship; birds + liberated; Mr. Bills). Other details were searched directly, e.g. the address of certain purchasers of the birds, routes of ships. For additional information we also searched through archives of Australian (trove.nla.gov.au/newspaper) and British (newspaperarchive.com; www.bl.uk/reshelp/findhelprestype/news/newspdigproj/database) newspapers.

Resources kept by Acclimatisation Societies

In addition to the availability of newspaper archives, access to original data records made by Acclimatisation Societies is facilitated by the friendly attitude of New Zealand libraries towards researchers. We obtained the reports of three principal Societies – Auckland, Canterbury and Otago – from various libraries in New Zealand, which fully cover the period in which yellowhammers were introduced there (1863–1875). Beside reports, some Societies kept letter books, cashbooks and minutes, and we also obtained access to these records via the same libraries.

Other resources

There are also several original books and papers concerning bird introductions that date from the period when yellowhammers were being introduced to New Zealand (Taylor

1868; Hutton 1871; Wilson 1875) or from the early 1900s (Drummond 1906; Andersen 1916), including Thomson's well-known book and other compilations (Thomson 1922; Lamb 1964; Ashby 1967; Williams 1969; McDowall 1994; Veltman et al. 1996; Sullivan 1998). These sources served as a check on our searches of primary sources – if any information included in these secondary sources was new to us, we searched for its original source. We used information obtained from all of these resources to produce a comprehensive history of the introduction of the yellowhammer to New Zealand.

Results and discussion

Reasons for introduction

Contrary to common belief, fed also by some naturalists (Chrisholm 1907), yellowhammers and other small passerines were not introduced from Britain to New Zealand for sentimental reasons, but for a purely practical one: as a biological control agent to reduce the populations of insect pests (Wellington Independent 17 April 1852, Page 2; Lyttelton Times 19 February 1862, Page 3; Daily Southern Cross 4 April 1863, Page 3; Canterbury Acclimatisation Society 1867), most notably army worms (caterpillars of *Mythimna separata*) and black field crickets (*Teleogryllus commodus*) (Daily Southern Cross 19 March 1861, Page 3). Native bird species were obviously not able to do the job because their populations were retreating in step with their diminishing habitats (Wellington Independent 20 July 1865, Page 5). In 1868, Canterbury Acclimatisation Society even decided not to allow introductions of any animal species that were not useful for humans, in order not to waste the time of the Society's Curator (Canterbury Acclimatisation Society 1868). That said, the beauty of the yellowhammer's song was mentioned when the benefits of introductions were discussed in newspapers (Lyttelton Times 20 October 1864, Page 3). The pleasure derived from their songs, as a reminder of 'home', was a welcome bonus to the original pragmatic reason for introduction (New Zealand Herald 19 December 1872, Page 2).

It is rather surprising that the yellowhammer was introduced as a biological control agent for outbreaks of insect pests, as it is a mainly granivorous bird. Indeed, the list of species for introduction surprised even contemporary New Zealand naturalist Richard Taylor, who pointed out that the very same species (particularly sparrows) were targets of negative campaigns in their home country just a few years back (Taylor 1868). Yet, in New Zealand, the yellowhammer was initially regarded as a strictly insectivorous species (Otago Witness 15 October 1864, Page 4), desirable for introductions and protected by law (Nelson Examiner 12 January 1864, Page 6) and one of the most useful birds (Auckland Star 7 June 1870, Page 2). Yellowhammers were also regarded as beneficial (The Star, 10 January 1862, Page 1S) and almost purely insectivorous (Empire 12 July 1864, Page 2; Australian Town and Country Journal 25 June 1870, Page 19) in Australia. In 1863 the obvious granivory of yellowhammers, long known to British farmers (Quarterly Journal of Agriculture 7, 1837; Stephens 1851), was even questioned in England (The South Australian Advertiser 4 May 1863, Page 3, citing

Newry Examiner; Brighton Herald 26 November 1870). Despite early complaints by farmers (Lyttelton Times 22 January 1866, Page 4; Auckland Star 31 August 1875, Page 2), it took members of Acclimatisation Societies more than 15 years to realise their mistake; only as late as 1880 did the yellowhammer finally appear on the list of granivorous birds (North Otago Times, 13 March 1880, Page 2).

It would be tempting on the basis of this history to view the Acclimatisation Societies as peopled by amateurs, but this was far from the case. Their members included respected scientists, albeit with primary areas of expertise that did not encompass ornithology (e.g. botanists Thomas Kirk and Thomas Frederick Cheeseman – Auckland Acclimatisation Society 1873, 1876; doctor and historian Thomas Hocken – Otago Acclimatisation Society 1867; geologist Julius von Haast – Canterbury Acclimatisation Society 1866), as well as prominent members of government (e.g. the Governor of the New Zealand, George Grey – Otago Acclimatisation Society 1865; the Prime Minister of New Zealand, Frederick Weld – Canterbury Acclimatisation Society 1866), and thus may be viewed as relatively authoritative groups. Rather, this history illustrates the huge gap that existed between scientific and agricultural experience at the time, in England and New Zealand alike.

Capture in the native range

All yellowhammers imported to New Zealand were obtained in the United Kingdom, although we cannot rule out completely the possibility that some of them were caught in continental Europe and subsequently transported to UK markets, as was documented for goldfinches from Portugal (The Mercury 3 June 1871, Page 3). The origins of at least some of the yellowhammers are known with surprising precision. According to reports of the Otago Acclimatisation Society, only 39 yellowhammers came to Port Chalmers (Otago) and were released into nature (Fourth Annual report of the Otago Acclimatisation Society extracted from Otago Acclimatisation Society's Minutes; Otago Acclimatisation Society 1871). All these birds were personally collected in Brighton by Richard Bills (initially referred to as Edward Bills, although subsequent articles confirmed that Richard and Edward were one and the same), former respected bird fancier (Press 25 February 1871, Page 3), or several potentially by his wife (Otago Witness 8 February 1868, Page 5), and probably caught not far away from the city (Star 30 January 1871, Page 2); eight in 1868 (Daily Southern Cross 30 December 1867, Page 2; North Otago Times 4 February 1868, Page 2) and 31 from various districts around Brighton in 1871 (Press 25 February 1871, Page 3; Otago Witness 4 March 1871, Page 6). The first large transportation of yellowhammers to Canterbury (on the Charlotte Gladstone in 1873) was also arranged by Richard Bills (his services being more and more in demand, Otago Daily Times 4 May 1871, Page 3), and the birds were also collected in Brighton (Star 30 November 1872, Page 2). Later, an even larger transportation to Canterbury (on the Tintern Abbey in 1875) was organised by Richard's son Henry Bills, after his father retired to a sheep farm in Australia (Otago Witness 12 February 1876, Page 18). Henry

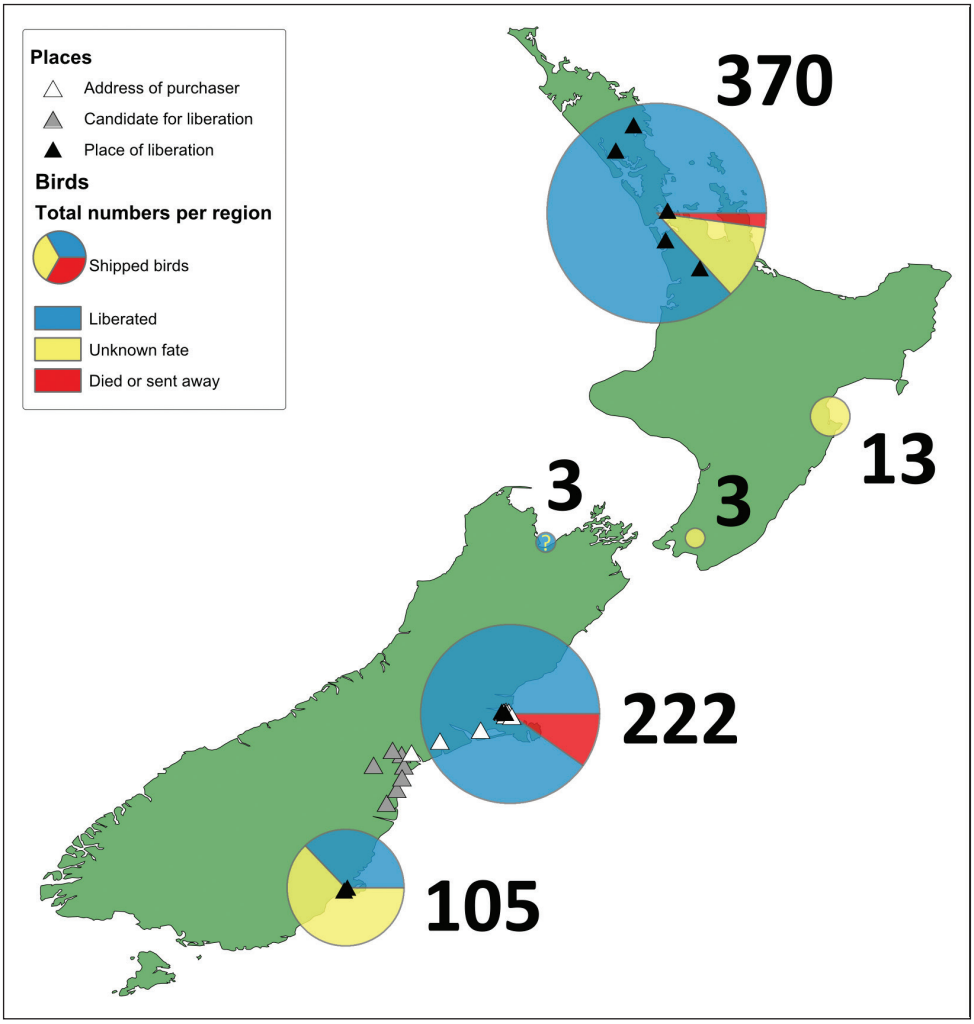

Figure 3. The total numbers of yellowhammers imported into individual regions of New Zealand. The piecharts show the proportions of birds with different fates (see inset legend).

lived in London when collecting birds (Press 20 January 1875, Page 2), and so the origin of these birds could therefore have been quite different.

Transport

In total, 25 ships can be identified heading to New Zealand with yellowhammers on board, all but one of which departed from London or Gravesend. The majority sailed to Auckland, although the numbers of birds arriving to South Island and North Island are similar (~330 vs 386; Figure 3). Details of individual ships are listed in Table 1.

Table 1. List of ships known to have been importing yellowhammers to New Zealand. In case that different numbers of arriving/departing birds are reported, those we consider more likely to be correct are in bold.

Name	From	To	Departure	Arrival	Loaded	Survived	Note	Source
Flying Fish		Auckland	first half of 1859		NA	NA	Only information available is that yellowhammers were sent via her to Auckland	Stamford Mercury 12 August 1859, Page 3
Aloe	Gravesend	Auckland	5th Feb 1863	7th Jun 1863	NA	4	In total 112 birds loaded, among them 24 yellowhammers and chaffinches = no more than 23 yellowhammers loaded. Overall only 10% (12 birds) survived	Otago Witness 11 July 1863, Page 5; Daily Southern Cross 9 June 1863, Page 3
British Empire	Gravesend	Lyttelton	15th May 1864	6th Sep 1864	12	2	Private effort of Mr. Prince	Lyttelton Times 10 September 1864, Page 5; Press 7 September 1864, Page 2
Violet	London	Nelson	16th Mar 1864	5th Jun 1864	48	0 or **8**	One article claim, that all had died, however, according to other 8 have arrived, which is more likely, as before the arrival of Violet no yellowhammers were present in the colony. The same holds for all-dying chaffinches.	Colonist 12 July 1864, Page 5; Nelson Examiner and New Zealand Chronicle 7 July 1864, Page 2
Novelty	London	Auckland	before 6th Nov 1867	8th Feb 1868	NA	4	However, 3 of them died after arrival	New Zealand Herald 10 February 1868, Page 3
Empress	Gravesend	Auckland	3rd Dec 1867	28th Mar 1868	NA	5	Information from reports. In total 400 birds loaded, 200 arriving.	Daily Southern Cross 14 March 1868, Page 4; Wellington Independent 19 March 1868, Page 4
Warrior Queen	London	Port Chalmers	21th Oct 1867	28th Jan 1868	12	8	Birds coming from Brighton area, released in Society's garden. Bills travelling with his son.	Daily Southern Cross 30 December 1867, Page 2; North Otago Times 4 February 1868, Page 2
Matoaka	London	Lyttelton	16th Nov 1867	11th Feb 1868	NA	1		Lyttelton Times 4 March 1868, Page 4
Blue Jacket	Gravesend	Lyttelton	7th Aug 1868	30th Oct 1868	NA	5		New Zealand Herald 28 November 1868, Page 6
Wild Duck	London	Wellington	1st Oct 1868	5th Jan 1869	NA	NA	Loaded 36 chaffinches and yellowhammers, 3 yellowhammers and 10 chaffinches sold on the market, should be total number, as almost all birds were sold.	Hawke's Bay Herald 12 January 1869, Page 3; Hawke's Bay Herald 23 January 1869, Page 3

Name	From	To	Departure	Arrival	Loaded	Survived	Note	Source
City of Auckland	London	Auckland	19th Oct 1870	29th Jan 1870	NA	NA	40 birds in total, just 14 survived, some of them could be yellowhammers as the Society bought some before 9th March 1870	New Zealand Herald 2 February 1870, Page 3; Auckland Acclimatisation Society 1870
Inflexible	London	Auckland	22nd Dec 1869	3rd Apr 1870	24	**10** or 18		New Zealand Herald 4 April 1870, Page 3; Wellington Independent 12 April 1870, Page 3
Mary Shepherd	London	Auckland	1st Feb 1870	29th May 1870	120	**40** or 30		Daily Southern Cross 5 April 1870, Page 4; New Zealand Herald 30 May 1870, Page 3; Daily Southern Cross 30 May 1870, Page 3 (30)
Schiehallion	London	Auckland	23th Feb 1870	4th Jun 1870	**128** or 130	5	Claimed to be third shipment of yellowhammers, however wrongly (see above)	Auckland Star 7 June 1870, Page 2; Daily Southern Cross 7 June 1870, Page 3 (130); New Zealand Herald 6 July 1870, Page 6
Queen Bee	London	Auckland	22th Oct 1870	8th Feb 1871	140	NA	No information about its arrival	New Zealand Herald 10 January 1871, Page 2; Daily Southern Cross 6 February 1871, Page 3
Warrior Queen	London	Port Chalmers	28th Nov 1870	25th Feb 1871	50	31	Birds coming from Brighton area, released in Cavernsham	Colonist 4 April 1871, Page 4; Otago Daily Times 4 March 1871, Page 2
Caduceus	Gravesend	Auckland	16th Dec 1870	23rd Mar 1871	250	128 or **125**	5 died after arrival. 120 (60 pairs) released in Domain	New Zealand Herald 6 April 1871, Page 2; Daily Southern Cross 4 April 1871, Page 3
Alexandrina	London	Auckland	5th Feb 1871	4th Jun 1871	250	NA	Experienced a heavy thunderstorm, however, it must brought at least 100birds. Liberated in Whangarei.	Daily Southern Cross 9 May 1871, Page 2
Countess of Kintore	London	Auckland	14th Jun 1871	26th Sep 1871	21	large quantity	Probably 19, that were liberated in Waiuku	New Zealand Herald 5 September 1871, Page 2; New Zealand Herald 27 September 1871, Page 2
City of Auckland	London	Auckland	10th Sep 1871	10th Dec 1871	70	20	Probably 18 of these liberated in Waikato	Grey River Argus 4 November 1871, Page 2; Daily Southern Cross 29 December 1871, Page 7

Name	From	To	Departure	Arrival	Loaded	Survived	Note	Source
Caduceus	London	Auckland	18th Oct 1871	2th Feb 1872	70	48	Probably released in Kaipara	New Zealand Herald 12 December 1871, Page 3; Auckland Star 3 February 1872, Page 2
Charlotte Gladstone	London	Port Chalmers	29th Oct 1872	16th Feb 1873	NA	100	34 sent to Lyttelton, fate of 66 unknown	Bruce Herald 21 February 1873, Page 5; Star 3 March 1873, Page 2
Forfarshire	London	Wellington	16th Nov 1872	2nd Mar 1873	NA	12	However, the birds were forwarded on steamer Rangitira to Napier. in total 300 out of 500 loaded birds died.	Wanganui Herald 19 March 1873, Page 2; Press 4 March 1873, Page 2; Press 20 March 1873, Page 2; Wellington Independent 3 March 1873, Page 2
Tintern Abbey	London	Lyttelton	7th Jan 1875	4th May 1875	180	180	Some articles claim that only 160 or 170 were loaded, however, 180 arrived.	Star 5 May 1875, Page 2
Waimate	London	Lyttelton	27th Nov 1879	5th Mar 1880	50 or 40	22	Birds not released to wild – sent to Australia	New Zealand Herald 16 January 1880, Page 5; North Otago Times 16 January 1880, Page 2 (40); Star 5 March 1880, Page 2

It is generally believed that data on bird survival during voyages on ships is lacking (Duncan et al. 2006). However, we can retrieve information of this sort from the digitised newspaper archives. For yellowhammers, we have complete data on the number of loaded birds, and the number of survivors, for 11 ships (Table 1). On average the survival rate for yellowhammers was about 50% (481–502 survivors out of 956–968 birds shipped). Some birds died before the ships departed (Daily Southern Cross 14 March 1868, Page 4) or in the first few days of the voyage (Otago Witness 11 July 1863, Page 5). The main sources of bird mortality were poor care due to the absence of an experienced bird keeper on board (Canterbury Acclimatisation Society 1870), suboptimal positioning of cages next to the galley, lack of food (Otago Witness 8 February 1868, Page 5), drowning when water reached the deck (Wellington Independent 8 February 1868, Page 4), disease caused by contaminated water (Otago Acclimatisation Society's Minutes; Otago Daily Times 4 March 1871, Page 2), and severe cold weather (Daily Southern Cross 11 February 1868, Page 4). In one reported case, mortality of waterfowl was ascribed to hungry passengers (Otago Daily Times 5 March 1873, Page 2). Some birds also escaped from their cages and were lost at sea (Otago Daily Times 4 March 1871, Page 2). Voyages with yellowhammers on board took on average 102 days, but varied from 80 to 122 days. However, there was no correlation between the duration of the voyage and the mortality rate of yellowhammers ($r = 0.33$, $P = 0.29$). We might expect higher mortality of birds coming from the Northern Hemisphere summer across the Tropics to the Southern Hemisphere winter, but the number of ships for which data are available is too low ($n = 11$) to test for the effect of departure season on mortality.

Attempts were also made to transport alien bird species as eggs, in the hope of reducing costs of transport. In 1862, Captain Francis Stevens imported a box of eggs of English birds coated with glycerine, which he offered to (and was accepted by) the Auckland Acclimatisation Society. He had undertaken this importation as an experiment to test whether birds could be transported as eggs, with the glycerine coating presumably to preserve the egg in a state of "suspended animation". Stevens suggested removing the glycerine just prior to putting the egg under an appropriate surrogate mother (Daily Southern Cross 27 October 1862, Page 3). The outcome of this experiment is not recorded, although it is predictable. This method of extending the viability of eggs was nevertheless also taken seriously five years later by the Canterbury (Canterbury Acclimatisation Society 1867) and Otago Acclimatisation Societies (Fifth Annual report of the Otago Acclimatisation Society extracted from Otago Acclimatisation Society's Minutes), and some 13 years later by an experimenter from Australia (New Zealand Herald 2 November 1880, Page 3). Various experiments have shown that, under certain conditions, eggs can be successfully hatched even several weeks after laying (Yoo and Wientjes 1991; Dudusula 2009; Gomez-de-Travecedo et al. 2014), and so the idea may not be so far-fetched. Nevertheless, the shortest voyage time to New Zealand at the time found by us (69 days for a ship transporting skylarks; New Zealand Herald 15 February 1866, Page 4) was still well above the maximum storage period in tests to date (42 days, Gomez-de-Travecedo et al. 2014).

Introduction into New Zealand

Data from newspapers, Acclimatisation Society records and other sources reveal that yellowhammers were imported to six regions of New Zealand: Auckland, Nelson, Canterbury, Otago, Hawke's Bay and Wellington (Table 2, Figure 1). The last two have been overlooked in previous studies (Thomson 1922; Wellwood 1968; Veltman et al. 1996; Duncan 1997).

Private efforts to introduce English birds happened before the first Acclimatisation Society was established in Auckland in 1861 (Daily Southern Cross 26 November 1861, Page 3). For example, in 1859, some yellowhammers were sent to Auckland on the ship Flying Fish (London Standard 4 August 1859). However, these haphazard trials were probably not successful (Daily Southern Cross 26 November 1861, Page 3). The Canterbury Acclimatisation Society also had a bad experience with uncoordinated importations of birds, as most of the birds died during the voyage (Canterbury Acclimatisation Society 1866), and as a result concentrated its later efforts on fewer shipments consisting of more birds (Canterbury Acclimatisation Society 1870). Richard Bills insisted that birds should be liberated in large numbers at one locality and be allowed to spread naturally. This attitude was later adopted by the Otago Acclimatisation Society (Otago Daily Times 23 June 1871, Page 2) and also by the Canterbury Acclimatisation Society, when Richard Bills took care of birds (Press 1 March 1872, Page 3; Press 1 March 1873, Page 2). When his son was in charge in 1875, the Canterbury Acclimatisation Society had very little control over where birds were eventually introduced as these were sold to subscribers and other applicants, though on condition that they would be liberated within the Canterbury region (Canterbury Acclimatisation Society's Minutes, Star 27 January 1875, Page 2). Similarly, Auckland Acclimatisation Society spread yellowhammers to more regions in 1871 (Figure 4).

According to Thomson (1922) yellowhammers were first introduced by the Nelson Acclimatisation Society in 1862. However, the first report of this Society, presented in September 1864 (Nelson Examiner and New Zealand Chronicle 12 September 1864, Page 2), makes it obvious that the first three yellowhammers were not liberated before 1863, and probably as late as 1864: the first known ship with yellowhammers on board, the Violet (Colonist 12 July 1864, Page 5), did not arrive into Nelson until June 1864. Broad (1892) and Thomson (1922) claim that, after that, the Society kept no records. That is not actually true (Nelson Evening Mail 2 May 1867, Page 2; Daily Southern Cross 1 May 1868, Page 4): rather, both Minutes and Letterbook of the Society from the period between 1863 and 1879 were destroyed in a fire (Sowman 1981). Fortunately, at least some information about the activities of the Society was preserved in newspapers. However, apart from the report from 1864, there is no information about yellowhammers from Nelson, and neither are they mentioned in an 1870 report on the English birds introduced by the Acclimatisation Society there (Star 18 November 1870, Page 2; Sowman 1981).

Thomson (1922) claimed that the Auckland Acclimatisation Society introduced eight yellowhammers as early as 1865, but at that time the Society barely existed, as it had

Table 2. A list of introduction and translocation events for yellowhammers to New Zealand.

Year	Type	Region	Locality	Number	Note	Source
1863/4	Introduction	Nelson	NA	3		Nelson Examiner and New Zealand Chronicle 12 September 1864, Page 2
1865	Introduction	Auckland	NA	8	No confirmation either in reports or in Newspapers	Thomson (1922)
1868	Introduction	Auckland	NA	5	From Sciehallion	Thomson (1922), Auckland Acclimatisation Society 1869
1870	Introduction	Auckland	Auckland	14	According to reports, 16 were liberated (Auckland Acclimatisation Society 1870)	Daily Southern Cross 2 August 1870, Page 3
1871	Introduction	Auckland	Whangarei	100	Probably birds from Alexandrine	Daily Southern Cross 4 July 1871, Page 3; Daily Southern Cross 19 August 1871, Page 2
1871	Introduction	Auckland	Auckland	120	Birds from Caduceus	Auckland Acclimatisation Society 1872 (where), Daily Southern Cross 4 April 1871, Page 3 (how much)
1871	Introduction	Auckland	Waiuku	19	Probably birds from Countess of Kintore	Daily Southern Cross 3 October 1871, Page 2
1872	Introduction	Auckland	Waikato	18	Probably from City of Auckland	New Zealand Herald 10 January 1872, Page 3
1871/2	Introduction	Auckland	Kaipara	43+	The sum for 1871 is 300+, numbers known for other locations. Probably birds from Caduceus.	Auckland Acclimatisation Society 1872; Auckland Star 3 February 1872, Page 2
1872	Introduction?	Auckland	Matakohe	NA	Remainders from Caduceus?	New Zealand Herald 31 March 1873, Page 2
1876	Translocation	Auckland	NA	27	Gift to Sir George Grey	Daily Southern Cross 4 April 1876, Page 1
1876	Translocation	Auckland	Bay of Islands	18		New Zealand Herald 2 May 1876, Page 3
1876	Translocation	Auckland	Kawau	16		New Zealand Herald 20 June 1876, Page 3
1876	Translocation	Auckland	Kaipara / Hokianga	several		New Zealand Herald 2 May 1876, Page 3
1877	Translocation	Auckland	New Plymouth	28		Taranaki Herald 25 September 1877, Page 2
1869	Introduction?	Wellington	NA	3?	3 were sold. Were they released as well?	Hawke's Bay Herald 23 January 1869, Page 3; Evening Post 6 January 1869, Page 3
1873	Introduction	Hawke's Bay	districts around Napier	12 or 13	arrived on Forfarshire	Wanganui Herald 19 March 1873, Page 2; Evening Post 7 March 1873, Page 2; Press 20 March 1873, Page 2
1867	Introduction	Canterbury	Christchurch gardens	1		Lyttelton Times 7 January 1868, Page 2; Canterbury Acclimatisation Society 1867
1868	Intruduction	Canterbury	NA	5	arrived on ship Blue Jacket	Lyttelton Times 19 December 1868, Page 2

1873	Introduction	Canterbury	Christchurch (gardens)	16		Press 1 March 1873, Page 2
1873	Introduction	Canterbury	Ilam	18	34 minus those liberated in Gardens	Star 3 March 1873, Page 2
1875	Introduction	Canterbury	South Canterbury, within 50km from Timaru	40	Part of those arriving by Tintern Abbey	Timaru Herald 2 June 1875, Page 3
1875	Introduction	Canterbury	North Canterbury	140	The rest from 180 birds arriving by Tintern Abbey	Star 31 May 1875, Page 2; Figure 5
1868	Introduction	Otago	Dunedin	8	arrived on Warrior Queen	Otago Daily Times 14 February 1868, Page 4
1871	Introduction	Otago	Caversham	31	arrived on Warrior Queen	Otago Acclimatisation Society's Minutes
1876	Translocation	Otago	Tapanui	29 or less, possibly 14	caught in North East Valley, not confirmed in report	Clutha Leader 30 March 1876, Page 5; Tuapeka Times 26 April 1876, Page 4
1876	Translocation	Otago	Inch Clutha	6	caught in North East Valley	Otago Acclimatisation Society 1878; Star 22 February 1876, Page 3
1879	Translocation	Otago	Queenstown	24	probably released in Arrowtown	Otago Acclimatisation Society's Minutes; Lake Wakatip Mail 26 July 1879, Page 2
1879	Translocation	Otago	Stewart Island	32		Otago Acclimatisation Society's Minutes; Otago Daily Times 13 May 1879, Page 3

lost its Secretary through his involvement in the Waikato Wars (New Zealand Herald 28 October 1865, Page 4). It is at least theoretically possible that those eight birds were descendants of yellowhammers arriving to Auckland on the Aloe in 1863 (Otago Witness 11 July 1863, Page 5). The Society was re-established in 1867 (and the reports are only available from that year on). Four birds claimed by Thomson (1922) to have been introduced in 1867 were actually not released, because three of them died after arrival (Auckland Acclimatisation Society 1868). In 1868, five yellowhammers arrived on board of the Empress (Daily Southern Cross 14 March 1868, Page 4, Auckland Acclimatisation Society 1869); however, it is not clear whether they were liberated. If they were, then it was probably directly to a garden of the Society (Daily Southern Cross 4 August 1868, Page 4; Auckland Acclimatisation Society 1869). In 1869, some yellowhammers were observed in Papatoetoe, 17 km from the Society's garden (Daily Southern Cross 4 May 1869, Page 6). It is possible that these could have been birds released the previous year (or their offspring). According to reports, 16 yellowhammers were imported in 1870 and liberated directly on the Society's grounds (Auckland Acclimatisation Society 1871), although the number of birds coming to Auckland harbour that year was at least 45 (Table 1).

The most important year for yellowhammer releases in the Auckland region was 1871, when more than 300 birds were liberated: 100 to Whangarei, 120 to Auckland, 43 or more to Kaipara, 19 to Waiuku and 18 to Waikato (Auckland Acclimatisation Society 1872; Daily Southern Cross 19 August 1871, Page 2; Daily Southern Cross 4 April 1871, Page 3; Daily Southern Cross 3 October 1871, Page 2; New Zealand Herald 10 January 1872, Page 3; Figure 4). In 1872, some birds were released in Matakohe (Auckland Acclimatisation Society 1873), probably remainders from previous shipments. In 1876, the Society hired a full-time bird catcher, whose duty was to catch birds for translocations, and two consignments of yellowhammers were translocated to Kawau and the Bay of Islands (Auckland Acclimatisation Society 1877), and one given to George Grey (Daily Southern Cross 4 April 1876, Page 1). Later on, another two consignments were sent to Australia (Evening News 30 September 1879, Page 3; Poverty Bay Herald 29 June 1880, Page 2) and one to New Plymouth for the Taranaki Acclimatisation Society (Taranaki Herald 25 September 1877, Page 2; Taranaki Herald 18 March 1878, Page 2).

In Otago, the Acclimatisation Society did not waste resources on introductions of yellowhammer. Eight yellowhammers were liberated in Dunedin in 1868 (Otago Acclimatisation Society's Minutes); in 1871, 31 were released in Cavernsham, now part of Dunedin (Otago Acclimatisation Society 1871; Otago Witness 11 March 1871, Page 5), where they were observed in large numbers three years later (Otago Daily Times 30 September 1874, Page 7). After 1871, all liberated birds appear to have been translocations from one part of Otago to another. There is still one uncertainty, though. In 1873, the Otago Acclimatisation Society helped Canterbury to transport birds from England (there was no ship going to Lyttelton from London soon enough, and so the birds were put on a ship to Otago). One hundred yellowhammers arrived into Port Chalmers (Wellington Independent 27 February 1873, Page 2), but only 34 were forwarded to Lyttelton (Star 3 March 1873, Page 2; Canterbury Acclimatisation Society's Letterbook, page 197). It is unclear what happened to the remaining 66 birds. They probably were

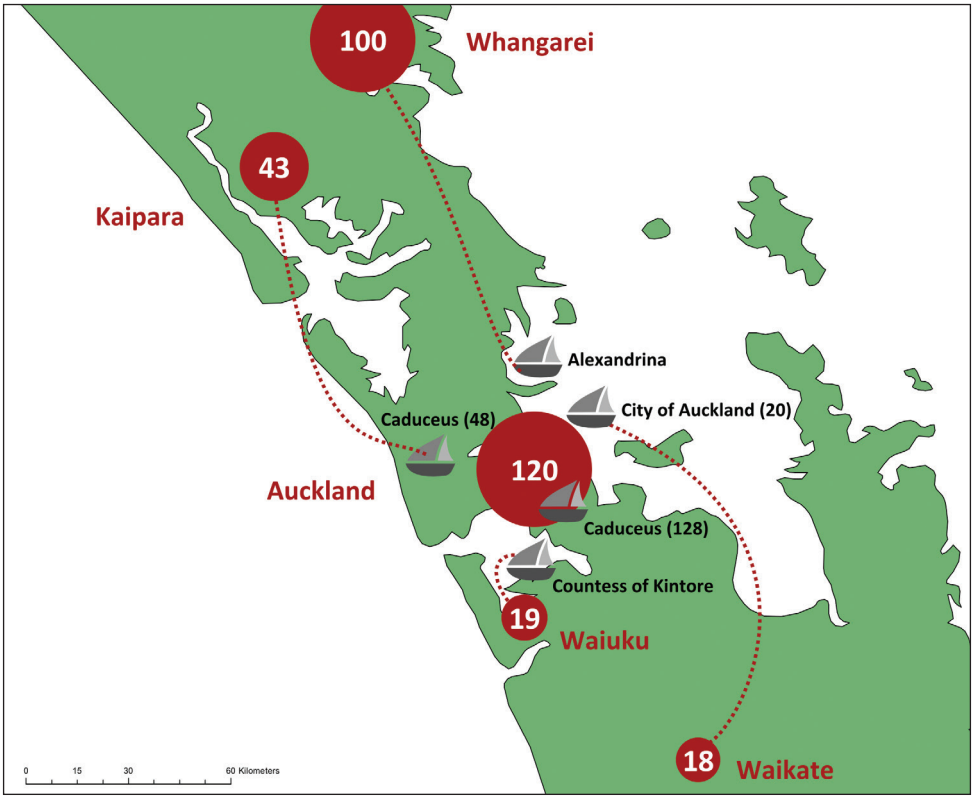

Figure 4. The number of imports and liberations of yellowhammers in the Auckland region in 1871 (likely scenario; see text for more details).

not liberated in Otago, as the Otago Acclimatisation Society kept careful records. They were not lost on the way either, as the re-shipment on the Phoebe from Dunedin to Christchuch arrived with scarcely any loss (Otago Daily Times 7 March 1873, Page 2), while the number of birds arriving to Lyttelton reported in newspapers is confirmed by a letter from the Honorary secretary of the Society (Canterbury Acclimatisation Society's Letterbook, page 197). Closer examination suggests that it is the number of birds arriving to Dunedin that is probably incorrect (Star 18 February 1873, Page 2; Press 19 February 1873, Page 2; Press 28 February 1873, Page 2; Otago Witness 1 March 1873, Page 12; Star 3 March 1873, Page 2; Press 4 March 1873, Page 2; Star 5 March 1873, Page 2; Timaru Herald 7 March 1873, Page 2; Otago Daily Times 12 March 1873, Page 6; Press 13 March 1873, Page 3; Canterbury Acclimatisation Society's Letterbook, pages 192–199). It may be that yellowhammers died after arrival due to the lack of water (Press 13 March 1873, Page 3) – the ship had to stay 2 days in quarantine because of the epidemic of typhoid fever (Canterbury Acclimatisation Society's Letterbook, page 197; Otago Daily Times 18 February 1873, Page 2).

Another doubt is cast by Chrisholm's (1907) statement that until 1870, there were not eight but 18 yellowhammers imported to Otago – however this is most likely a

typographical error. In 1876, six yellowhammers were translocated from North East Valley to Inch Clutcha (Otago Acclimatisation Society 1878; Star 22 February 1876, Page 3). A further 40 were sent to Tapanui, but at least 11 of them died during the voyage due to poor conditions, as they all travelled in one box (Clutha Leader 30 March 1876, Page 5). Probably only 14 of them reached the final destination (Tuapeka Times 26 April 1876, Page 4). In 1879, 32 yellowhammers caught in Otago by Richard Bills' second son Charles were liberated on Stewart Island, and 24 in Queenstown (Otago Acclimatisation Society's Minutes; Otago Acclimatisation Society 1880).

As already noted, the Canterbury Acclimatisation Society has significant gaps in its reports and, without newspapers, it would appear they introduced only 35 birds. In fact, they actually introduced 219 or more. Moreover, two yellowhammers (out of 12 boarded) appear to have arrived in 1864, shortly after the Society started, thanks to the private efforts of a Mr. Prince (Lyttelton Times 10 September 1864, Page 5; Inverness Courier 27 April 1865). The first yellowhammer (a singleton) was released by the Canterbury Acclimatisation Society in 1867 (Canterbury Acclimatisation Society 1868; Lyttelton Times 4 February 1868, Page 3). In 1868, another one arrived on the Matoaka (Lyttelton Times 4 March 1868, Page 4), and later on, five arriving on the ship Blue Jacket were liberated, likely in Society's gardens (New Zealand Herald 28 November 1868, Page 6; Lyttelton Times 19 December 1868, Page 2). Even when added to the previous shipment of the pair by Mr. Prince, these are low numbers. Yet, flocks of yellowhammers were already being seen in the Society's garden in March 1870 (Press 2 March 1870, Page 2). Furthermore, in the Canterbury Acclimatisation Society Secretary's letter to the Taranaki Acclimatisation Society that same year, yellowhammers were mentioned on the list of successfully acclimatised bird species (Taranaki Herald 21 September 1870, Page 2). The following year, Hutton mentions Canterbury as a region, where yellowhammers had been introduced, in his Catalogue of New Zealand birds (Hutton 1871). Despite the successful establishment of yellowhammer, birds kept coming. In 1873, 34 yellowhammers were forwarded from Dunedin (see above) and released in Christchurch (Star 3 March 1873, Page 2). In 1875, 180 yellowhammers arrived on the Tintern Abbey (Press 4 May 1875, Page 2). Although there is no mention of the arrival of this ship or of the subsequent release of the birds in the Society's report, newspapers and the Society's minutes make it possible to reconstruct the fate of the birds to a certain degree. Forty were forwarded to South Canterbury and distributed as equally as possible among several localities within a distance of 50 km from Timaru (Star 15 May 1875, Page 2; Figure 5). Most of the remaining 140 birds were sold and released in various localities in North Canterbury, probably mainly in Christchurch and partly along the coast towards the South of Christchurch (Press 26 May 1875, Page 3; Star 31 May 1875, Page 2; Figure 5). That each location received at least three pairs was ensured by the fact that no one could buy fewer birds than that (Canterbury Acclimatisation Society's Minutes).

In 1880, the ship Waimate docked at Lyttleton, bringing a considerable number of birds that had not been requested, including 22 yellowhammers (Star 5 March 1880, Page 2). These birds were never released into the wild as the objections of local farmers

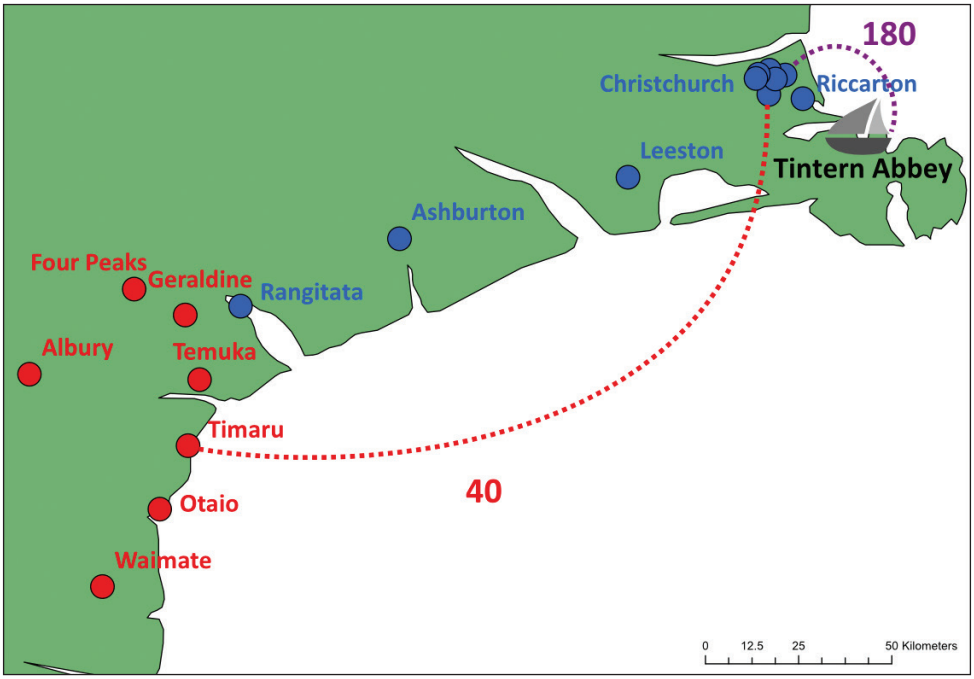

Figure 5. A map of possible localities of release of yellowhammers from the ship Tintern Abbey in 1875; red – localities selected for introduction in South Canterbury (40 in total), blue – home addresses of purchasers of yellowhammers in North Canterbury (140 in total).

were already too strong (Auckland Star 5 March 1880, Page 2). The Canterbury Acclimatisation Society had only two options – to destroy the birds, or to send them to another colony. They were sent to Adelaide in Australia (Press 27 March 1880, Page 3) and probably sold there (Canterbury Acclimatisation Society 1881).

The Wellington Acclimatisation Society never introduced yellowhammers. However, before this Society was formally recognised in 1871 (Wellington Independent 2 May 1871, Page 2), yellowhammers brought for acclimatisation purposes by the Provincial Government arrived on the ship Wild Duck in 1869 (Wellington Independent 16 January 1869, Page 6), and three of them were sold on the market (Hawke's Bay Herald 23 January 1869, Page 3). These were probably the only survivors of the transportation as all individuals of other species, for which the number of surviving individuals is known (New Zealand Herald 14 January 1869, Page 4), were sold (Wellington Independent 14 January 1869, Page 2) following the instruction of the Provincial Government (Evening Post 6 January 1869, Page 3). In 1875, an advertisement was circulated in the UK offering a reward for yellowhammers (Evening Post 17 July 1875, Page 2); this probably had no effect, as the Society did not spend any money on yellowhammers between 1871 and 1884, whereas transactions involving other bird species were noted (Wellington Acclimatisation Society's Cashbook for years 1871–1884; Figure 2). Yellowhammers are also not listed in the table of species introduced by the

Wellington Acclimatisation Society between 1874 and 1884 (Wellington Acclimatisation Society 1887).

The Hawke's Bay Acclimatisation Society received 12 or 13 yellowhammers in 1873 from the ship Forfarshire, which were forwarded on the steam ship Rangitira (Wanganui Herald 19 March 1873, Page 2; Press 20 March 1873, Page 2). These were most likely released within 15 km of the city Napier (Evening Post 7 March 1873, Page 2; Press 20 March 1873, Page 2). The shipment was overseen by one of Richard Bills' sons (Press 4 March 1873, Page 2).

Establishment in the wild

The introduction of yellowhammers to New Zealand was rapidly successful. In 1871, when most of the yellowhammers introduced to the Auckland region had been released, the Acclimatisation Society was already claiming that the species was established and spreading. The Society even wrote to its agent in London, Grahame, not to send any more birds (New Zealand Herald 8 August 1871, Page 3). Yellowhammers were claimed to be acclimatised in the Canterbury region even earlier, in 1870 (Taranaki Herald 21 September 1870, Page 2), although shipments to there were not discontinued until 1880. Natural spread was enhanced by direct translocations, which were carried out in the Otago and Auckland regions (Table 2). By the 1900s, yellowhammers were established all over New Zealand (Figure 6), although the population close to Dunedin (Otago) almost perished for an unknown reason (Press 24 July 1897, Page 7; Otago Witness 21 September 1899, Page 62).

Environmental conditions in New Zealand would have been amenable to establishment. It is climatically similar to the UK. Large portions of the landscape were being cleared of forests even before the arrival of British colonists (McWethy et al. 2010), and were later transformed into cultivated habitats, fields or pastures (Wilmshurst et al. 1999), representing an ideal habitat for yellowhammers (del Hoyo et al. 2011).

Successful establishment in New Zealand was additionally supported by legislation. The Protection Act made any shooting of introduced small passerines illegal and fines were paid for violations (Nelson Examiner and New Zealand Chronicle 12 January 1864, Page 6; Daily Southern Cross 19 July 1866, Page 4; Protection of Animals Act 1867). The two native bird predators, New Zealand falcon (*Falco novaeseelandiae*) (Daily Southern Cross 5 December 1872, Page 2) and morepork (*Ninox novaeseelandiae*), were killed to stop them taking introduced birds (Daily Southern Cross 10 March 1870, Page 4), and even the native kingfisher (*Todiramphus sanctus*) was regarded as an enemy of introduced birds (Auckland Acclimatisation Society 1870). What difference this may have made in practice is unclear, as Europeans had introduced cats (Canterbury Acclimatisation Society 1867; New Zealand Herald 13 July 1878, Page 7) and ship rats *(Rattus rattus)*, which attacked yellowhammers even on trees (New Zealand Herald 4 April 1871, Page 2), as well as a wide range of other alien mammalian predators (King 2005). Yellowhammers and other birds of English origin

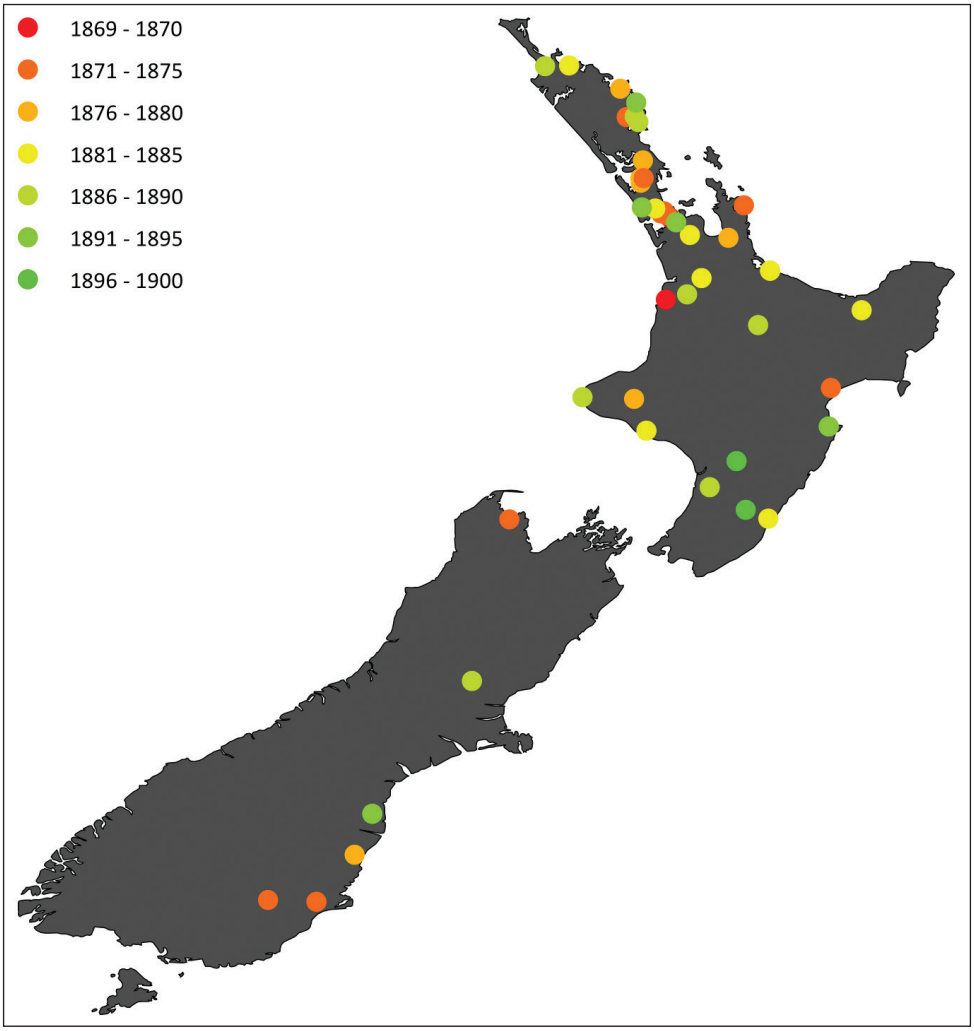

Figure 6. A map of observation records of yellowhammers from the date of first introduction 1864 to 1900, based on reports from newspapers and from Drummond (1906).

would nevertheless presumably have been well adapted to the predation risk presented by these mammal species from their native range, as well as to bird predators due to the threat of the European sparrowhawk (*Accipiter nisus*).

Spread, public perception, and attempts at eradication

The first warning about the destructive behaviour of yellowhammers came as early as the mid-1860s (Lyttelton Times, 22 January 1866, Page 4), even before large-scale introductions had commenced. In the 1870s, the number of negative voices

increased as farmers started to experience direct consequences of yellowhammer establishment and spread (Auckland Star 31 August 1875, Page 2; New Zealand Herald 18 November 1876, Page 1; New Zealand Herald 11 July 1878, Page 3) – in total, negative references to yellowhammers appear twelve times in newspapers in the period 1872 to 1879. In early 1870's, the Canterbury Acclimatisation Society defended sparrows and regretted that farmers could not see the evident benefit from "insectivorous" birds brought for the fight against the ravages of insect pests (Canterbury Acclimatisation Society 1872–1874). Similarly, in 1877, farmers were decried as short-sighted by Mr. Firth, the president of the Auckland Acclimatisation Society, for their designation of these birds as feathered pests (New Zealand Herald 23 October 1877, Page 5).

By 1880, however, the tide had turned, and it was the intelligence and competence of the members of Acclimatisation Societies that was being questioned (Auckland Star 5 March 1880, Page 2). The "precious" load of birds being imported on the ship Waimate was the subject of criticism even before it had arrived, and given the abundance of the yellowhammer in New Zealand, was viewed as "carrying coals to Newcastle" in the eyes of one author (Star 26 January 1880, Page 4). Yellowhammers not only had to be forwarded on from the New Zealand territory, but were included for the first time, though not officially, on a list of granivorous birds (North Otago Times 13 March 1880, Page 2). From then on, they started to be killed in large numbers (New Zealand Herald 13 July 1880, Page 3) by various means: boys competed in egg collection (Bay of Plenty Times 4 December 1883, Page 2; Feilding Star 22 October 1898, Page 2), money was offered for their heads (Bay of Plenty Times 29 August 1882, Page 2) and poisoned grain was spread in winter fields (Waikato Times 14 July 1883, Page 2; Waikato Times 28 September 1889, Page 3). The public attitude towards yellowhammers was nicely expressed in a report from Parua Bay after the autumn harvest: "sparrows and yellowhammers will have to do a starve until sowing time comes" (New Zealand Herald 2 February 1889, Page 6).

In 1882, The Small Birds Nuisance Act came into force, which specified which means it was possible to use in the battle with birds injurious to crops, and under what conditions (www.nzlii.org/nz/legis/hist_act/sbna188246v1882n14275.pdf). Although yellowhammers are (unlike sparrows) not mentioned in the law, it is likely that it concerned them as it concerned all birds not protected as stated in other acts.

Some people continued to defend small birds into the 1880s and 1890s (New Zealand Herald 2 February 1884, Page 1), arguing that their temporary insectivory outweighed the damage to crops. In 1891, for example, an author calling himself "entomologist" speculated that the yellowhammer could be a useful and inexpensive weapon against codlin moth (*Cydia pomonella*), as it had proven to be in United States (Otago Witness 2 April 1891, Page 5). However, another writer questioned whether the U.S. yellowhammer is the same species as that in New Zealand (Nelson Evening Mail 11 February 1891, Page 3), which indeed it is not: 'yellowhammer' is an American vernacular name for the northern flicker (*Colaptes auratus*), a species of woodpecker. These voices of defence petered out in the 1890s, although in some locations the

yellowhammer was still argued to be a farmer's friend even into the twentieth century (Bay of Plenty Times 12 June 1901, Page 2).

In 1902, the yellowhammer was proclaimed an injurious bird under the Birds Nuisance Act, and the whole of the South Island was divided into eight parts to enhance coordinated efforts to tackle bird pests (New Zealand Herald 22 May 1903, Page 5; www.nzlii.org/nz/legis/hist_act/bna19022ev1902n25239). In 1905, Acclimatisation Societies introduced a bird predator, the little owl (*Athene noctua*), to help with these efforts, with no thought to its likely impact on already vanishing populations of native birds (Otago Acclimatisation Society Letterbook 1887-1914, page 220; Drummond 1912). Yellowhammers were still being killed in large numbers even in the late 1920s (Thomson 1926), and Oliver (1930) wrote that it must be ranked among the most harmful birds ever introduced to New Zealand. In some places it was considered to be more damaging than the sparrow (New Zealand Herald 17 May 1894, Page 6; New Zealand Herald 26 December 1904, Page 6). Nowadays, the yellowhammer is no longer regarded as a serious threat to New Zealand agriculture, although it is still listed as a crop pest there (Porter et al. 1994).

Although yellowhammers had attained the status of public enemy, some people were still willing to pay for them (Auckland Star 22 February 1888, Page 1; Auckland Star 26 August 1896, Page 1; Auckland Star 1 April 1910, Page 2). Among them was Charles Bills, son of Richard (Ashburton Guardian 18 October 1910, Page 3), who was probably interested in reselling the birds for profit. In 1911, yellowhammers were sold from Ashburton to a bird fancier in Dunedin (Ashburton Guardian 15 December 1911, Page 4), and the species was still being offered for sale as late as 1934 (Auckland Star 25 August 1934, Page 2). Thus, there existed a flow of birds across New Zealand even towards the middle of the twentieth century, the extent of which is difficult to assess.

Conclusions

Current biological invasions are the result of past human activities, and hence historical information potentially has a significant role to play in their study. The quality of New Zealand historical data on bird introductions has recently been criticised by Moulton et al. (2011, 2012a). They go so far as to state that "these historical records are in many cases mere rumors and impressions, and not actual "data" in any sense (Moulton et al. 2012a). We agree that the data presented by Thomson (1922) turn out on close inspection to contain inaccuracies, as clearly illustrated by our exploration of the historical records for the yellowhammer. Dates in Thomson (1922) are sometimes mismatched, there are significant omissions, all birds shipped are erroneously claimed to have been released and translocation is counted as introduction. Some later authors introduced further errors by misinterpreting the information (Williams 1969, Lever 2005). Nevertheless, it is far from the truth that historical data on bird introductions are poor. Our paper demonstrates that the quantity and quality of historical information may be much higher than has been argued, which can potentially improve

the precision of analyses based on it (Pyšek et al. 2015). Rather, they are simply hard work to unearth. That work has been made easier by the digitisation of key newspaper sources, but even so remains substantial. Focusing on just one species allowed us to mine the enormous seam of relevant primary sources as much as possible, and to assess the quality of records from Acclimatisation Societies and secondary compilations; it would be a Herculean task to assemble a faultless compilation of data for all species that the New Zealanders attempted to introduce (at least 120; Duncan et al. 2006).

Our exploration of the historical literature in fact reveals a wealth of information on bird introductions to New Zealand – indeed, far more is available, and in far more detail, than has hitherto been appreciated. Using it, we have been able to produce a detailed and nuanced history of the invasion of yellowhammer, tracking not only the transportation, introduction and establishment of the species, but also local attitudes to the species as it spread. Our study has significantly improved knowledge about the numbers, localities and dates of introductions, provided details about shipments, and filled in gaps and corrected misinterpretations in the literature. Assuming that the newspaper and Acclimatisation reports are reliable (and that the fact that different sources frequently confirm the same information suggests that they are), we have shown that Thomson (1922) underestimated introduction effort, whilst subsequent compilations (Andersen 1916, Williams 1969, Veltman et al. 1996; Duncan 1997) sometimes overestimated it. We have shown that the localities of release are often known, and that where they are not, it is often possible to identify likely sites. We have shown that it was common practice for birds to be liberated in large numbers at one locality and allowed to spread naturally. We have also found information about unorganised shipments, and shown that such birds represented a tiny fraction of the overall introduction effort for the yellowhammer.

We have also identified remaining gaps in our knowledge of yellowhammer introductions. Examples include the fate of the ship Queen Bee with 140 yellowhammers on board and the fate of the 66 birds arriving into Port Chalmers on the Charlotte Gladstone that were not forwarded to Lyttelton (Table 1). Nevertheless, these uncertainties are small relative to the body of information that is available. Despite them, it is clear that repeating our study on all the other bird species that New Zealanders attempted or succeeded in introducing would give an unparalleled database to study key features of the invasion process. Not least, it would put to bed ongoing arguments about the influence of propagule pressure on these species (Blackburn et al. 2013).

Although our study set out to understand the invasion history of the yellowhammer in New Zealand, our exploration of the historical literature also revealed snippets of information about the history of the yellowhammer in its native range. Nowadays, the yellowhammer is widespread and abundant in New Zealand, whereas in the UK it has experienced a rapid population decrease (Baillie et al. 2002). Recent studies have shown that it reaches three times higher densities in New Zealand than in similar habitats in its native range in the UK (MacLeod et al. 2005a, b). Historical sources show that the populations in the wild were already becoming scarcer in the UK around the time that birds were being shipped to New Zealand, partly due to the loss of habitat (typically hedges) and changes in agricultural land use (intensive harvesting),

and partly because of "predation" pressure from humans, for food, population control of a perceived crop pest (Pall Mall Gazette 8 June 1872), or for use in the manufacture of fashionable objects (New Zealand Herald 11 March 1876, Page 1). Exploring the population history of a species from newspaper reports would until recently have been a lifetime's work, but the digitisation of archives is changing that. Our study suggests that the popular press, while not always very accurate in its reporting, may also represent a mine of information for studying changes in native bird populations that pre-date modern monitoring programmes. Indeed, data on acclimatisation represents only a tiny fraction of the information hidden in old newspapers, thus our study could even inspire research from other fields of study.

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