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LETTER

A clarification of the origins of birds released by the Otago Acclimatisation Society from 1876 to 1882

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Records of birds introduced into New Zealand in the 19th and 20th centuries for the purposes of acclimatization underpin several of the analyses that show propagule pressure (*sensu* Lockwood *et al.* 2005) is a key driver of the establishment success of alien populations (reviewed in Blackburn *et al.* 2009a, 2009b). Recently, however, the accuracy of the data used in these analyses has been called into question. In particular, two articles published in *Notornis* claimed to provide evidence of new and previously unreported records of bird introductions from Europe to New Zealand (Santos 2012; Moulton *et al.* 2014). These records have already been cited several times as evidence of the unreliability of previous studies of the effect of propagule pressure (Santos *et al.* 2013; Santos & Nakagawa 2013; Moulton & Cropper 2014, 2015). Here, we point out that most of the information presented by Santos (2012) and Moulton *et al.* (2014) is incorrect, as a result of the data being compiled without using all available historical documents. Our aim is to prevent these new inaccuracies becoming incorporated into further analyses of the establishment success of birds introduced to New Zealand.

The primary source of information for studies on birds introduced to New Zealand has been the classic compilation by Thomson (1922). Moulton *et al.* (2014) presented data on birds listed as introduced in reports of the Otago Acclimatization Society (OAS), but missing from Thomson's book, to show that Thomson actually underestimated

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the numbers of birds imported to New Zealand, and hence to argue that his book is an unreliable source of propagule information. It is true that Thomson (1922) does not include records of all birds imported to New Zealand, but the numbers presented in Moulton *et al.* (2014) are themselves a misinterpretation (and include some typographical errors in the numbers presented). In a recent analysis of historical yellowhammer (*Emberiza citrinella*) introductions to New Zealand (Pipek *et al.* 2015), we pointed out that it is not just the numbers of birds that are important, but also where those birds came from, and where they end up. The tables in the OAS Reports (Otago Acclimatisation Society 1880, 1881, 1883) cited by Moulton *et al.* (2014) do not give the numbers of birds imported from Europe, but those released into the wild. This distinction would be important in and of itself, but it is important to note that these birds were not always released into the wild in Otago. The accompanying text in the OAS reports, and additional information sources such as newspapers, show that a significant proportion of the birds caught in the late 1870s were actually caught in New Zealand, to be released in different parts of the country. As an officer of the Otago Acclimatisation Society (Otago Acclimatisation Society 1893), Thomson was likely to have been aware of this fact, which may have been why these liberations were not included in his book (Thomson 1922).

A more complete and accurate understanding of bird introductions to New Zealand can be obtained by incorporating information from a range of historical documents. The power of this approach was recently demonstrated by Pipek *et al.* (2015), and we use it here to interpret the data given by Moulton *et al.* (2014) for individual species. Our corrected information is based, besides the Annual Reports of the OAS, on other documents of this Society, such as Minute Books, Letters and Cashbooks, and on the freely available archive of New Zealand newspapers (http://paperspast.natlibgovt.nz).

Moulton *et al.* (2014) suggested that 1799 additional birds were introduced to New Zealand than reported in Thomson (1922). In fact, a high proportion of these birds were local descendants of the original introductions from Europe that were hatched in New Zealand (Table 1). Historical documents provide direct evidence of this for 807 of the 1799 birds, but it is reasonable to assume that once birds started being caught in the region, they were not imported any more from the country of origin. Indeed, after 1876 there is no further information about shipments from England for any of the species listed in Table 1. In 1877, it was already the case that birds such as blackbirds (*Turdus merula*), starlings (*Sturnus vulgaris*) and skylarks (*Alauda arvensis*) were being caught locally in their hundreds, as can be deduced from cashflow and letters (Otago Acclimatisation Society 1878, 1900). Furthermore, considerable numbers of the birds (773) reported by Moulton *et al.* (2014) were not released in the OAS region as claimed by the authors, but in other parts of the country, or indeed in other countries (Table 1). In fact, the OAS exported even more birds than Moulton *et al.* (2014) report (Table 2). From 1875, the OAS was redistributing birds common around Dunedin to other parts of the region (Press 1875).

Moulton *et al.* (2011, 2012) have repeatedly criticised the importance attributed in mainstream invasion biology to propagule pressure as a determinant of the outcome of introductions (Blackburn & Duncan 2001; Cassey *et al.* 2004; Blackburn *et al.* 2011). They have correctly pointed out that other researchers (Veltman *et al.* 1996; Duncan 1997; Green 1997) have been inconsistent in terms of the numbers of birds introduced to New Zealand used for their analyses. However, while this criticism may be justified to some extent, Moulton *et al.* themselves do not identify the causes of these discrepancies (Santos 2012; Moulton *et al.* 2014). Rather, they also follow the approach of analysing numbers without attention to their provenance (Pipek *et al.* 2015). In doing so, they bring in new inaccuracies and misinterpretations. Most of the extra birds they identify as liberated by the OAS were actually not introduced, but were instead only translocated from one part of the region to another. These birds are not extra propagules, but rather a consequence of the initial establishment success. Sometimes they were not liberated in the same region, and so arguably may contribute to success in other regions, but they cannot be a factor in establishment success in the region in which they were caught, nor indeed in New Zealand as a whole. Thus, while it is true that the data in Thomson (1922) are inaccurate, as Moulton *et al.* (2014) claim, they are not inaccurate for the reasons presented by these authors. Nor are Thomson's data as inaccurate as the data presented by Moulton *et al.* (2014): of the 1799 birds that they claim were introduced and missed by Thomson (1922), a maximum of only 425 could potentially have been introduced to Otago from elsewhere. Furthermore, this maximum is based on a lack of knowledge of the origins of those 425 birds. As we argue above, it is more likely that they were locally caught birds. In fact, the principal error in Thomson's book is that he missed a large shipment of birds in 1875 (Pipek *et al.* 2015).

Attention to a range of sources suggests other issues with interpreting the bird introduction data in Moulton *et al.* (2014). For example, they stated that records indicated people in Otago simply released what birds they could acquire, whenever

Table 1. Numbers of birds presented by Moulton *et al.* (2014; their Table 1) as being introduced to Otago (a), with comments on how many of these are known actually to have been caught in Otago (b), how many of the birds are known to have been exported to other regions (c), and the maximum number of birds reported by Moulton *et al.* (2014) as introduced to Otago that actually could have been so (*i.e.*, birds that were not caught there or released elsewhere; d). The year when the species started to be redistributed within New Zealand is indicated in bold. Note that the birds caught (b) and exported (c) are not exclusive groups (birds caught in Otago were sometimes exported to other regions), thus their sum can exceed the total number of birds claimed by Moulton *et al.* (2104) to have been released. *For more details see Pipek *et al.* (2015).

Species	Year	Number of birds				Notes	Source
		Reported as introduced to Otago	Caught in Otago	Exported to other regions	Possibly introduced to Otago from outside		
Turdus merula	**1876**	5	5		0	Caught by C. Bills & Mr. Deans. Blackbirds already quite numerous; however, 4 blackbirds also brought by ship *Maulesdeen*.	Clutha Leader 1876; Otago Daily Times 1876a, 1876b, 1876c; Tuapeka Times 1876
	1877	12			12	Likely caught by C. Bills.	Otago Acclimatisation Society 1878, 1900
	1878	26			26		
	1879	48	36	18	12	12 to Sydney, 6 to Stewart Island, 19 to Tapanui, 11 to Queenstown. At least 36 (for S. Island, Tapanui & Queenstown) caught in Otago.	Otago Daily Times 1876a; Otago Acclimatisation Society 1880, 1896
	1881	76			76		
	1882	16			16		
Turdus philomelos	1882	6			6		
Sturnus vulgaris	**1876**	154	154		0	Caught in Maori Hills (Otago).	Clutha Leader 1876; Otago Daily Times 1876b; 1876c
	1877	220		156	64	48 to Wellington, 36 to Hawke's Bay, 72 to Southland, leaving only 64 for Otago. Obtained by C. Bills, corresponding to *c.* 28 dozen (336) birds, origin unknown, though likely from Otago.	Otago Daily Times 1877b; Otago Acclimatisation Society 1878, 1900
	1878	168		138	30	In 1878 already numerous and captured for exchange purposes. 138 sent outside Otago: 54 to Wellington, 84 to Hawke's Bay.	North Otago Times 1878; Otago Acclimatisation Society 1896
	1879	22	22	22	0	Liberated on Stewart Island, caught in Otago by C. Bills.	Otago Acclimatisation Society 1880, 1896
	1880	182		182	0	Liberated in Southland. Species already quite numerous in Otago.	Otago Witness 1880
Alauda arvensis	**1876**	87	87		0	All caught in Otago. However, 11 were brought by ship *Maulesdeen*.	Clutha Leader 1876; Otago Daily Times 1876a, 1876b; Tuapeka Times 1876

Table 1. Continued.

Alauda arvensis	1877	297	60+	121	146	Skylarks already numerous in Otago and caught for distribution near Tokomairiro (minimum of 60, possibly more). Ironically, these birds most likely descendants of 100 birds caught by Mr. Bills in Nelson in 1873. 121 released outside of Otago: 84 to Canterbury and 37 to Southland. Of the remaining 176, 30 sent to Queenstown were likely caught in Otago. Likely all caught there, as sum Mr. Bills received for collecting corresponds to about 40 dozen (480) birds.	Bruce Herald 1873; North Otago Times 1873; Clutha Leader 1877; Otago Daily Times 1877a, 1877b; Oumaru Mail 1877; Tuapeka Times 1877; Otago Acclimatisation Society 1900
	1879	70	70	70	0	Liberated in Stewart Island, all caught by Mr. Bills in Otago.	Otago Daily Times 1876a; Otago Acclimatisation Society 1880, 1896
Carduelis carduelis	**1879**	6	6		0	Caught by Mr. Bills in Otago and liberated in Queenstown.	Otago Acclimatisation Society 1880, 1896
Fringilla coelebs	**1879**	18	18	13	0	Caught by Mr. Bills in Otago, 13 to Stewart Island, 5 to Queenstown.	Otago Acclimatisation Society 1880, 1896
Carduelis chloris	**1876**	192	192		0	Caught by Mr. Bills and Mr. Deans in Otago.	Clutha Leader 1876; Otago Daily Times 1876a, 1876b
Prunella modularis	**1876**	33	33		0	Caught by Mr. Bills and Mr. Deans in Otago	Clutha Leader 1876; Otago Daily Times 1876a, 1876b
	1877	6			6		
	1879	20	20	3	0	3 to Stewart Island, 17 to Queenstown, all caught in Otago.	Otago Acclimatisation Society 1880, 1896
	1881	28			28		
Emberiza citrinella	**1876**	6	6		0	Caught in North East Valley, Otago.	Clutha Leader 1876; Otago Daily Times 1876a, 1876b
	1878	3			3	Likely a typographical error by repeated copying in reports; first version did not contain this number.	Otago Acclimatisation Society 1883
	1879	56	56	32	0	24 liberated next to Queenstown, 32 on Stewart Island, all caught in Otago.	Otago Acclimatisation Society 1896
Emberiza cirlus	**1879**	42	42	18	0	18 to Stewart Island, 24 to Queenstown, all caught in Otago.	Otago Acclimatisation Society 1880, 1896
Total		1799	**807**	**773**	425		

they could acquire them. In fact, the species listed for introduction were carefully selected (Daily Southern Cross 1868; Star 1872; Waikato Times 1874; Otago Acclimatisation Society 1878 p. 24) and were even specifically protected by law (Nelson Examiner and New Zealand Chronicle 1863). Moulton *et al.* (2014) further suggest that it is not possible to determine the fate of any single introduction event, a statement that Pipek *et al.* (2015) showed to be incorrect. Neither is it true that acclimatisation societies were not paying attention to the fate of the introductions, as Moulton argued elsewhere (Moulton & Cropper 2014). For example, in 1871 shipments of yellowhammers and hares were discontinued as a result of successful establishment of these species in the Auckland region that meant that new introductions were no longer needed (New Zealand Herald 1871). Moulton & Cropper (2015) also criticise studies of propagule pressure for using total numbers of individuals released per species to explain establishment success, when some of the birds were being liberated after successful introduction. While this may be the case, the authors exaggerate the problem by introducing new errors. Birds that were translocated within New Zealand, rather than introduced from without, were generally not included by Thomson (1922; an exception may be skylarks from 1875; Otago Daily Times 1875). Thomson's (1922) estimates of numbers of birds introduced are probably not as wrong as Moulton *et al.*'s figures would suggest. That the birds started to be translocated to new regions within New Zealand is the best proof of them being successfully established at the time.

Moulton *et al.* (2015) argue that the robust positive relationship between propagule pressure and establishment success widely observed in invasion studies (Lockwood *et al.* 2005; Colautti *et al.* 2006; Hayes & Barry 2008; Blackburn *et al.* 2009a, 2009b; Simberloff 2009) is more likely to arise because of the Franklin Delano Roosevelt (FDR) effect (species are introduced in large numbers because the initial releases are successful; Blackburn *et al.* 2013), rather than because larger populations are less susceptible to stochastic extinction (Lockwood *et al.* 2005; Blackburn *et al.* 2009b, 2015). Tests of the FDR effect show that it is an insufficient explanation for variation in establishment success (Blackburn *et al.* 2013), but the historical record of bird introductions to New Zealand suggests that it may nevertheless contribute to the invasion process. Basic population biology tells us that the more individuals of an alien species that are introduced, the more likely they are to establish a viable population (Duncan *et al.* 2014), but the subsequent spread of the species can be further accelerated by translocating individuals from an already established alien population. This would be much more time- and cost-effective than importing successful species from their distant homelands.

In conclusion, there is a wealth of information on bird introductions that can, and should, be used to obtain as precise estimates as possible on the numbers of individuals released (Pipek *et al.* 2015). The dangers of relying on partial evidence are illustrated by the errors made by Moulton *et al.* (2014), and the primary point of this note is to ensure that these errors are not propagated in future analyses. Thomson (1922) undoubtedly includes errors, but these are small compared to errors that have been introduced through the inclusion of incorrect data by other authors (Andersen 1916; Williams 1969; Lever 2005). Nevertheless, the information on propagule pressure for historical bird invasions is of unique quality, especially compared to other groups where researchers have to rely on proxies (Pyšek & Richardson 2006; Dehnen-Schmutz *et al.* 2007a, 2007b; Dehnen-Schmutz & Touza 2008; Lee & Chown 2009b; Pyšek *et al.* 2011), and where quantitative data are still rare (Lee & Chown 2009a). It would be unfortunate if this advantage were jeopardised by the incorporation of incorrect information into the pool of data on bird introductions widely shared by researchers.

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Table 2. Translocations of birds by the Otago Acclimatisation Society not documented by Moulton *et al.* (2014). These are birds that the sources listed in the final column indicate were captured in Otago for liberation elsewhere.

Species	Years	Total number	Details	Source
Turdus merula	1880	68	4 to Hawke's Bay, 52 to Wellington, & 12 to Melbourne, Australia.	Otago Acclimatisation Society 1896, p. 143
	1881	18	18 to Wellington Acclimatisation Society.	Otago Daily Times 1882
	1882	22		Clutha Leader 1883; Otago Acclimatisation Society 1883
Turdus philomelos	1882	12		Clutha Leader 1883; Otago Acclimatisation Society 1883
Sturnus vulgaris	1880	316	307 sent to Hawke's Bay & 9 to Melbourne, Australia. Obtained by C. Bills (likely caught in Otago).	Otago Witness 1880; Otago Acclimatisation Society 1900
	1881	371	100 to Hobart, Australia, 100 to Nelson, 97 to Hawke's Bay, 60 to Greymouth, 14 to Wellington; obtained by C. Bills & likely caught in Otago.	Otago Daily Times 1882; Otago Acclimatisation Society 1900
	1882	315	Obtained by C. Bills & likely caught in Otago.	Clutha Leader 1883; Otago Acclimatisation Society 1883, 1900
Carduelis carduelis	1880	30	10 to Wellington, 20 to Victoria , Australia.	Otago Acclimatisation Society 1896, p. 143
	1881	22	Wellington	Otago Daily Times 1882
Fringilla coelebs	1880	9	Sent to Wellington	Otago Acclimatisation Society 1896, p. 143
Prunella modularis	1880	52	10 to Hawke's Bay, 32 to Wellington, 10 to Victoria, Australia.	Otago Acclimatisation Society 1880
	1881	30	Sent to Wellington	Otago Daily Times 1882
Emberiza citrinella	1880	4	Sent to Wellington	Otago Acclimatisation Society 1896, p. 143
Total		1269		

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