

1 *BINV-D-16-00598 R1*

2 Pandora's Box down-under: Origins and numbers of mustelids
3 transported to New Zealand for biological control of rabbits

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9 [Short title: Ferrets, Stoats and Weasels transported to New Zealand](#)

10

11 **Abstract** This paper describes one of the world's first large-scale experiments in biological
12 control of a major vertebrate pest of agriculture, which was tried in New Zealand during the
13 second half of the 19th century. Starting from the late 1860s, pasture damage in Southland
14 and Otago by European rabbits was causing serious reductions in productivity of sheep
15 (wool clip and lambing percentages) associated with malnutrition of the breeding ewes, and
16 a consequent decline in the value of pastoral land. In response, and despite repeated local
17 and international warnings, ferrets, stoats and weasels (*Mustela furo*, *M. erminea* and *M.*
18 *nivalis*) were liberated on the worst of the rabbit-infested pastures. They were perceived as

1 the 'natural enemies of the rabbit' but (unlike foxes) too small to threaten lambs. Over the
2 50 years after 1870, upwards of 75,000 ferrets, most imported from Australia or locally
3 bred, were released in the South Island. Over the decade 1883-1892, at least 7,838 stoats
4 and weasels arrived from Britain. At least than 25 shipments are known, with an average of
5 only 10% mortality per shipment. Of the 3585 animals listed by species, 73% were weasels.
6 The total cost of the ferret programme cannot now be estimated; that of stoats and weasels
7 alone was *at least* £5441, probably twice that, or > \$NZ 1-2 million in today's money.
8 Mustelids (and cats) killed many young rabbits, which was helpful because rates of change
9 in rabbit populations are sensitive to variations in juvenile mortality, but in the most rabbit-
10 prone semi-arid lands, mustelids could not remove enough rabbits to prevent the
11 continuing damage to sheep pastures. The era of deliberate introductions of mustelids to
12 control rabbits in New Zealand was short, expensive, and unsuccessful.

13 **Keywords** invasive species; biological control; New Zealand history; *Oryctolagus cuniculus*;
14 *Mustela furo*; *Mustela erminea*; *Mustela nivalis*

1 Introduction

2 New Zealand was the last major archipelago to be colonised by Europeans during the 19th
3 century (Dunlap 1999). The Maori people who had occupied the islands since c. 1280 AD
4 had modified the environment by burning forests and hunting native birds, but the only
5 native land mammals were bats. Until the first European explorers gifted pigs and goats to
6 the Maori for food in the late 18th century, the country was completely devoid of any
7 animals useful for European-style farming or sport hunting (King 2005).

8 As soon as the Treaty of Waitangi (signed in 1840) permitted, an increasing tide of European
9 settlers imported thousands of domestic livestock (sheep, cattle, goats, horses), and
10 adapted familiar farming methods to suit their new environment. From the 1850s onwards,
11 the first and largest leasehold pastoral enterprises spread rapidly across the extensive fire-
12 induced grasslands of the eastern South Island (Fig.1), converting it into huge privately-run
13 sheep runs (Peden 2011). By 1882, more than a thousand runs were established, of which all
14 but 26 were in the South Island (Blue Book 1882:214).

15 [Here Fig 1](#)

16 Wild European rabbits spread rapidly from their early liberation sites in Southland,
17 Marlborough and Hawke's Bay (King submitted-a). Their numbers escalated to legendary
18 proportions (Norbury and Reddiex 2005), inducing massive pasture damage with drastic
19 consequences for the economics of pastoral farming (King submitted-a). Some idea of the
20 extraordinary increase in numbers of rabbits after the mid 1870s can be gleaned from the
21 annual Government export statistics (Fig 2). The number of rabbits exported as skins or
22 meat is not a measure of the national population of rabbits, but is surely correlated with it.
23 Furthermore, official export data have the advantage of being accurately monitored, which

1 the numbers of live rabbits were not. On a more local scale, detailed farm records clearly
2 illustrate the dramatic impact of rabbits on wool production on individual properties
3 (Holland and Figgins 2015).

4 [Here Fig 2](#)

5 Of course, rabbits did not have the same effect everywhere, and other environmental
6 changes (especially periodic droughts and rampant weeds) contributed to the declining
7 fortunes of the southern South Island pastoral industry (Holland 2013), but rabbits were the
8 most obvious problem. In May 1876, a Parliamentary report (Richardson and Pearson 1876)
9 found that pasture damage and malnutrition of ewes following the spread rabbits had
10 caused the reduction of the Southland wool clip by 700-800 fewer bales over 12 months,
11 and losses of lambs averaging up to 20% across the province per season. It identified the
12 absence of the rabbit's natural enemy as the reason for the unexpected irruption, and
13 recommended the importation of ferrets, stoats and weasels. The New Zealand House of
14 Representatives set up a Rabbit Nuisance Committee, which in August 1876 came to the
15 same conclusion (Hodgkinson 1876).

16 The dominant run-holders persuaded the Colonial Government to agree to these
17 recommendations, on the twin assumptions that ferrets, stoats and weasels really were
18 capable of keeping down rabbit numbers, but too small to pose a serious threat to lambs.
19 Attempts to make the proposed imports illegal failed (Wells 2006). In 1881, the Government
20 strengthened earlier and less effective anti-rabbit legislation, and appointed a new
21 Superintending Inspector, Mr Benjamin P. Bayly. The new legislation provided for legal
22 protection for all enemies of the rabbit, including fines of up to £10 for killing a ferret or

1 weasel, and up to £20 for failing to control rabbits. The average agricultural worker of the
2 time earned about £1 a week (<http://logicmgmt.com/1876/living/occupations.htm>).

3 Thence began an unprecedented, ambitious and uncontrolled experiment in state-
4 sponsored biological control. The result has been the establishment of the largest invasive
5 populations of these three species in the world, causing serious conservation damage to
6 native fauna continuing to the present day. A strategy that seemed at the time to be merely
7 logical turned New Zealand into a textbook example of the perils of misguided nineteenth-
8 century acclimatisation (Gibb and Williams 1994).

9 Ferrets, stoats and weasels

10 The ferret *Mustela furo* is a domesticated version of, probably, the European polecat
11 (*M. putorius*) (Davison et al. 1999). Ferrets were the first specialist rabbit predators to be
12 imported, because they were easy to obtain and handle, and already present in Australia.
13 Ferrets can be easily bred in large numbers given good housing and protection from disease,
14 so many ferret stud farms were established from imported stock to supply animals for
15 release on pastoral runs. Their long history of domestication and the confusing numbers of
16 introductions around the world make any genetic analysis unhelpful for identifying origins,
17 so this enquiry is concerned only with the numbers of domestic ferrets brought to and bred
18 for release in New Zealand over at least 50 years from 1870.

19 By contrast, stoats and weasels (*Mustela erminea*, *M. nivalis*) are specialist predators of
20 small rodents and rabbits native to the cooler parts of the northern hemisphere (King and
21 Powell 2007; McDonald et al. 2000). Over a short period of ten years 1883-1892, multiple
22 private and official shipments of wild stoats and weasels arrived from Britain, and the
23 imported animals were immediately released in the most severely rabbit-infested areas.

1 The numbers of stoats removed from Britain were inconsequential to the remaining stoat
2 population, but have since had an unexpected potential benefit for their descendants. A
3 recent analysis found five mitochondrial haplotypes in New Zealand stoats, only one of
4 which survives in Britain (Veale et al. 2015).

5 This surprising result seems to be because the extensive sampling and transportation of
6 British stoats to New Zealand in the 1880s has preserved much of the genetic diversity
7 among stoats then living in Britain. Since then, British stoats barely survived a catastrophic
8 population decline that followed the removal of their main food supply by the rabbit disease
9 myxomatosis in 1953-55 (Sumption and Flowerdew 1985); contrariwise, weasels and voles
10 benefited from the removal of competition (King and Powell 2007).

11 Comparison of the genetic signatures of invasive species with those of their presumed
12 ancestors can uncover information about the history of the invasion invisible to other forms
13 of analysis, subject to certain assumptions. The critical data required for modelling of any
14 invasion include informed estimates of the sizes and origins of the invading propagules,
15 which strongly affect their chances of establishment (Blackburn et al. 2015).

16 The aim of this paper is to summarise what is known of the numbers of all three species
17 imported, plus, for stoats and weasels though not for ferrets, where the wild animals were
18 collected, and when they arrived.

19 **Methods**

20 Primary data detailing how the shipments were organised are preserved in archives and
21 research libraries in New Zealand and in England. Digitised versions of official reports of the
22 New Zealand Parliamentary debates, and the Appendices to the Journal of the House of

1 Representatives (AJHR), are the most reliable online sources. Deposits of unpublished
2 official documents (handwritten letters, and unpublished files) are held in Archives NZ, most
3 freely accessible to readers on site, and locatable in their catalogue
4 <https://www.archway.archives.govt.nz/> from the Record Number given here. I have
5 personally searched all of the main depositories held by Archives New Zealand, Statistics
6 New Zealand and the Alexander Turnbull Library (all in Wellington); the Hocken Library
7 (Dunedin); the Auckland Institute and Museum; the city libraries of Auckland and Dunedin;
8 the Maritime Museums of Auckland, Port Chalmers and Bluff; the UK National Archives at
9 Kew, the Caird Library of the National Maritime Museum, in Greenwich; the Bodleian Library
10 (Oxford) and the Cambridge University Library; and the Museum of English Rural Life
11 (Reading). Some smaller local depositories in New Zealand were searched by their archivists
12 on my behalf. Dates of ship departures from England and arrivals in New Zealand are taken
13 from Comber's Index, which ends in December 1889:
14 <http://freepages.genealogy.rootsweb.ancestry.com/~nzbound/comber.htm>.

15 Online newspaper databases (<https://paperspast.natlib.govt.nz/> and
16 <http://www.britishnewspaperarchive.co.uk/search>) are valuable and easily accessible.

17 Stoats and weasels are similar in appearance and often confused, because the distinguishing
18 black-tipped tail of the stoat is not always noticed, then or now. Most of the primary
19 sources cited here refer to both together, often under the general term 'weasels'; variant
20 spellings ('weasle', 'weazel') are given here as in the original sources, to facilitate follow-up.

21 Ferrets (*M. furo*) and polecats (*M. putorius*) are quite different, in appearance, biology and
22 origin, but the generic label 'mustelids' includes all four species.

1 The very large body of information uncovered by these searches has been subdivided for
2 publication as follows. (1) The present summary of the origins and numbers of all three
3 mustelid species landed, with the minimum of historical details needed to appreciate the
4 story. (2) A description of the locations where the imported stoats and weasels were
5 released, and the pattern and timing of their subsequent spread across the South and North
6 Islands (King in press-b). (3) A pair of companion reviews exploring the political and socio-
7 economic conditions behind the decisions to import first, rabbits and ferrets, and second,
8 stoats and weasels, with full historical details of the complex transport arrangements, the
9 personalities of the main actors and the assumptions under which they operated, which
10 need explaining because they were very different from ours (King submitted-a; King
11 submitted-b). (4) The consequences of ferret predation for the native (weka, a flightless
12 predatory rail *Gallirallus australis hectori*) of the southeastern South Island (King in press-a).
13 (5) New Zealand's narrow escape from importations of other alien predators of rabbits
14 which arrived but failed to establish (mongoose *Herpestes* sp.) or for which serious
15 proposals were made but never activated (Patagonian fox, pine marten, Scottish wild cat
16 and others) (King in prep.).

17 Ethics Statement: This project did not require the use of any human or vertebrate animal
18 subjects or tissues. No permits were required.

19 Results

20 Ferrets, 1870s to 1920s

21 At the time that British agents were collecting ferrets for transport to New Zealand and
22 Australia, Britain's wild native polecat was almost extinct, largely due to historic persecution
23 by gamekeepers (Langley and Yalden 1977). So there is little chance that any true polecats,

1 which might have been more likely to survive independently, were included among the
2 shipments. Nevertheless, domesticated ferrets with dark polecat-like pelage were often
3 believed to be crossbreeds.

4 Despite strong objections, importing alien predators remained legal (Wells 2009). A firm of
5 stock agents in Melbourne asking for an import permit from the Colonial Secretary in
6 Wellington was reassured that ‘There is no law against it, and ferrets are not mentioned in
7 S 2d of Protection of Animals Act 1873’ (Bishop 1878). Table 1 lists the only official data
8 found so far on the numbers of ferrets imported, which are probably a gross underestimate.

9 [Here Table 1](#)

10 However, ferrets turned out to be over-sensitive travellers, and very susceptible to canine
11 distemper. Several shipments were entirely destroyed by disease or bad handling en route;
12 one runholder reported getting only two live ferrets out of a total of 1300 shipped (Randall
13 Johnson 1884). From 25 consignments paid for by the Government between March 1882
14 and June 1883, only 178 of 1217 shipped from England landed alive, plus 198 of 241 from
15 Melbourne (Bayly 1883). In 1884, the Government abandoned imports and shifted to a
16 policy of purchasing ferrets bred in local stud farms (Bayly 1884).

17 The number of ferrets bred for deliberate release soon reached astonishing levels: e.g.,
18 7,539 in 1884-1886 alone (Anon. 1886). Over 18 months in 1887-88, contracts for supply of
19 ferrets for district rabbit inspectors totalled 21,760 (Stock Department 1888). Clarke
20 (1949:266) cites an unpublished estimate by R. M. Burdon that overall a total of ‘upward of
21 75,000’ ferrets were bred and released on the South Island. But right from the beginning it
22 was observed that the mortality of the ferrets released into mountain country was often

1 very high, especially over winter. Stoats and weasels, already adapted to colder conditions,
2 were seen as a more hardy alternative (Anon. 1881).

3 [Stoats and weasels, 1883-1892](#)

4 The idea of exporting weasels to New Zealand provoked strong objections from leading
5 ornithologists concerned with the threat to New Zealand's endemic flightless native birds
6 (Buller 1877), and despair among New Zealand landowners who had been investing heavily
7 in acclimatising game birds for sport (Thomson 1922). Ignoring them, a few attempts were
8 made to import small numbers of weasels or stoats privately during the 1870s, but none
9 was successful (King submitted-b). No-one at that time knew how to care for such active,
10 highly-strung and aggressive animals for long enough to bring them safely round the world
11 (Hodgkinson 1876), and land them alive in numbers sufficient to establish a population. The
12 rabbits continued to ravage the South Island runs.

13 In early nineteenth-century England, rabbit-warrening and fur-dressing were important rural
14 industries, especially in northern Lincolnshire (Beastall 1978; Bygott 1952; Thompson and
15 King 1994: 64-67). Wild rabbits were protected by networks of traps set to remove the
16 stoats and weasels (native carnivores but regarded as vermin) that reduced the farmers'
17 harvest of rabbitskins. Trappers were also employed on sporting estates to protect game
18 birds (McDonald and Murphy 2000).

19 One English gentleman farmer, Samuel Grant, had a farm at Castlethorpe (Fig 1), where he
20 employed local professional vermin destroyers, including Walter Allbones (1863-1948) from
21 the nearby town of Brigg. On an 1880 tour of New Zealand's South Island (Grant and Foster
22 1880), Grant had probably met Francis Dyer Rich, owner of Bushey Park, near Palmerston
23 (Fig 1). In 1882, Rich commissioned Grant to supply a trial shipment of mustelids for his

1 estate, with an experienced man to accompany them on the journey from England (Grant
2 1883). Grant recommended Walter Allbones for the job. Over the next ten years, Walter
3 undertook at least five more deliveries to New Zealand, and his father Henry at least seven.
4 Other and un-named couriers brought the total number of known shipments to 25 (Table 2).

5 The great majority of the animals shipped to New Zealand in the early-mid 1880s were
6 collected from farms around Allbones' home base in northern England. A much later review
7 of his work (Lincolnshire Times 1976) states that Walter got many of them from a farm at
8 Croxby Top (Fig 1, inset), near Rothwell in the Lincolnshire wolds, which is still a working
9 arable farm quilted with hedges and copses, the classic gamekeepers' trapping sites.

10 While Walter was away, Henry Allbones collected animals for the next consignment at his
11 property in Brigg. He received offers of animals from all over the country but, at least in
12 mid-1885, was still finding it cheaper to collect them himself in Lincolnshire (Auckland Star
13 1885a). As the demand grew, Henry advertised in other county newspapers in northern
14 England and lowland Scotland, and in a national sporting journal (The Field 1884a).

15 Throughout his operation he still continued advertising in Lincolnshire, offering to supply
16 traps at 3s 6d and instructions if needed.

17 Other collectors worked in Hampshire, Devonshire and in Edinburgh. Henry was at one point
18 offered 'a full supply from Ireland' (Nelson Evening Mail 1885b), but no New Zealand stoats
19 sampled so far have showed any genetic connections with Ireland, or from continental
20 Europe (Veale et al. 2015). So far as it goes, the documentary evidence confirms that most
21 stoats and weasels brought to New Zealand came from northern England, plus perhaps
22 some from other parts of Britain. The Allbones dropped out of the trade in mid 1890, and
23 all imports ceased in 1892.

1 Table 2 compiles annual estimates of stoat and weasel arrivals from published and
2 unpublished sources. The total of 7,838 could not have been carried in only 25 shipments,
3 averaging about 270 animals per consignment, which confirms my suspicions that some
4 unknown number of shipments were never reported. Many more weasels than stoats (2622
5 to 963) were listed in the 16 records distinguishing the two species (King in press-b).

6 [Here Table 2](#)

7 The first trial consignment of 25 stoats and weasels plus 8-10 ferrets was loaded onto the
8 sailing vessel *Waitangi*, but when the ship hit a storm in the English Channel, all but ten
9 mustelids were lost overboard. The ship recovered, and eventually arrived at Port Chalmers
10 on 26 March 1883 (Otago Daily Times 1883b). The surviving animals were delivered to Rich
11 as Bushey Park. At Bayly's urging (Bayly 1883), the Colonial Secretary in Wellington
12 commissioned the New Zealand Agent General in London to begin an official programme of
13 sending cargoes of weasels and stoats to New Zealand in the care of Walter Allbones
14 (Colonial Secretary 1883). The first official consignment arrived on the steamer *Doric* six
15 months later.

16 Between June 1884 and January 1886, six shipments totalling 1,312 stoats and weasels
17 arrived in New Zealand (Table 2). Four lots were commissioned by the Government for
18 turning out on Crown lands, mainly in the South Island. Bayly's plan was to populate the
19 inland mountains with mustelids, so that the grey horde moving steadily north through
20 Southland into Otago would be met by 'industrious foes' on reaching the Canterbury
21 boundary (Mataura Ensign 1884b). Another two shipments were private orders for
22 properties in the lower North Island.

1 In January 1886 the Shaw, Savill and Albion Co., who chartered the *Ionic* and the *Doric*
2 (Table 2) for the New Zealand trade (Waters 1961: 76), suddenly refused to convey stoats
3 and weasels to New Zealand because of passenger complaints (Agent-General 1886). Bayly
4 spent 18 fruitless months searching for alternative ships willing to accept official bookings,
5 while fears among the run-holders continued to escalate. If rabbits did indeed overrun the
6 whole high country, as seemed inevitable, the predicted cost to the Government would be
7 £10,000 a year in lost revenue, plus the loss to wool producers of £35-40,000 a year (Baker
8 1887). Eventually, the shipping stalemate was resolved by a new agreement arranged by
9 Henry Allbones in May 1887 with Shaw Savill's rivals, the New Zealand Shipping Company,
10 with immediate effect – the next shipment arrived in October (Table 2).

11 From 1887, the annual import records distinguished stoats and weasels as a separate
12 category {Blue Book, 1870-1899 #557}. These figures provide independent estimates of the
13 numbers of animals arriving each calendar year (Table 2), although without any further
14 details. From 1887 to 1891 inclusive, these import categories recorded the arrival of 6,516
15 animals – an astonishing total, but likely to be more accurate than the 3,847 animals
16 mentioned in press reports for the same years. The large numbers of stoats and weasels
17 brought in during that period reflect the desperation of the run-holders and the pressure
18 they were putting on the Government.

19 Continuing objections against Bayly's policies eventually precipitated an important change
20 in Government policy in 1889. Bayly was demoted (Anon. 1889), and official support for his
21 programme was withdrawn. Local communities had to organise themselves, encouraged by
22 a new official policy from October 1889 which stated that, where the settlers established a
23 Rabbit Board formed under the rabbit nuisance legislation, it would be entitled to a pound

1 for pound subsidy. If they did not constitute themselves into a Rabbit Board, they would be
2 entitled to a bonus of £1 per stoat and 10s per weasel imported by them into the Colony
3 (Otago and East Coast Rabbit Association 1889). The Awatere Rabbit Board of Marlborough
4 ordered 1,000 stoats and weasels (NZ Herald 1888), which arrived in five lots from January
5 1888 and August 1889. The same Board then placed another similar order. In 1890 alone, a
6 total of 2,292 stoats and weasels arrived, followed by 1,100 in 1891 (Table 2).

7 Disagreements on rabbit control policy within nineteenth-century official circles are well
8 illustrated by the report of the Joint Committee on Livestock and Rabbits in 1890. Long after
9 Bayly's departure, the Committee repeated its trenchant 1889 criticism of the change in
10 policy. They strongly recommended that the Government 'should continue the
11 introduction of stoats and weasels in large and continuous numbers' (Randall Johnson
12 1890). Nothing changed: the Rabbit Nuisance Committee's report for 1891 does not
13 mention natural enemies at all (Lawry 1891).

14 Rabbit Boards continued to order shipments for another year, but after three of the six
15 consignments sent in 1891 to the Wairarapa Rabbit Board suffered high mortality in transit
16 (leaving the Board to pay for the loss), it decided to cease importing stoats and weasels.
17 Rising protests against the introductions, and wider supplies of cheaper, locally-bred ferrets,
18 helped to hasten the decision. Other Boards must have agreed, because from 1892
19 onwards, the 'Stoats and weasels' import category disappeared from the annual statistical
20 report.

1 Discussion

2 Total numbers and costs of imports

3 It is obvious that the known records do not tell the complete story. Private agencies could
4 and did release as many ferrets as they could obtain, and locally bred ferrets were easy to
5 come by. Burdon's estimated total of 75,000 ferrets released is barely more than a guess,
6 supported but not proven by multiple overlapping references in the literature mentioning
7 liberations by the thousands. New Zealand now has the largest population of feral ferrets in
8 the world (Clapperton and Byrom 2005).

9 For stoats and weasels, the list of consignments arriving up to January 1886 is probably
10 reliable, because every shipment was of intense public interest, widely observed, officially
11 reported and frequently commented on in the press and in Parliamentary documents. After
12 1887, Government switched to subsidising private importations, and press reports became
13 increasingly vague, if existing at all (King submitted-b). Most published records of shipping
14 movements do not mention the animals, and no detailed cargo lists for the relevant voyages
15 have survived. Published passenger lists do not always name the people travelling in
16 steerage class, as both the Allbones and other stock managers always did. Private
17 consignments accompanied by un-named agents would be nearly impossible to find. Some
18 at least could have arrived in response to the Government's promise of 'liberal support' for
19 private importers (Poverty Bay Herald 1883a).

20 Even so, Table 2 shows that the bare minimum number of stoats and weasels known to
21 have been landed must have been at least 7,838 individuals, of which about 5,169 were
22 reported in the press. The difference of 2,669 animals could explain, at an average of 270
23 per shipment, some of the gaps in Table 2 plus perhaps other consignments in addition to

1 the 25 known. The total cost of the programme was well over £5,000, or (allowing for the
2 number of gaps in the data, more likely twice that by the end of 1892), more than \$NZ 1-2
3 million in today's money (<http://www.rbnz.govt.nz/monetary-policy/inflation-calculator>).

4 Was the benefit worth the cost?

5 Experimental work in Australia by Pech et al (1992) has demonstrated that the relationship
6 between rabbits and foxes can alternate between two complementary states. The same two
7 states can be identified in the history of rabbit predators in New Zealand.

8 In the first state A, rabbits at very high density are unaffected by predation, as is illustrated
9 by conditions in the most rabbit-prone parts of the South Island high country and arid lands.
10 The rabbit breeding season is short (September to January), and the seasonal shortage of
11 young rabbits reduces the numbers of overwintering mustelids and cats until late spring
12 (November). In isolated areas, e.g., the peninsula on Lake Wanaka, where the first weasels
13 were released in the winter of 1884 (Bayly 1886), rabbit numbers were at first reported to
14 be declining, but this benefit could not be extended to the surrounding huge, unfenced
15 areas of high country where rabbit control was most needed. Hence, at the height of the
16 nineteenth century crisis, the simple liberation of predators onto very large unfenced
17 pastoral land could not add to, rather than merely replace, other forms of rabbit mortality,
18 so had very little effect on rabbit numbers.

19 In the second state B, rabbits already at low density can be kept down by predation. This
20 state is illustrated in much of the North Island, where good rainfall, mild winters and close
21 pasture management create habitat conditions in which rabbits at low density can breed
22 almost year-round, maintaining the numbers of mustelids and cats over winter. Predation
23 falls most heavily on young rabbits, and if high numbers of these predators are already

1 present early in spring, when young rabbits first appear, they can have a substantial effect
2 on a rabbit population (Gibb et al. 1978; Norbury and Jones 2015). Mustelids are especially
3 good at this because they can enter the burrows and find the nestlings before they emerge.
4 For example, five years after the first stoats and weasels were liberated on E J Riddiford's Te
5 Awaiti station on the east coast of the Wairarapa in July 1885 (Winser 1885, 1886), his
6 manager reported seeing few lactating doe rabbits and very few young rabbits. Organised
7 management of rabbit populations in state B is rarely necessary (Parkes 1995), as was
8 experimentally demonstrated in the North Island by Gibb et al. (1969).

9 Could predators help defeat the problem of unmanageable state A rabbit numbers by
10 inducing a switch into state B? Foxes in Australia can achieve this effect after a drought, but
11 in nineteenth century New Zealand the imported mustelids were usually liberated where
12 rabbits were already hugely abundant, in numbers too small to achieve this effect. There
13 were rare and local exceptions (King submitted-a), but in most places ferrets had little effect
14 on the numbers of rabbits. The same is true now, because ferret numbers are determined
15 by rabbit numbers rather than vice versa (Norbury et al. 2002). Likewise, stoat numbers are
16 closely linked to the abundance of rodents in spring (King and Powell 2011), and stoats have
17 no compensatory benefit to New Zealand by controlling the numbers of introduced rats and
18 mice (Jones et al. 2011; Ruscoe et al. 2011). So the answer, regrettably, is that the cost of
19 Bayly's programme, in money and in conservation damage, was and remains beyond
20 counting, while the benefit was roughly zero.

21 Conclusion

22 Faced with the unsustainable damage and losses caused by over-abundant rabbit
23 populations, land managers in nineteenth-century New Zealand searched for more effective

1 and economically feasible means of killing rabbits. At first they hoped to cover the ruinous
2 expenses of employing men to trap and poison rabbits over huge areas of high country by
3 making the rabbits contribute to the costs of their own destruction. Hence the growth of
4 ancilliary industries trading in rabbit skins and later, canned and frozen rabbit meat, but of
5 course those so engaged would always leave a breeding stock for next year (Ritchie 1892).
6 The problem with any policy of controlling a pest by using men paid for their work in
7 products of the pest is that it guaranteed a workforce with a vested interest in doing
8 profitable work that was ineffective in controlling rabbits. Only a de-commercialisation
9 policy could overcome that unhelpful feedback, and that was not done until 1947 (Gibb and
10 Williams 1994).

11 The theoretical attraction of employing natural enemies was the assumption that they
12 would do the same work as paid labour, but cost-free. Unfortunately, the very same
13 sentence as above could be re-stated: The problem with the policy of controlling rabbits
14 using mustelids paid for their work in meals is that it guaranteed a workforce of animals
15 with a vested interest in doing profitable work that was ineffective in controlling rabbits.

16 Nineteenth-century observers both in New Zealand and in Britain pointed out the certainty,
17 even before the first mustelids arrived, that Bayly's policy would introduce a supposed
18 remedy that would turn out to be worse than the disease. Their most urgent question was:
19 How can we find more and better ways of killing rabbits to save our wool industry? In the
20 21st century we face a similar question: How can we find more and better ways of killing
21 mustelids to save our native fauna? We can sympathise with the traumatic rabbit dilemma
22 of 130 years ago, and should be careful to understand the issues at stake as the people of

1 those times did. There are some interesting parallels with the pest management challenges
2 of our own times (King submitted-a).

3 Acknowledgements

4 This project would have been impossible without the help of many people, especially Ken
5 Ayers, who did much of the early archive searching both in New Zealand and in UK.

6 Librarians: Judith Holloway (Hocken), Cheryl Ward (Waikato University), Emma Knowles
7 (Otago Early Settlers Museum), Rachael Gardner and Marion Lowman (Bodleian), and staff
8 at the libraries of the Zoological Society of London, and Cambridge University.

9 Archivists: Chris Meech (Waitaki District Archive), Katherine C'Ailceta, Donal Raethel, Trish
10 McCormack (Archives NZ, Wellington), Kas McEntyre (Alexandra), Rebecca Smith, Sonya
11 Johnson (Invercargill), Anne Maguire (Arrowtown) Fiona Passi (Auckland), many staff at
12 National Archives (Kew), National Maritime Museum (Greenwich), Berkshire Record Office
13 and Museum of English Rural Life (Reading).

14 Information: David Allbones, Ken Ayers, Dawn Coburn, Nigel Fisher, Peter Holland, Frank
15 Leckie, Rachel Letofsky, Fay McDonald, Tessa Mills, Maxine Moerbe, Mark and Claire
16 Strawson, Evan Tosh, John Dyer.

17 Graphics: Max Oulton, Conrad Pilditch.

18 Hospitality: Daphne and Bill Lee (Dunedin), Anne Sudell, Jeff and Kate Booth (Wellington),
19 Joan Moerbe née Allbones and Maxine Moerbe (Brigg), Wolfson College (Cambridge),
20 Lauren Harrington (Oxford).

1 Funding: University of Waikato RTCF Grant 2016/104615. The funder had no role in study
2 design, data collection and analysis, decision to publish, or preparation of the manuscript.
3 Helpful comments on drafts: Ken Ayers, Tom Brooking, Peter Holland, Daphne Lee, Andrew
4 Veale, and the Editor and two referees.

5

6 Figure captions

7 Fig. 1. Locations of places mentioned in the text. Dark lines enclose the extent of open
8 country, as defined by Holland & Figgins (2015), i.e., the main area covered by pastoral runs
9 and the favoured habitat for rabbits. For names, numbers and further descriptions of runs in
10 Otago and Southland, see Pinney (1981) and Sinclair (2003). Inset, above left: New Zealand
11 North Island. Inset, lower right: Locations of places in UK, with an enlargement for northern
12 Lincolnshire, the centre of the former rabbit fur industry and of the mustelid collecting
13 operations of Henry and Walter Allbones of Brigg.

14

15 Fig. 2.

16 Exports of wool (in millions of pounds weight) and numbers of rabbits (in skins alone until
17 1893, then in frozen carcasses with skins on 1884-1899) (Glasgow 1901), from New Zealand
18 in 1873-1899 {Blue Book, 1870-1892 #557}.

19

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4 <https://www.archway.archives.govt.nz/>

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