The distribution of Argentine ant in New Zealand: Can a ten-year old decision not to eradicate be re-visited?

J.G. Charles[1], D.M. Suckling[2], D.J. Allan[1], K.J. Froud[1], P.R. Dentener[1], P.G. Connolly[1] and H. Verberne[3]

[1]*HortResearch, Private Bag 92 169, Auckland, New Zealand*
[2]*HortResearch, P.O. Box 51, Lincoln, New Zealand*
[3]*AgriQuality, Private Bag 3080, Hamilton, New Zealand*
Corresponding author: jcharles@hortresearch.co.nz

Summary

Decisions to eradicate, contain or accept new invaders are made in the face of often complex interactions between biological, social, economic and environmental factors. The outcomes of this dynamic mix may change over time, so that, for any species, a decision made in the past may differ to that made in the present or future. This is illustrated by the Argentine ant, *Linepithema humile*, which established in New Zealand in about 1990, with no attempt at eradication or containment. Changing attitudes and control options since then have led to a study of the geographical distribution of the ant throughout New Zealand over a 10 week period from mid-March until the end of May 2001. Foraging workers were collected in jam-baited traps over a 24 h period. Traps were deployed in 'starburst arrays' of up to 33 traps, or in groups of four, or singly at selected locations and habitats where *L. humile* was, or might be expected to be, a problem. Argentine ants were caught in 84 traps (out of 2216) and were shown to be widely, though patchily, distributed throughout New Zealand, especially in the north of the North Island. They were found for the first time in Kaitaia and Hamilton, and were patchily distributed through the greater metropolitan area of Auckland. The presence of other ant species in most traps, but the absence of *L. humile*, provided evidence that *L. humile* had not yet established at most locations. Modelling showed that climate is not a limiting factor to the eventual distribution of *L. humile* throughout most

of New Zealand. The poor dispersal of *L. humile* from Auckland over a 10 year period, the availability of new pesticides and efficient delimiting surveys may make regional containment or local eradication feasible.

Keywords: *Linepithema humile*, *Doleromyrma darwiniana*, geographical distribution, new records, modelling, containment and eradication.

Introduction - Containment or Eradication?

One of the first decisions that must be made following the discovery of any exotic insect in New Zealand is whether to attempt to eradicate it, or accept that it is present and to develop strategies to manage it. If the latter, then further decisions revolve around whether to contain it regionally (e.g. keep it out of the South Island) or locally (e.g. manage it within an orchard). These decisions are made in the face of an often complex blend of incompletely understood biological, social, economic and environmental factors, each of which can be difficult to quantify. In fact, the cost of a short-term eradication programme is likely to be relatively easy to calculate compared with the possible economic damage to crops, international trade, or the possible impacts on human health or the environment, over many decades. In practice, the immediate decision to eradicate or control a new invader almost invariably depends on a rapid assessment of a few biotic and abiotic factors. These include its reproductive biology and ability to disperse, how long it has been in NZ, where it is present in NZ now, and possible options for managing or eradicating it. A final decision to eradicate or contain may be made after considering relative or perceived values of crops, international trade, tourism, community health and the natural estate, together with the extent of public interest or lobbying.

This dynamic mix of scientific, social, economic and political criteria leads to the inevitable realisation that a decision to eradicate a pest today might be different if the same pest arrived ten years ago or in ten years time. A good example of changing attitudes is provided by *L. humile*. This ant is a native of South America (Suarez et al. 2001) but has spread to the USA (Bolger et al. 2000), Europe - from the Netherlands in the north to Italy in the south (Roland et al. 1999), the

United Arab Emirates (Collingwood et al. 1997), South Africa (Kock et al. 1989), Japan (Sugiyama 2000), Australia (Anon. 1986) and New Zealand (Green 1990). *Linepithema humile* is considered one of the 100 worst invasive species (Global Invasive Species Group, IUCN (www.issg.org)), in agricultural, urban and natural environments (Vega & Rust 2001). With this background, it would seem hard to deny today that this ant should be a prime candidate for eradication. Yet when *L. humile* was first found in central Auckland on 19 January 1990, the then Ministry for Agriculture and Fisheries decided not to attempt eradication or containment. The decision was made primarily on the basis of a survey which determined that the ant was already well established in Auckland, and had probably been present for at least a year (Green 1990). In addition, there were no known effective control methods.

In the decade following its arrival, *L. humile* was recorded spasmodically from Northland to the Waikato and Bay of Plenty. Reports of its presence in Wellington and Christchurch in 2000 coincided with recognition of its potential as a significant environmental threat when it was found on Tiritiri Matangi Island in the Hauraki Gulf (Harris & Green 2001). At about this time a new poison bait was developed in Western Australia that showed potential for control and local eradication of *L. humile*, so in November 2000, central government (through MAF Biosecurity Authority) agreed to fund a new investigation into *L. humile*. The initial phase was to be a nationwide survey, which was considered to be important for the development of any new containment or eradication initiatives.

National Survey for Argentine ant: Methodology

The ant survey was carried out over a 10 week period from mid-March until the end of May 2001. It was designed to provide qualitative rather than quantitative results – i.e. to determine if *L. humile* was present at a location rather than to fully delimit or quantify its presence within a district.

Trap design

Ants were collected passively by trapping foraging workers, rather than actively by searching for *L. humile* trails. Active searching for the

distinctive *L. humile* trails was recognised as a valid approach to surveying, but the standardisation of results offered by passive trapping (so that traps of the same design could be set anywhere in the country, by anyone with little or no understanding of ant ecology) was considered to be a greater advantage. In essence, the decision to use a passive rather than active trapping method assumed that the ability of ants to find sugar-baited traps was greater than the ability of surveyors to find ants.

Traps were designed to be efficient, simple, robust, inexpensive and easy to transport. Each consisted of a 15 x 120 mm strip of yellow, double-sided sticky 'flytrap', baited with a small dollop of jam (about 1 cm^2) in the centre of one side, inserted into an open-ended 150 mm length of 19 mm internal diameter clear plastic tube (Fig. 1).

A pilot trial in Auckland in early March 2001 showed that *L. humile* (and other ant species) found 67% of traps after 4 h, and nearly all traps after about 20 h. As a result, the traps were set on one day and retrieved the following day, whenever feasible. Ant species such as *Pheidole megacephala* and *Iridomyrmex anceps*, which habitually feed on meat or protein, were also trapped during the pilot trial. This provided some confidence that *L. humile* would continue to be attracted to the jam-baited traps even if food preferences changed during the survey period.

Survey design and site selection

New Zealand has a land area of about 250,000 km^2, so a complete 'nationwide' survey at, say, 500 m squares would require an impractical number of samples (approaching 1 million). Because most of the known *L. humile* populations in New Zealand were distributed around human habitation, the trapping effort centred on all international and domestic maritime ports, and the Central Post Office (CPO) of all towns with a human population of >35,000. The greater Auckland suburban regions were not targeted, because *L. humile* was already known to be widely, but patchily, distributed there. Where Argentine ant was already known to be present (except Auckland) traps were deployed in "starburst arrays" centred on the known point record of *L. humile*. Traps were placed on the ground at approximately 100 m, 200 m, 400 m and 800 m from a central point. Up to 8 radiating transects were established from that point, giving a maximum of 33 traps per starburst. In practice, and especially in suburbia, the direction and number of transects were

dictated by street layout. The data thus obtained did provide an estimate of the distribution of *L. humile*. In addition to the starbursts, or at selected towns of <35,000 people, traps were placed (up to about 50 m apart) in railway yards, commercial transfer stations, commercial trading centres and hospitals. Sites with high volumes of inter-city commercial traffic were preferred to those with local traffic only. Geographically dispersed sites were selected where possible in order to increase the probability of locating a rare event, so that if the largest businesses were grouped in an industrial park in one part of town then smaller businesses elsewhere were also selected. Large businesses or factories outside city boundaries were also selected (e.g. Kawerau pulp and paper mill, Tiwai Point smelter, freezing works, dairy companies, etc). A hospital, if present, was always included. Finally, a more discretionary approach to site selection was also employed. One to four traps were placed about 50 m apart, by AgriQuality and HortResearch staff, pest-control operators or Regional Council staff, in areas known to have an ant problem, or where *L. humile* was expected to be a problem. The first traps were collected from Invercargill in March and the last from the northern North Island in late May after the onset of a period of cold and wet weather across most of the country.

Traps were baited immediately before being placed on the ground, on warm sunny days whenever possible, in or close to micro-habitats that were likely to contain *L. humile*. After ca 24 h they were retrieved into a zip-lock plastic bag to prevent contamination by other ants. Collection data, including Global Positioning Systems (GPS) readings and habitat and weather details, were recorded, and, together with the associated traps, were couriered via a central collection point to HortResearch at Mt Albert, Auckland.

Ant removal from traps

In the laboratory, the yellow sticky-strip from every trap was scanned under a binocular microscope by one scientist (JGC), to determine if any ants were possibly *L. humile*, or definitely other species. If *L. humile* was suspected, then those ants were removed with kerosene and mounted on card points for closer examination and final identification (also by JGC). In practice, the only two species for which this exercise was necessary were *L. humile* and the very similar Darwin's ant (*Doleromyrma darwiniana*). All other ants on a trap (if n<15/trap), or representatives of all other ant species on a trap

(if n>15/trap) were stored in ethanol, with their unique trap number, for future study.

Voucher specimens and PPIN records of L. humile
A location code (Crosby 1976) was assigned to each trap, and all collection data were transferred to an electronic database. Voucher specimens were deposited in the New Zealand Arthropod Collection (NZAC) at Landcare Research, Mt Albert. Location records and other details of the Argentine ants found during the survey were entered in PPIN (MAF National Plant Pest Reference Laboratory).

Climate modelling
L. humile is most successful in Mediterranean and some subtropical climates but appears unable to survive in cold-temperate, tropical or extremely arid environments. It may, however, persist locally in areas with unfavourable climates through its close association with humans (Suarez et al. 2001). The potential limitations to *L. humile* distribution imposed by New Zealand's diverse climatic conditions and seasonal weather were investigated using the "Match Climates" function of CLIMEX (CSIRO 1999). Meteorological data (monthly minimum and maximum temperatures, rainfall and relative humidity at 9 am and 3 pm) from 286 New Zealand locations were matched to places elsewhere in the world where *L. humile* has established.

National Survey for Argentine ant: Results

Number of traps deployed and trap efficiency
A total of 2850 traps was distributed; 614 were either unused or lost and 2236 were returned for examination. Twenty were returned with no documentation, so that data from 2216 traps were analysed, including 23 from Auckland. In the northern half of the North Island, most traps caught some ants over a 24 h period. The proportion of empty traps increased at more southerly latitudes (Fig. 2), probably as a result of cooler weather. They also coincided with a changing composition of ant species, with fewer exotic tramp species and more native species in the South Island. Note that tramp species are ants distributed widely by human commerce and living in close association with man. Most of the ants trapped during the survey were not *L. humile*, but belonged to relatively few tramp species. *Doleromymra darwiniana, Iridomyrmex*

anceps, Technomyrmex albipes and *Ochetellus glaber* were commonly trapped Dolichoderinae. Further analysis of the data from the other ant species in due course may yield new information on the distribution and ecology of other exotic species in New Zealand.

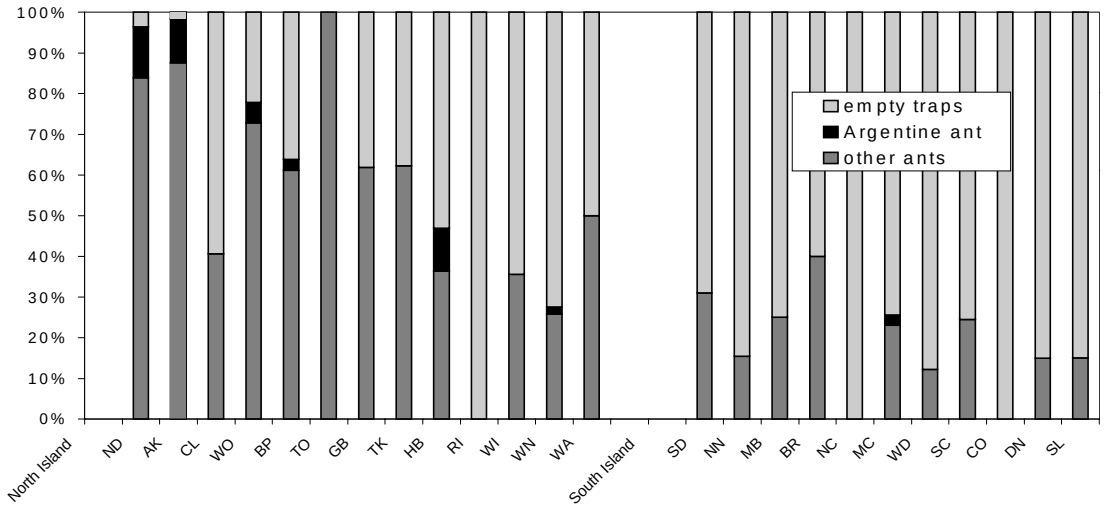

Figure 2: Trap occupancy by region. Key to regions: ND = Northland; AK = Auckland; CL = Coromandel; WO = Waikato; BP = Bay of Plenty; TO = Taupo; GB = Gisborne; TK = Taranaki; HB = Hawke's Bay; RI = Rangitikei; WI = Wanganui; WN = Wellington; WA = Wairarapa; SD = Marlborough Sounds; NN = Nelson; MB = Marlborough; BR = Buller; NC = North Canterbury; MC = Mid-Canterbury; WD = Westland; SC = South Canterbury; CO = Central Otago; DN = Dunedin; SL = Southland (Crosby et al. 1976). NB. No traps were placed in Stewart Island.

L. humile distribution in New Zealand

L. humile were caught in 84 traps, from 12 locations in 6 North Island regions (Table 1, Fig. 2). They had been previously recorded from 10 of the locations, but were found for the first time at Kaitaia and Hamilton. None was trapped in the South Island, although they had been recovered from a known site in Christchurch (Riccarton) in late March during pilot studies for the survey.

Table 1: Summary of number of ant traps set in different locations.

City/Town	No. traps	Arg. ant?	City/Town	No. traps	Arg. ant?
Alexandra	4	.	Otorohanga	2	.
Ashburton	2	.	Paeroa	2	.
Auckland	22	+	Palmerston North†	66	.
Balclutha	1	.	Picton †	29	.
Blenheim †	56	.	Porirua	7	.
Cambridge	2	.	Rangiora	1	.
Carterton	1	.	Rotorua	92	.
Christchurch †	35	*+	Ruawai	1	.
Dargaville †	31	+	Stratford	1	.
Dunedin †	124	.	Taihape	2	.
Fairlie	2	.	Taumarunui	2	.
Feilding	2	.	Taupo	2	.
Gisborne	123	.	Tauranga	78	ϑ
Greymouth †	53	.	Tawa	4	.
Hamilton	127	++	Te Awamutu	2	.
Hastings †	47	+	Te Puke	5	.
Havelock North	2	.	Thames	2	ϑ
Hawera	1	.	Timaru †	91	.
Invercargill †	72	.	Waimate	1	.
Johnsonville	3	.	Wairoa	1	.
Kaiapoi	1	.	Wanganui	112	.
Kaikohe	1	.	Warkworth †	35	+
Kaitaia	2	++	Wellington †	67	+
Kerikeri †	76	ϑ	Westland	1	.
Levin	4	.	Westport	1	.
Lower Hutt †	90	.	Whakatane	2	.
Lyttleton	1	.	Whangaparaoa	1	+
Mangaturoto	1	.	Whangarei †	159	+
Masterton	1	.	Whitianga †	28	ϑ
Matamata	2	.			
Milton	1	.			
Morrinsville †	35	+			
Motueka	13	.			
Mt Maunganui	81	+			
Napier †	109	ϑ			
Nelson †	135	ϑ			
New Plymouth †	112	.			
Ngaruawahia	1	.			
Ngongotaha	1	.			
Oamaru †	42				
Otane	1	.			

Key:

†	Cities or towns where a starburst array was deployed
* +	*L. humile* caught during pre-season trapping
++	New record of *L. humile*
ϑ	*L. humile* not found, but known from previous records
+	Reconfirmation of existing record of *L. humile*
.	*L. humile* not found

Figure 1: Trap design and placement.

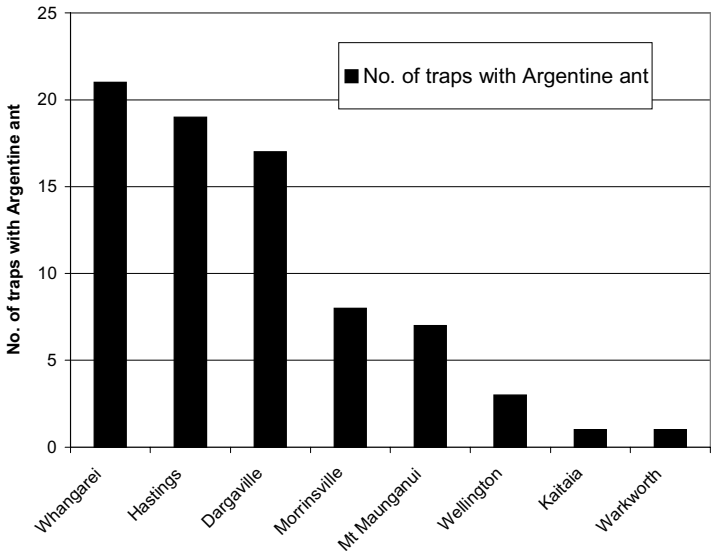

Figure 3: Distribution of Argentine ant by city/town

Key to Figures 4-6. Blue stars = traps with Argentine ants; White stars = empty traps; Green stars = traps with 'other' ants.

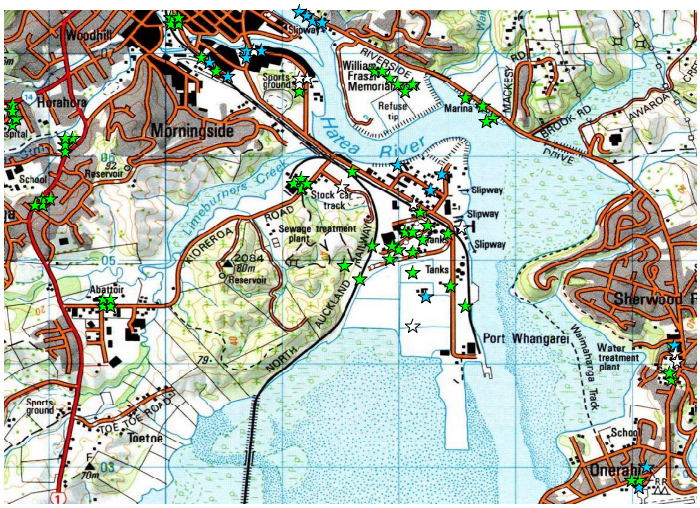

Figure 4: Location of* L. humile *in the Whangarei district

Figure 5: Location of* L. humile *in Dargaville

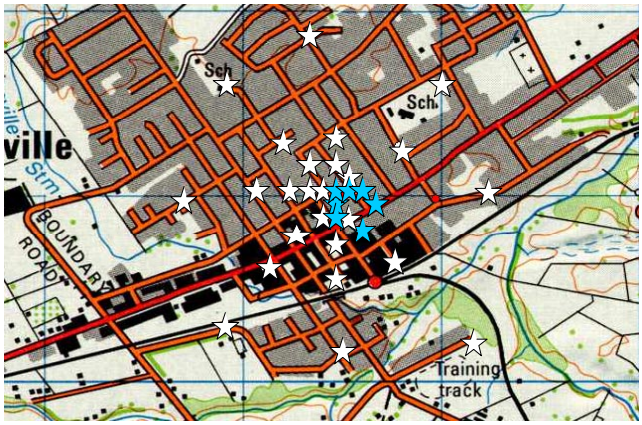

Figure 6: Location of* L. humile *in Morrinsville

At those locations where *L. humile* was previously known to be present, the starburst arrays provided some indication of distribution, and a starting point for further delimiting surveys. Sixty-eight percent (n=57) of all *L. humile* occupied traps came from three towns, Whangarei, Hastings and Dargaville (Fig. 3), although these peaks may simply have reflected the number of traps laid or good fortune to lay them close to ant nests. *Linepithema humile* was most widespread in commercial locations around Whangarei (Fig. 4). The clumped distribution of Argentine ant occupied traps at some sites may reveal limited distribution, as, for example, in Dargaville (Fig. 5) and Morrinsville (Fig. 6).

It is not known why *L. humile* were not detected from 8 previously known locations (Table 1). It is possible that they were present in very low numbers, or that poor weather limited the trap catches. New Zealand as a whole experienced a relatively warm, late summer during the survey, but there was a brief period of cold, wet weather. Cooler ground temperatures may have led to reduced ant activity and numbers especially in Kerikeri, Rotorua, Gisborne, Wanganui, Nelson/ Motueka and Invercargill, although trap temperatures were not recorded. Alternatively, the ants may no longer have been there. In Nelson, for example, an extensive eradication programme followed their discovery in early 2001. Empty traps may have indicated the absence of any ant species due to poor trap placement and hence did not necessarily mean an absence of *L. humile*. However, because *L. humile* rapidly out-competes and displaces other ant species, the presence of any other ant species in a trap did suggest the absence of *L. humile*. *Linepithema humile* were found with other species in only 5 traps, and data from associated 'starburst' traps suggested that these ants may have been at the leading edge of an expanding *L. humile* population at those locations.

Habitat

L. humile were trapped in 10 habitat categories (Fig. 7). Of the total number of traps deployed in each habitat, 3-10% caught Argentine ant. Of the 84 traps in which *L. humile* were recovered, most were from a 'residential' habitat, predominantly among trees and shrubs around private dwellings. Most of the remainder were recovered from transport depots, commercial areas or ports. Together, these data provide strong evidence that, in New Zealand, *L. humile* are most commonly found in

association with human activity. Few Argentine ants were found in more open spaces such as recreation or 'rural' areas, and none was found in 'horticultural habitats' (which included garden centres). These data indicated that potted soil mix may not be a significant medium for dispersal of *L. humile* (Fig. 7).

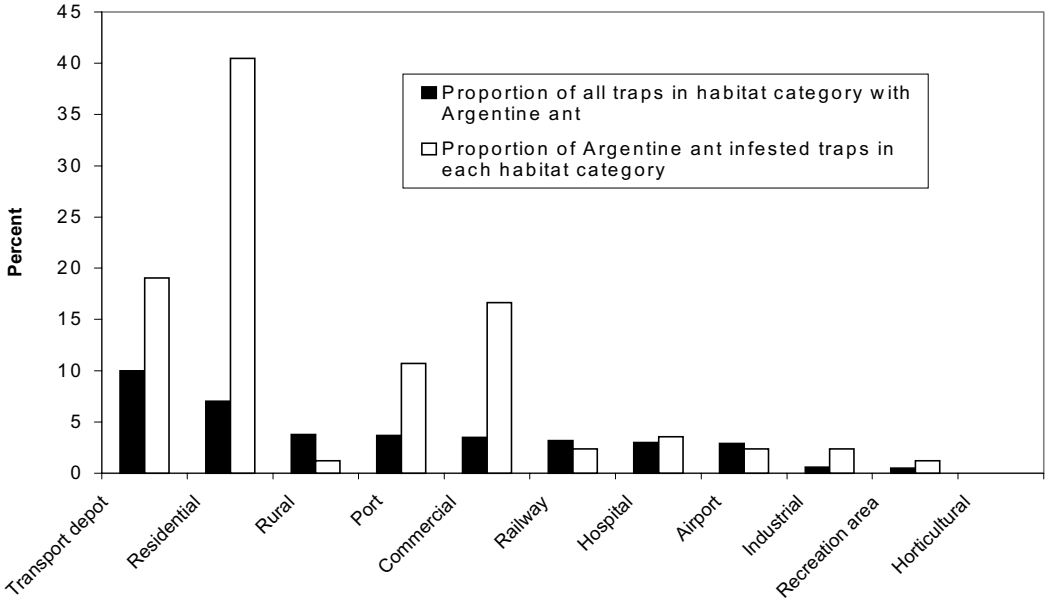

Figure 7: Distribution of* L. humile *within survey habitat categories.

Within Auckland, this survey and other collection records also show that *L. humile* is found in a wide range of residential, commercial, recreational and bush habitats. Such data confirm that *L. humile* is established widely throughout the Auckland isthmus, but also that it is so far absent from some locations. While it may be assumed that it is only a matter of time before they occupy the whole isthmus, the currently 'empty' patches may provide clues as to habitat limitations of *L. humile*.

Doleromymra darwiniana

Doleromymra darwiniana (Forel, 1907) (Darwin's ant or brown house ant) was first recorded in New Zealand in 1959, and is morphologically extremely similar to *L. humile*. Also like *L. humile* it tends honeydew-

producing insects, can displace other ants and spreads slowly (Keall & Somerfield 1980). Thus the two species may exhibit very similar dispersal patterns over time. All specimens of *D. darwiniana* collected during the survey were positively identified in order to separate them from *L. humile*. *Doleromymra darwiniana* were collected from Auckland (Cockle Bay), Gisborne (Awapuni), Hawke's Bay (Napier), Marlborough (Blenheim) and mid-Canterbury at Christchurch (Sumner and Heathcote Valley) and Lyttleton (Cass Bay). Prior to this survey *D. darwiniana* was known only from Auckland and Christchurch (Keall & Somerfield 1980), but the new records indicate that even after 40 years in New Zealand, Darwin's ant may still remain only locally distributed throughout much of the North and South Islands between Auckland and Christchurch.

Weather and climate

The results from the CLIMEX model indicated that *L. humile* may establish throughout New Zealand except for Buller, Westland and Fiordland. Data could not be matched with Stewart Island due to the absence of weather data (see Charles et al. 2001 for further details).

Conclusions

The survey showed that, after 12 years of uninterrupted dispersal from Auckland, *L. humile* remains only patchily distributed throughout New Zealand, and especially in the north of the North Island. *Linepithema humile* has a slow natural dispersal (due to the absence of winged adults), and its spread to distant locations has clearly been facilitated by human activity. Yet the persistently limited distribution indicates that either the human dispersal model, or the establishment of *L. humile* at a new location, is inefficient. The robustness of this conclusion was demonstrated by the large numbers of other ant species that were trapped in most locations. Because *L. humile* forms large "super-colonies" which destroy all other ant species within their areas of activity, the widespread absence of *L. humile* specimens – but the presence of other ant species – provided positive evidence that Argentine ant has not yet established in most of the country. This situation should be regarded as temporary because the CLIMEX model shows that most of New Zealand is climatically suitable for Argentine ant establishment in the future. However, the limited distribution of

D. darwiniana after a period of 40 years in New Zealand shows how long it can take for a new invading insect to colonise a new country.

The 'starburst' arrays provided useful indications of the boundaries of local *L. humile* infestations, and provided evidence of a restricted distribution in all locations. Clearly, more targeted surveys would increase precision of the estimates of local Argentine ant distribution. Annual surveys at a very local level may also show colony expansion or contraction, and hence allow measurement of the effectiveness of control programmes.

The development and availability of an effective poisoning system has dramatically changed options for managing *L. humile.* A fipronil insecticide-based bait has been deployed in both urban and rural settings and shows promise for containment or even localised eradication of the ant (e.g. Harris & Green 2001; Dykzeul 2001). Further delimiting studies of *L. humile* may now indicate that local or even more widespread eradication could be a practical option. Such future studies may include both passive (e.g. traps of various sorts) and active (e.g. looking for *L. humile* trails) means for finding the limits of the Argentine ant infestation (Dykzeul 2001; Denholm & Cochrane 2001).
The data provided from this survey show that *L. humile* dispersal in New Zealand has been slow, and that it is not yet widespread. When added to recent data on the successful use of poison baits, it may be concluded that containment or even local eradication is technically feasible. Further decisions on action against this pest revolve around cost and the social and political will to act.

Acknowledgements

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