Invasibility of native habitats by Argentine ants, *Linepithema humile,* in New Zealand

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Abstract: The Argentine ant, *Linepithema humile*, was found established in New Zealand in 1990. During summer 2001/2002 the spread of Argentine ants from urban environments into native habitats was investigated. During an initial large-scale survey around the northern cities of Auckland and Whangarei, Argentine ants were observed at 35 of 211 sites. Eight sites in Auckland were subsequently surveyed in greater detail to determine the extent of movement by Argentine ants into native habitats. The presence of Argentine ants was determined every 10 m along a total of 28 transects into native forest, scrub and mangrove habitats. Argentine ants moved up to 20 m into forest habitats. In habitats with more open canopy (mangrove and scrub), ants moved at least 30 m and 60 m, respectively. We predict that open habitats and relatively open canopy scrub environments in northern New Zealand are likely to be vulnerable to invasion, and to experience the highest densities and the greatest impacts of Argentine ants. Our preliminary data, coupled with data from other parts of the world suggests that intact indigenous forest in New Zealand will probably not be invaded. Indigenous forests are likely to have Argentine ants only at the boundary with open habitat, but in highly fragmented landscapes the impact could be significant.

Keywords: insect invasion; dispersal; native habitats; invasive ants; risk assessment

Introduction

Biological invasions by exotic species pose serious threats to native species and ecosystems worldwide (Soulé 1990). Although the most notorious effects in New Zealand stem from introduced mammals due to their impacts on native forest structure and predation of endemic birds (Atkinson, 1993; Clout, 1999), invasive invertebrates also cause considerable conservation damage. For example, vespulid wasps (*Vespula germanica* and *V. vulgaris*) restructure invertebrate communities and disrupt nutrient cycling in honeydew beech (*Nothofagus solandri, N. fusca, N. truncata*) forests (Beggs, 2001). Invasive ants are also serious threats to native species and ecosystems in New Zealand, as indicated by their impacts elsewhere (Moller, 1996; Human and Gordon, 1997; Holway *et al*., 2002).

The Argentine ant, *Linepithema humile* (Mayr) (Hymenoptera: Formicidae), a native of South America, is highly invasive and now occurs on all continents except Antarctica (Suarez *et al*., 2001). Outside their native range Argentine ants are mostly associated with human settlement and appear to be well suited to high levels of disturbance (Passera, 1993). However, the species is capable of invading native habitats with little anthropogenic disturbance. These include fynbos in South Africa (de Kock, 1989), sub-alpine shrubland in Hawaii (Cole *et al*., 1992), oak and pine woodland in Portugal (Cammell *et al*., 1996), coastal sage scrub in southern California (Suarez *et al*., 1998), and riparian woodland in California (Holway, 1998a).

In 1990, a small Argentine ant population was found in Auckland (Green, 1990). The distribution of Argentine ants remains concentrated in the Auckland region, but it is increasingly being found in other urban centres in northern New Zealand (Ward *et al*., 2005). The potential distribution of Argentine ants based on climate modelling predicts that, outside urban areas, Argentine ants will be largely restricted to the upper North Island (Harris *et al*., 2002a; Hartley and Lester, 2003). The first record of a semi-native site invaded emerged in 2000, from Tiritiri Matangi Island, a highly valued conservation sanctuary (Harris 2001). Subsequently, the population of Argentine ants has been reduced to <0.2% of pre-treatment levels by poison baiting. Eradication of the ant from the island seems possible (Harris *et al*., 2002b).

Current information on the invasibility of native habitats by Argentine ants comes from other parts of the world (de Kock, 1989; Cammell *et al*., 1996; Holway, 1998a), where native ecosystems are very different to those in New Zealand. There is also little literature from other countries on the invasibility of native habitats compared with urban areas. The purpose of this paper is to examine the occurrence and extent of the spread of Argentine ants from urban environments into native habitats in New Zealand.

Methods

Large-scale survey

An initial large-scale survey involved the northern cities of Auckland and Whangarei and their surroundings. Argentine ants have been present in Auckland since 1990 (Green 1990) and in Whangarei earlier than 2000 (R. Harris, unpubl. data) and thus provide the best opportunity to determine if Argentine ants are spreading into native habitats. In most other areas of New Zealand, the ant is unlikely to have been present long enough to build up large populations and spread into native habitats.

We consulted staff from the Department of Conservation and local government agencies to identify survey sites with native habitat. A survey site was defined as a discrete margin between native and modified habitats (e.g., house frontages, car park at a reserve, road verge). Sites were surveyed between December 2001 and February 2002. Surveyed sites were well separated (>1 km), but where there were several different types of native habitats at a location, sites were surveyed within 250 m. Sites previously known to have Argentine ant infestations near native habitats were surveyed, and surveys were also conducted at the margin of any fragment of native habitat near human habitation passed while visiting the pre-selected sites.

The presence of ants was determined by direct searching for a minimum of 10 min at each site. This method provides an excellent assessment of the presence/absence of ants in New Zealand, particularly in semi-native and urban areas where most ants are exotic, diurnal and highly conspicuous. The length of searching time varied (20 minutes to 1 hour) at some sites depending on the area, shape and terrain of the native/non-native margin being surveyed (e.g., coastal beach sites received more searching time because of their length). The number of Argentine ants at each site was subjectively assessed as high, medium or low, based on the extent of ant trails and number of foraging individuals. A sample was taken of all ant species encountered and stored in a vial of 75% ethanol. All ants were identified to species using a binocular microscope and a web-based key (Harris, 2002). A Kruskal-Wallis test was used to compare the richness of other ant species collected at sites to different numbers of Argentine ants (high, medium, low, absent).

To classify the native habitat at the surveyed sites, the Land Cover Data Base classification (1:50 000), and the Vegetation Inventory of New Zealand Land Resource (1:63 360 or 1:50 000 scale) (Hunter and Blaschke 1986) were used. Sites were classified as scrub, forest, mangrove, inland wetland, coastal wetland, and sand dunes. At 28 sites more than one habitat category was present. A list of all sites surveyed is available from the authors.

Detailed survey

From the initial large-scale survey, eight sites in Auckland were selected and surveyed in greater detail in February–March 2002. These sites had large numbers of Argentine ants at the margins of native habitat, and were considered most likely to provide useful information on Argentine ant movement into native habitats. These sites (and number of transects) were: 1. Marawhara Stream track, Piha (3); 2. southern hilltop walk, Piha (2); 3. The Drive Reserve, Titirangi (4); 4. Waikowhai Park, Waikowhai (4); 5. Hillsborough Reserve and Granny Bay Reserve, Lynfield (3); 6. Rotary Reserve, Northcote (1); 7. Ngataringa Park walkway, Stanley Bay (4); 8. Dingle Dell Reserve, St Heliers (7). Transects were placed on the border of the 'urban' habitat and ran perpendicular into the native habitat (forest, n = 7, maximum 40 m; scrub, n = 16, maximum 100 m; mangrove, n = 5, maximum 50 m). The vegetation composition of the forest sites was either mixed Podocarp and regenerating kauri, or a mixture of mature pohutukawa and nikau palms. Scrub sites included a range of vegetation types, from open areas such as coastal *Muehlenbeckia* and flax-covered hillsides, restoration plantings of predominantly manuka and mahoe, through to early successional forest stages with tall kanuka and pohutukawa. Transects at a site were at least 50–150 m apart and 10 min were spent searching for the presence of Argentine ant workers, trails and nests at every 10-m interval. For all transects, an additional 20–30 m was examined past the last point at where Argentine ants were found, except where the habitat abruptly ended (e.g. cliff face, stream).

Results

Large-scale survey

A total of 211 sites were surveyed, 35 of which had Argentine ants (Table 1). With the exception of inland wetlands (only two surveyed), Argentine ants were found on the margin of all the native habitat types

Table 1. The number and frequency of ant species on the boundary of urban-native habitats. The numbers in parentheses are the number of sites in each habitat.

Ant species	Forest (81)	Scrub (33)	Forest + Scrub (55)	Mangrove (19)	Inland wetland (2)	Coastal wetland (5)	Coastal dunes (16)	Total (211)
Native								
Monomorium antarcticum	35	8	11	4	1		4	63
Pachycondyla spp.	1	9	5		1			16
Monomorium antipodum	6	1	5		1		2	15
Prolasius advenus	7			1	1			9
Huberia striata	1							1
Exotic								
Paratrechina spp.	65	25	36	14	2	4	12	158
Iridomyrmex spp.	51	23	30	12	2	3	5	126
Ochetellus glaber	29	16	16	11	2	3	11	88
Tetramorium grassii	35	14	13	2	1	3	12	80
Technomyrmex albipes	24	11	11	6			5	57
Pheidole rugosula	22	8	5	7	2	2	4	50
Linepithema humile	10	6	14	4			1	35
Hypoponera eduardi	5	2	2	1			1	11
Mayriella abstinens	4		1					5
Amblyopone australis		1						1
Pheidole vigilans							1	1
Rhytidoponera chalybaea							1	1
Tetramorium bicarinatum					1			1

sampled. Seventeen other species of ants were also collected during the survey (Table 1). Significantly fewer ant species were collected when Argentine ants were present in high (mean number of other ant species 1.3, s.e. ± 0.4) or medium numbers (mean = 1.4, s.e. ± 0.3), compared with low numbers (mean = 3.5, s.e. ± 0.7) or in the absence of Argentine ants (mean = 3.4, s.e. ± 0.1) (Kruskal-Wallis test = 29.3, d.f. = 3, $P < 0.001$).

Detailed survey

Argentine ants moved up to a maximum of 20 m into forest habitat (Figure 1). However in mangrove and scrub, which had more open-canopy habitats, Argentine ants moved up to 30 m and 60 m from the habitat edge, respectively (Figure 1). At some mangrove sites, physical barriers were largely responsible for these maximum distances. For example, Argentine ants foraged into mangroves using the foliage as bridges, but this was constrained by links between plants at high tide. Small mangrove plants became covered at high tide, or tidal channels cut through mangroves; both limited the movement of Argentine ants. Wherever tree canopy was dense, and little light reached the ground, Argentine ants were absent except at the habitat margin. However, suitable microhabitats within forests can be invaded. At one site, Argentine ants extended 25–30 m into a remnant where the canopy height was reduced and the vegetation resembled that of an open scrub habitat.

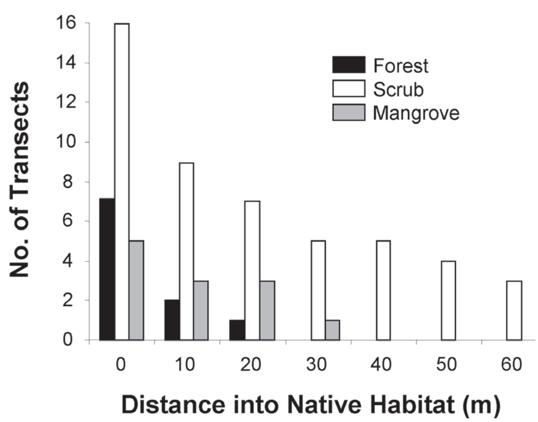

Figure 1. The number of transects where Argentine ants were present, at different distances from the edge of the urban-native vegetation boundary.

Discussion

The assessment of risk to native habitats posed by Argentine ants in New Zealand is limited by the short time since their establishment. In many areas Argentine ants have not been established long enough to build up a large population and spread into native habitat, assuming they are able to do so. Despite this, there is growing evidence to suggest that some habitats in New Zealand are not being used although Argentine ants have been present at a site for a number of years. For example, at Piha, Argentine ants were first recorded in 1999 (R. Harris, *unpub. data*) and the closed canopy scrub and dune areas from which they are absent are well within the distances over which they could have dispersed unaided in this time period (~150 m/yr, Holway 1998b; Suarez *et al*., 2001). At the Marawhara stream site, the spread of Argentine ants into the adjacent forest did not change over two consecutive seasons (R. Harris *unpub. data*).

Where Argentine ants have invaded native habitats in other parts of the world it has predominantly been in open areas and in scrub vegetation of low stature (de Kock, 1989; Cole *et al*., 1992; Suarez *et al*., 1998; Holway, 1998). Our results are consistent with these studies, and in New Zealand relatively open scrub and mangrove habitats will be susceptible to invasion by Argentine ants. However, information from other parts of the world show that forests are less susceptible to invasion, or are not invaded. Our prediction is that closed canopy forest in New Zealand is unlikely to be a habitat favoured by Argentine ants. Further data collection around forest sites in subsequent years will help confirm or re-evaluate this prediction.

The distinction between scrub and forest is often arbitrary. Some habitat, classified as "scrub" will have very low light penetration to ground level and more closely resemble forest habitat in terms of soil temperature and risk of invasion by Argentine ants. Conversely, some types of forest are relatively open (e.g. woodland, pine forests, coastal potuakawa) and may be at greater risk of invasion by Argentine ants. A detailed seasonal microclimate study of the relationship between light levels, soil temperature and the distribution of Argentine ants in scrub and forest habitats would be valuable to further identify where in the light/temperature gradient nesting and foraging ceases.

A wide range of impacts of Argentine ants on native ecosystems has been documented from other parts of the world (Holway *et al*., 2002). The results from the present study are consistent with data from overseas demonstrating lower ant species richness at sites with Argentine ants, which displace most other ant species through competition (e.g. de Kock, 1989; Cammell *et al*., 1996; Human and Gordon, 1997). Impacts on other invertebrates can be through direct predation, competition, and invertebrate egg predation. Argentine ants commonly feed on the excretions of scale insects and aphids (Insecta: Homoptera) and actively disperse and protect homopterans from predation to maintain the food source (Holway *et al*., 2002). This may increase populations of adventive homopterans in native habitats, interfere with native predators, and aid transmission of diseases between plants. Pollination and seed dispersal may also be disrupted (Bond and Slingsby, 1984; Christian, 2001), and both indirect and direct impacts on vertebrates are also possible, for example, attacking and killing nesting birds (Newell and Barber 1913) and competition for food (Suarez *et al*., 2000).

The impacts of Argentine ants in New Zealand's natural ecosystems have not been quantified and remain unclear. Part of the problem is that only in recent years have Argentine ants begun to invade native habitats surrounding urban areas. Given the striking absence of a large indigenous ant fauna, the introduction of exotic ants into New Zealand ecosystems may be particularly severe, especially for large, flightless, ground-dwelling invertebrate species (Moller 1996). Despite an increased awareness of insect pests and commitment to biosecurity in New Zealand, there remains relatively little information on the dynamics of invertebrate invaders. Assessing the risks posed by invasive invertebrates will require more detailed information on the population dynamics, the susceptibility of native habitats and the mechanisms by which invaders overcome abiotic limitations and biotic resistance to invasion.

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