Human-Mediated Range Expansion of Argentine Ants *Linepithema humile* (Hymenoptera: Formicidae) in New Zealand

by

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ABSTRACT

The Argentine ant, *Linepithema humile*, was first found in New Zealand in 1990. At present, its distribution is predominantly in towns and cities in northern New Zealand, although its presence is increasingly being reported from new locations. Its distribution in many of these new locations cannot be explained by natural spread, but by human mediated dispersal (HMD). Estimates of the distances of HMD for Argentine ants in New Zealand (minimum and maximum median distances 9.97 - 71.99 km, respectively) suggest that this type of dispersal occurs often, and as such is primarily responsible for the range expansion of the species in New Zealand. Additionally, HMD can operate over relatively short distances, demonstrating that the main movement of this species between and within urban environments is by humans and associated pathways. Examining the frequency, direction and distances, and pathways over which HMD occurs may assist in the control and management of ant pest species closely associated with humans.

Keywords: invasive ants, biosecurity risk, dispersal models, human activities, rate of invasion.

INTRODUCTION

A critical aspect to the control and management of invasive ant species is understanding the dynamics and processes underlying their dispersal. The occurrence of long distance dispersal events by invading ant species is often noted in the literature (Jourdan *et al*. 2002, Espadaler & Gomez 2003), but its role in invasion and spread is seldom examined in greater detail (Suarez *et al*. 2001). It is well recognized that long distance dispersal events may limit the usefulness, or even violate the assumptions, of theoretical models used to predict the spread of an

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invasive species (Hengeveld 1989; Higgins & Richardson 1999, Suarez *et al.* 2001). Long-distance dispersal events may drastically increase rates of spread of an invading organism (Higgins & Richardson 1999).

Coupled with long-distance dispersal, is the role that humans, and human activities, have in dispersal events. Human activities such as international trade are known to play an important role in the transfer of invasive species around the globe (Jenkins 1996, McGlynn 1999). However, humans can also unintentionally transport and disperse species at smaller scales, for example within a country (Suarez *et al.* 2001) and between islands (Jourdan *et al.* 2002). The frequency and distance of these long-distance dispersal events are often thought to be difficult to determine (Suarez *et al.* 2001). This is in part due to the fact that a detailed chronological history of an invader rarely exists. However, where such information exists, considerable insight can be gained from examining the pattern of invasion over time.

Suarez *et al.* (2001) is one of the few detailed examinations of long distance dispersal for a species. They examine the invasion history of the Argentine ant, *Linepithema humile* (Mayr) (Hymenoptera: Formicidae), in the United States. Argentine ants are native to South America, but are highly invasive and now occur on all continents except Antarctica (Suarez *et al.*, 2001, Holway *et al.* 2002). Outside their native range, Argentine ants are mostly associated with human settlement, but are capable of invading some types of native vegetation that have undergone little anthropogenic disturbance (Kock 1989, Human & Gordon 1997).

The dispersal of Argentine ants involves two discrete process: colony diffusion and long distance dispersal mediated by humans. Established Argentine ant colonies spread by a process called budding – where new colonies are formed by inseminated queens walking with a group of workers to form a new colony nearby. This typically occurs over a relatively small scale of <150 meters per year (Suarez *et al.* 2001, Holway 1998). A second form of dispersal involves human-mediated dispersal (HMD) of colonies which is common for Argentine ants because they are often closely associated with humans. Argentine ant queens are not known to undertake mating flights to form colonies as in most ant species. Because of the lack of mating flights it is relatively easy to distinguish between the two distinct modes of spread.

The first report of Argentine ant establishment in New Zealand was in 1990 (Green 1990). Since then Argentine ants have been reported from a large number of locations in New Zealand. Given its relatively detailed chorological history and records it is possible to examine the spread of the species in detail. Here we report on the role of HMD in the range expansion of Argentine ants in New Zealand.

METHODS

Four sources of information were used to construct a chronological history of invasion for Argentine ants in New Zealand. These sources included regional and national literature, museum records, personal surveys, and personal communications (from academics/scientists, pest controllers, government authorities). To be considered, records needed a minimum of locality details, year collected. Records cover the period 1990 – 2003, with the original Argentine ant population recorded as Mt. Smart stadium in Onehunga, Auckland (Green 1990).

Because the source of a new population is not known, we use two models to estimate HMD - the same approach as Suarez *et al.* (2001). An 'origin' model measured the distance from Mt Smart Stadium to each new foci, providing the maximum estimates of HMD distances. A 'nearest neighbor' model was also used which assumed the source of a new population came from the nearest location that had been occupied for at least one year. This method provides a distribution composed of the minimum estimates of HMD.

To disconnect the risk that spatially close records were the result of local spread (colony budding) and not HMD, we mapped these records at a 1:50,000 scale. We established the first record of Argentine ants in this area and from that measured a radius outwards of maximum local spread based on a conservative estimate of 300 m/yr (from Suarez *et al.* 2001, Human & Gordon 1996). Ant records that fell within this radius were classified as local spread and not used in the estimated of HMD.

We used MapWorld Topomap, a digital topographical maps series of New Zealand (ranging from a scale of 1:2 million to 1:50,000), to measure the distance between locations. Distances were measured with a straight line, as for many places there was more than one possible route human dispersal could have taken.

RESULTS

We obtained 236 locality records of Argentine ants. After eliminating duplicate records and likely instances of local spread, 111 records were used to estimate HMD. Fifty percent of records are from Auckland, where populations of Argentine ants have established rapidly throughout the urban area. However, Argentine ants are present in a large number of smaller cities and towns in northern New Zealand (Fig. 1).

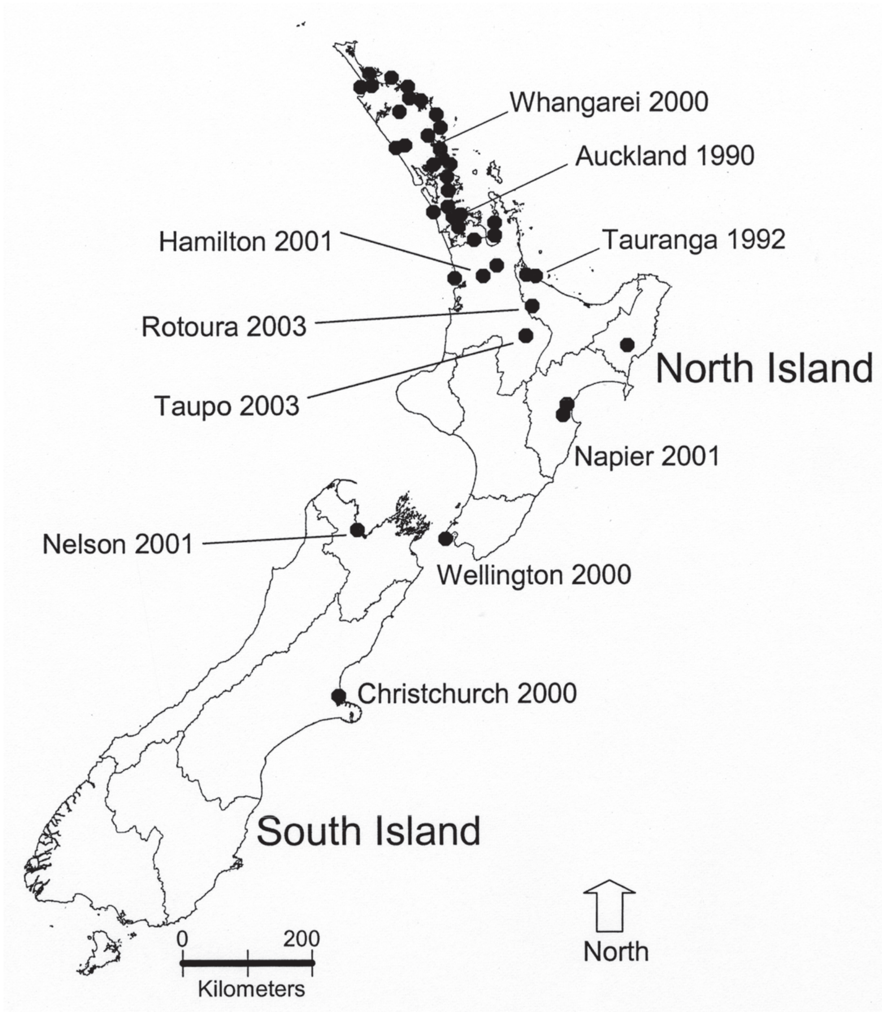

Fig. 1. Map of New Zealand showing locations where Argentine ants have been recorded. Major towns and cities (year of first record) are labelled.

There is also considerable long distance spread well away from the original site of infestation, to Tauranga, Napier, Wellington, Nelson and Christchurch.

Estimates of HMD for the origin model (mean = 119.67 km, ±SE = 13.78 km, median = 71.99 km) were significantly different from the nearest neighbor model (mean = 40.90 km, ±SE = 9.20 km, median =

9.97 km) (paired t-test, log transformed, $t = 33.83$, d.f. = 110, $p < 0.001$). These estimates are also significantly lower than those of Suarez *et al.* (2001): origin model (Suarez *et al.* 2001 mean = 361.72, one sample t-test, $t = 17.56$, d.f. = 110, $p < 0.001$), nearest neighbor model (Suarez *et al.* 2001 mean = 160.58, one sample t-test, $t = 13.00$, d.f. = 109, $p < 0.001$).

DISCUSSION

The spread of Argentine ants in New Zealand is characterized by new populations being established well away from the original site of infestation. These populations could not have been established as a result of the natural reproductive and dispersal biology of Argentine ants.

The two models used here provide a good assessment of the upper and lower boundaries of distances of HMD. At the start of the invasion process the initial spread of new populations will come primarily from the point of origin, but over time new populations will increasingly be sourced from either nearest neighbor populations or possibly from a specific focal point population that could be heavily associated with human activities (*e.g.* industrial area, plant nursery). The estimates of HMD here are significantly lower than that measured by Suarez *et al.* (2001) for Argentine ants. Many of the locality records obtained by Suarez *et al.* (2001) could only be traced to a 'county' level in the United States, rather than specific point localities. It is likely that this may have increased the estimates of distance of long distance dispersal. In our study, because of the relatively recent arrival of Argentine ants, locality records have been much more precise, allowing a greater level of detail to be obtained. The fact that the USA is also considerably larger than New Zealand may also increase the estimates of dispersal distance because there is the capacity for Argentine ants to be physically dispersed greater distances.

Through HMD Argentine ants are being spread between urban centers in New Zealand, but their spread is also occurring over relatively short distances (median distance of nearest neighbor model <10 km) within urban areas (*e.g.* Auckland city). As a consequence of HMD many more new foci populations of Argentine ants have established than would otherwise occur naturally. The presence of large numbers of small foci has important implications for the range expansion and management of pests (Moody & Mack 1988). As Suarez *et al.* (2001) notes, the distance and rate at which new foci are created are more important than the rate of spread through diffusion from established foci. Range expansion could be significantly reduced by controlling and limiting new foci (Moody & Mack 1988). In Hawaii, control of Argentine ants has shown to be effective in limiting their natural rates of spread (Krushelnycky *et al.* 2004), and small scale eradications appear to be effective in New Zealand (Harris *et al.* 2002).

This study illustrates that long distance dispersal events mediated by humans are relatively common and are primarily driving the range expansion of Argentine ants in New Zealand. It is likely that this pattern is repeated in other countries with Argentine ants. Determining the frequency, direction and distances of HMD will assist in the control and management of other pest species closely associated with humans. It also illustrates to biosecurity and pest management authorities the importance of long-term post-border monitoring and the significance of historical records in understanding the spread and potential future impacts of pests.

ACKNOWLEDGMENTS

We thank all the individuals and institutions that provided records. This work is supported by the New Zealand Foundation for Research Science and Technology (FRST) grant C09X0211, and a FRST doctoral grant to DW.

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