Current and Potential Ant Impacts in the Pacific Region

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Worldwide, ants are a powerful ecological force, and they appear to be dominant components of animal communities of many tropical and temperate ecosystems in terms of biomass and numbers of individuals (Bluthgen et al. 2000). For example, ants comprise up to 94% of arthropod individuals in fogging samples taken from diverse lowland tropical rainforest canopies, and 86% of the biomass (Davidson et al. 2003). The majority of these ant species and individuals obtain carbohydrates either from extrafloral nectaries or from sap-feeding Hemiptera that pass carbohydrate-rich "honeydew" to attending ants while concentrating nitrogen (N) from N-poor plant sap (Davidson et al. 2003). Honeydew and nectar represent key resources for arboreal ant species, although most ant species are at least partly carnivorous or scavengers (Bluthgen et al. 2004).

In contrast to most of the terrestrial world, the biotas of many Pacific islands evolved without ants. Whereas endemic ant species are found in New Zealand (ca. 10 spp.), Tonga (ca. 10 spp.), and Samoa (ca. 12 spp.), other islands of Polynesia and parts of Micronesia likely lack native ants (Wilson and Taylor 1967, Wetterer 2002, Wetterer and Vargo 2003). About 20 Indo-Australian and western Pacific ant species range to the east and north of Samoa, but it is unclear how many of these were transported there by humans at some time (Wilson and Taylor 1967). Most of the remainder of the ant species currently found on Pacific islands are widespread species that fall in the category of "tramp species," dispersed by recent human commerce and generally closely tied to human activity and urban areas (Wilson and Taylor 1967, McGlynn 1999). In Pacific island situations, some of these tramp ant species are able to thrive beyond areas of human activity.

Relatively few ant species have been successful invaders of native communities on continents, and these include most of the species that pose the greatest problems for Pacific islands. They generally have multiple queens per colony, are unicolonial (lacking internest aggression), quickly recruit to food items, thrive in a variety of habitats including disturbed areas, and can be highly aggressive to other ant species (McGlynn 1999).

Hawaii's arthropod fauna evolved in the absence of ants and has been observed by many biologists to be highly vulnerable to displacement by non-native ants. Pacific island biotas have also very likely suffered greatly from displacement by ants. However, in contrast to Hawaii, virtually nothing has been published on effects of non-native ants on native arthropod fauna elsewhere on Pacific islands, with the exception of the Galapagos archipelago, which may have at least four species of endemic ants (Lubin 1984, Nishida and Evenhuis 2000) and New Caledonia (Jourdan et al. 2001, Le Breton et al. 2005). In addition, many ant species in the Pacific have long been a nuisance for humans, and significant agricultural impacts have occurred from ants tending hemipteran insects of crop plants.

The Pacific's Most Harmful Ant Species

Pheidole megacephala, the big-headed ant, native to sub-Sahara Africa, is perhaps the most widely distributed and dominant ant species in Pacific islands. It had reached Hawaii

by 1879, where it is dominant in dry and mesic lowland areas, but occasionally occurring as high as 1800m elevation (Wetterer et al. 1998), and is believed to have caused major loss of endemic arthropod species (Nishida and Evenhuis 2000).

anoplolepis gracilipes, the long-legged ant or yellow crazy ant, native to somewhere in the Old World tropics, is found on most islands of Polynesia. It first reached Hawaii in 1952, but had invaded many other archipelagoes earlier—e.g., Tonga by 1870 and French Polynesia by the 1920s (Wilson and Taylor 1967). It is already found on many Pacific islands but continues to spread to new ones—e.g., within Tokelau (Lester and Tavite 2004). This ant has a reputation in the Pacific for attacking newly hatched domestic fowl and other animals (Nishida and Evenhuis 2000).

Non-forested areas up to 3000 m elevation in Hawaii are vulnerable to invasion and dramatic impacts by *linepithema humile* , the Argentine ant, including depletion of pollinators (Krushelnycky et al. 2005). *l. humile* first became established in Hawaii on Oahu in 1940 and in New Zealand in Auckland in 1990 (Anonymous 2001), and was recently discovered on Easter Island (Morrison 1997). It is not established elsewhere in the Pacific islands, and though it colonized Oahu in the 1940s, it may not be effective at invading tropical lowland environments.

Solenopsis geminata, native from Central America north to southeastern U.S., first appeared in Hawaii by 1879. It is a pest in India and Africa and is widespread on virtually all island groups in the Pacific (Yates 2005). It is a stinging species, posing some threat to newborn animals and discomfort to humans, but its stings are not nearly as severe as those of its South American relative *S. invicta*.

Although Hawaii's rainforests are relatively free of ants, *Solenopsis papuana* is a recent (1967) arrival in Hawaii that has invaded extensively in Hawaii's low-elevation rainforests, with a potentially major influence on the arthropod fauna (Gillespie and Reimer 1993). An Indo-Australian species, *S. papuana* is found in Samoa and Tonga (Wetterer 2002, Wetterer and Vargo 2003), but apparently has not been recorded elsewhere in Polynesia.

wasmannia auropunctata, the little fire ant, native to a not clearly determined portion of the Neotropics, is a major pest that can attain very high densities, damage native biota, and has a powerful sting that threatens domestic animals, wildlife, agricultural workers and others who come in contact with it (Wetterer and Porter 2003). In the Pacific, this ant was established in Galapagos by 1934, had invaded New Caledonia by 1972, and is causing dramatic damage to biodiversity and much misery to humans, especially in moderately dry sites (Jourdan 1997). Its severe effects on the eyes of domestic and wild mammals in West Africa and elsewhere have been noted for years and deserve more attention and investigation (Wetterer and Porter 2003, Walsh et al. 2004). This species was found in Hawaii in 1999 and was first detected in Tahiti in 2004. It is also found in Wallis and Futuna, the Solomon Islands, Vanuatu, and some islands of Fiji.

In the southern tier of continental U.S., *Solenopsis invicta,* a South American species known as the red imported fire ant, is a highly aggressive invader with an exceptionally powerful sting. It is infamous for its negative effects on public health and safety, industry, biodiversity and quality of life (Vinson 1997). It has invaded numerous Caribbean islands (Davis et al. 2001) from Florida in the last 20 years, and it is capable of doing the same in the Pacific unless concerted action is taken. If *S. invicta* establishes in Pacific islands, it is likely to invade most non-rainforest areas, except for very dry areas and the highest-elevation areas on Hawaii's volcanoes (Krushelnycky et al. 2005).

The red imported fire ant is not yet known to be established in Hawaii or anywhere in Polynesia or Micronesia, but has already spread around much of the Pacific Rim. It was found established in California in 1998, in Australia in 2001, in Taiwan in 2004 (Krushelnycky et al. 2005) and in Hong Kong and mainland China in 2005 (Chuan and Chan 2005).

There are other problematic ant species in the Pacific region (Nishida and Evenhuis 2000, Krushelnycky et al. 2005), but we believe those discussed above to be the worst. The rate of introduction of new ant species to Hawaii may be slowing (Krushelnycky et al. 2005), but *wasmannia auropunctata* and *Solenopsis invicta* probably pose a more serious threat to human quality-of-life than any or perhaps the entire suite of ants already in Hawaii, as well as quite significant prospects for further erosion of native biodiversity. The same diagnosis probably applies for other Pacific islands. Implementation of a collaborative Pacific Ant Prevention Plan is proposed but not yet funded (Krushelnycky et al. 2005).

"Invasional Meltdown" Involving Ants and Scale: A Wave of the Future for the Pacific?

O'Dowd et al. (2003) have made a case for "invasional meltdown" involving the ant *anoplolepis gracilipes* and scale insects (the cryptogenic lac insect *tachardina aurantiaca* (Kerridae) and *coccus celatus* (Coccidae)) in a site outside the Pacific (Christmas Island, south of Sumatra in the Indian Ocean). The ant populations had been present on the island for over seven decades but built up to outbreak levels beginning in 1989, presumably in response to interactions with the hemipterans on leaves of multiple species of rainforest trees. These high densities of *a. gracilipes* killed 10–15 million red land crabs within an area of ca. 25 km^2 over a period of several years through "sheer force of numbers and constant activity, overwhelming the crabs by spraying formic acid over their eyes and mouthparts." The scale insects stimulated growth of sooty molds, leading to extensive death of canopy trees. However, local death of the crab populations led to abundant tree seedling regeneration in areas where native crab populations had previously obliterated all forest understory.

Is there the potential for such ant outbreaks, fueled by hemipteran insects, in Pacific islands? Probably. Since at least mid-2001, *Pisonia grandis* (Nyctaginaceae) trees of Palmyra National Wildlife Refuge (at latitude 6°N, in the Line Islands, 1600 km S of Hawaii), have been under attack from high densities of a non-native scale insect, *Pulvinaria urbicola* Cockerell (Hemiptera: Coccidae), apparently facilitated by introduced ant species, which have also reached high densities. *Pisonia* forest canopy density at Palmyra has been decreased by much more than 50%, and survival of entire *Pisonia* forests, and thus a major habitat type of Palmyra NWR seems to be threatened. *P. grandis* has also recently come under attack from *P. urbicola* (a Caribbean species) in other localities throughout its wide range, from the Seychelles (Hill et al. 2003), east to the Coral Sea Islets of Australia's Great Barrier Reef (Smith and Papacek 2001), to Rose Atoll in American Samoa (J. Burgett, U.S. Fish and Wildlife Service, pers. comm.). In remarkably similar systems on coraline islands in Australia's Great Barrier Reef, the outbreak of *P. urbicola* has led to island-wide mortality of *Pisonia* forests (Smith and Papacek 2001). This same process appears to be occurring, and advancing rapidly, at Palmyra Atoll. The exact mechanism of tree death is not known, however a leading hypothesis centers on repeated episodes of leaf shedding by affected trees in response to heavy scale infestation. After several to numerous consecutive cycles of leaf growth and drop, weakened *Pisonia* trees, with a naturally shallow root system, may topple during heavy winds and storms.

At least seven species of ants are present on Palmyra atoll. The most destructive are bigheaded ants (*Pheidole megacephala*), crazy ants (*Paratrechina bourbonica* and *P. vaga*), and pavement ants (*tetramorium bicarinatum*). Ants reach very high densities on most of the islets. On some islets, *P. megacephala* is the clearly dominant species. On other islets, *t. bicarinatum* and *P. bourbonica* seem to exhibit co-dominance. In the Seychelles, the ant species tending the scale *Pulvinaria urbicola* (freshly arrived in the Seychelles) was *anoplolepis gracilipes* (Hill et al. 2003); in Australia's Coral Sea islets the ants were identified

as *tetramorium* sp. and *monomorium* sp. (Smith and Papacek 2001); in Rose Atoll the ant observed to be tending the scale was *tetramorium bicarinatum,* but *Pheidole megacephala* was also present. (J. Burgett, U.S. Fish and Wildlife Service, pers. comm.).

Conclusion

It would appear that the severity of future ant impacts in the Pacific might depend not only on the ability of agricultural quarantine efforts to reduce the spread of the relatively few high-impact ant species, especially *wasmannia auropunctata* and *Solenopsis invicta*, but also to prevent spread of scale insects to remote islands with small, perhaps particularly disharmonic faunas.

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