Department of **Agriculture and Fisheries**
Biosecurity Queensland

Invasive animal risk assessment

Yellow crazy ant

Anoplolepis gracilipes

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Front cover: *Anoplolepis gracilipes* at sugar bait (Lautoka, Fiji)
Photo: Sarnat (2008), used with permission

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Summary

Anoplolepis gracilipes is commonly known as the yellow crazy ant because of its colour and frantic behaviour when disturbed. While its origin is obscure, there is increasing evidence that it is native to South-East Asia. Yellow crazy ants are readily dispersed in sea cargo, especially timber, and have achieved a pantropical distribution as a consequence of global trade.

The yellow crazy ant has been included among 100 examples of the world's worst invasive species by the International Union for Conservation of Nature. It has naturalised in numerous places, especially tropical islands, across the world. On Christmas Island, yellow crazy ants are decimating the island's iconic red land crabs. A significant population also exists in the Northern Territory.

Yellow crazy ants were first detected in 2001 in Cairns. Since then, more than 20 additional sites have been found, in and around Cairns, Townsville, Hervey Bay, Caboolture and Brisbane. The total area of infestation involves at least 320 hectares. Populations at some of these sites have been eliminated, whereas others are subject to ongoing control.

This pest risk assessment presents evidence that yellow crazy ants have the potential to become a significant pest in Queensland. Climate modelling suggests the species could spread across substantial areas. Habitats most at risk are offshore islands with dense forest, monsoon forest/rainforest and plantations along the tropical east coast (generally shady, moist habitats). Negative impacts are likely to include indirect damage to fruit caused by the ants' tendency to protect various scale insects, loss or decreased abundance of native ant species, and predation of a wide range of invertebrates and small vertebrates, resulting in a general decline in biodiversity.

Introduction

Identity and taxonomy

Species	*Anoplolepis gracilipes* Smith
Synonyms	*Anoplolepis longipes* Jerdon *Anoplolepis (Anoplolepis) longipes* Jerdon *Anoplolepis trifaciata* Smith *Anoplolepis trifasciata* Smith *Formica gracilipes* Smith *Formica longipes* Jerdon *Formica trifasciata* Smith *Oecophylla longipes* Jerdon *Plagiolepis gracilipes* Smith *Plagiolepis (Anoplolepis) longipes* Jerdon *Plagiolepis longipes* Jerdon *Plogiolepis (Anoplolepis) longipes* Jerdon *Prenolepis gracilipes* Smith
Common names	Yellow crazy ant, crazy ant (English), gramang ant (Indonesian Bahasa), long-legged ant (English), Maldive ant (English, Seychelles)

Sources: Antbase (2010); GISD (2009); Harris and Berry (2010).

Family: Formicidae (sub-family: Formicinae)

Nomenclature

While the preferred scientific name is *Anoplolepis gracilipes*, much of the literature uses its synonym *Anoplolepis longipes* (ITIS 2010; GISD 2009).

It is questionable whether the yellow crazy ant should be included in the genus *Anoplolepis*. Even though the centre of diversity for *Anoplolepis* is in Africa, there is a growing body of evidence that the yellow crazy ant is native to South-East Asia. There is a possibility that the yellow crazy ant will be split from the *Anoplolepis* genus in a similar manner to *Paratrechina longicornis*, which is now recognised as a monotypic genus (LaPolla et al. 2010; B Hoffmann, CSIRO, pers. comm. 2010).

There is evidence of intraspecific variation. Based on mitochondrial DNA analysis of yellow crazy ants from the Tokelau Archipelago, Abbott et al. (2007) revealed the presence of two haplotypes (Type A and Type D). Haplotype D was more aggressive, invasive and able to displace a higher proportion of other ant species (50 per cent fewer ant species were found on islands invaded by haplotype D). The authors concluded that, contrary to previous evidence for invasive ant species where environmental factors were thought to play a key role, genetic characteristics may be equally or more important to invasion success.

Description

Yellow crazy ants are brownish-yellow or yellow-orange and 1–5 mm long (Figures 1 and 2).

Figure 1. Yellow crazy ant (*Anoplolepis gracilipes*) (Photo: Sarnat (2008), used with permission)

Figure 2. Yellow crazy ants defending their nest

Workers have uniform morphology (Holway et al. 2002), with a long slender body and a gaster that is usually darker than the head and thorax. The gaster is armed with an acidopore and erect hairs are present. A sting is absent (Abbott et al. 2005).

The species has a characteristic erratic walking style when disturbed, an attribute leading to its colloquial name 'crazy ant'. Also known as the long-legged ant, yellow crazy ants are noted for their remarkably long legs and antennae—the antennal scape length is more than 1.5 times the head length and is a key diagnostic feature (Figure 3). Antennae have 11 segments, including the scape.

Figure 3. Long antennal scapes of *Anoplolepis gracilipes* (Photo: Sarnat (2008), used with permission)

The body is relatively long, compared to other ants, and incorporates a long 'neck' attaching the head to the thorax. It has a single waist segment—the petiole—which is thick and raised (with an inverted U-shaped crest), not flat (Wikipedia 2010a). The mesosoma, or alitrunk, (the first three thoracic segments and the first abdominal segment) is slender and lacks hairs on the dorsum. The pronotum (the dorsal portion of the prothorax, the first of the three thoracic segments which bears the first pair of legs) is narrow, with an almost straight dorsum in profile. The anterior portion of the mesonotal dorsum, back to the propodeum, is gently concave in profile. The propodeal dorsum is convex in profile (Wikipedia 2010a). Spines are absent on the propodeum (Abbott et al. 2005). The head is oval, with large convex eyes and erect hairs. The mandibles have eight 'teeth' each and the clypeus is produced medially with a convex anterior margin, without longitudinal carinae (narrow, raised ridges) (Abbott et al. 2005).

The following species might be confused with the yellow crazy ant:

- other genera of Formicinae in Australia that have antennae with 11 segments, namely *Acropyga*, *Plagiolepis* and *Stigmacros*. Yellow crazy ants can be distinguished from these genera by their larger size, longer legs and scapes and yellow colour (CSIRO 2010)
- *Wasmannia auropunctata,* which also has 11 antennae segments, but the last is enlarged into a distinct club. It is smaller than the yellow crazy ant and has a painful sting—hence its name 'electric ant' or 'little fire ant' (Wikipedia 2010a)

- yellow tyrant ant (*Iridomyrmex pallidus*), which is native to open habitats in northern Australia and very common and similar in size and colour to yellow crazy ants. The latter can be distinguished by the length of the antennae, which extend far above the head, whereas the antennae of *I. pallidus* barely exceed the head. *I. pallidus* also has a larger heart-shaped face, bites when disturbed and exudes an extremely strong smell when crushed, unlike yellow crazy ants (TERC 2004)
- the genera Leptomyrmex and Oecophylla, which are both similar in size to the yellow crazy ant and have similarly long legs. Yellow crazy ants can be distinguished by a circular opening (acidopore) at the tip of the gaster, whereas *Leptomyrmex* has a slit-shaped opening (CSIRO 2010; Sarnat 2008). *Leptomyrmex rufipes* (red spider ant), found in Brisbane Forest Park, has an orange-black body with a black gaster and tends to forage alone (Brisbane Insects and Spiders 2010). Yellow crazy ants can be distinguished from Oecophylla by their more compact petiole (Sarnat 2008). *Oecophylla smaragdina* (green tree or weaver ant) is native to Australia and its body is elongate and pale yellow or green in colour. Its nests are arboreal and made of leaves stitched together with silk produced by the larvae (CSIRO 2010)
- *Paratrechina longicornis* (crazy ant/black crazy ant/slender crazy ant/hairy ant), which is known for its erratic behaviour, much like yellow crazy ants. It is also invasive and exists in Australia. It is smaller (2.5 mm) than yellow crazy ants and has numerous thick, paired hairs over its entire body, an impressed mesosoma and is black (Sarnat 2008)
- some species of *Camponotus* that are similar in overall size and shape to yellow crazy ants. *Camponotus maculatus* has 12 antennae segments, the mesosoma is not impressed and there is a metapleural gland opening above its hind leg (CSIRO 2010). *C. maculatus discors* is found in Australia (CSIRO 2010).

There are a number of species with the common name 'crazy ant', including *Paratrechina longicornus* (see above). The rasberry (sometimes spelt raspberry) crazy ant and Caribbean crazy ant are both species of *Nylanderia* and are not found in Australia.

Reproduction and dispersal

Many ant species build colonies with a single queen. Yellow crazy ants, however, build super-colonies with multiple queens (up to 300) and multiple nests, some of which are the largest of any ant species in the world, extending over 150 hectares (Wikipedia 2010a). Crazy ant densities of 20 million ants per hectare have been recorded on Christmas Island (Abbott 2005) and around 5 million per hectare on the Seychelles (Haines & Haines 1978). Super-colonies rely on a lack of aggression and cooperation between nests.

Worker ants have a life cycle of 76–84 days. Queens survive for several years (Walsh & Walters 2010). Workers are produced throughout the year, but production fluctuates.

Yellow crazy ants appear able to breed with siblings (internidal mating) without suffering inbreeding depression as high heterozygosity is maintained in workers (Drescher et al. 2007; Thomas et al. 2009). Sexual offspring are produced at any time in the year but generally 1–2 months prior to the rainy season (Abbott et al. 2005; GISD 2009). Brood production is dependent on the onset of the rainy season. In the Seychelles and Papua New Guinea, two brood production events per year have been recorded (Baker 1976; Haines & Haines 1978), whereas on Christmas Island only one has been recorded (Abbott et al. 2005).

Colonies reproduce using a process known as 'budding', where a queen (or queens) leave a nest together with some workers to form a new colony. Budding is a slower means of dispersal than winged dispersal of alates (young queens and males); however, colonies have been reported to spread 37–402 m per year on the Seychelles (Holway et al. 2002) and 1100 m per year on Christmas Island (equivalent to average spread of 3 m per day) (O'Dowd et al. 1999). *A. gracilipes* relies on human-mediated dispersal to establish more distant colonies (GISD 2009).

Winged dispersal is thought to be rare (GISD 2009), although mating flights of alates have been observed on Christmas Island (Abbott et al. 2005). Mated queens may be capable of starting new colonies, but there is no clear evidence of this. Workers alone are not capable of establishing a new colony. Colonies migrate readily if disturbed (Abbott et al. 2005).

Yellow crazy ants are readily dispersed between countries as contaminants in a range of cargo. They can be spread in soil and produce in the agricultural and horticultural industry; on contaminated military, mining and commercial road transport; and in sea and air freight on timber, goods, packaging material and pallets. They have been deliberately dispersed as a biological control agent in coconut, coffee and cacao production (GISD 2009).

Diet

The yellow crazy ant has been described as a 'scavenging predator' (Harris & Berry 2010). It has a broad, opportunistic diet, a common trait shared by many invasive ant species (GISD 2009), utilising whatever food resources are available (B Hoffmann, CSIRO, pers. comm. 2010). Hence, diet varies with location (K Abbott, Monash University, pers. comm. 2010), and presumably with the seasons. Like all ants, protein-rich foods are required for brood production (O'Dowd et al. 1999).

A high percentage of the diet is based on carbohydrate-rich foods such as plant nectar and honeydew. Yellow crazy ants farm all sap-sucking bugs (Hemiptera) (B Hoffmann, CSIRO, pers. comm. 2010) for honeydew, in particular scale insects. For example, in cocoa plantations in Papua New Guinea, Hemiptera populations are thought to be necessary to support and sustain *A. gracilipes* colonies (Holway et al. 2002). The proportion of honeydew in a worker ant on the Seychelles was calculated to be 50 per cent of its body weight (Haines et al. 1994).

Carbohydrate supply may play an important role in the success of crazy ant invasions (O'Dowd et al. 2003; Savage et al. 2010; GISD 2009). Similarly, population development and 'invasion success' in the African big-headed ant (*Pheidole megacephala*) is also thought to be limited by carbohydrate quality (*Pisonia grandis)* on the coral cays of the Great Barrier Reef (Hoffmann & Kay 2008). It has been suggested that survival of *A. gracilipes* in harsh, dry habitats in Arnhem Land, Northern Territory, may be due to the presence of acacias and other plants providing an adequate supply of extra-floral carbohydrates (B Hoffmann, CSIRO, pers. comm. 2010).

Vertebrates and invertebrates are regularly targeted as sources of protein-rich food. Yellow crazy ants can kill invertebrate prey, or small vertebrates, by spraying formic acid. This does not kill the target by itself, but can cause blindness and lead to death by starvation (Wikipedia 2010a; GISD 2009). Like many other ant species (in particular *Solenopsis invicta*, but also *Solenopsis geminata, Pheidole megacephala* and *Wasmannia auropunctata*), yellow crazy ants debilitate larger animals such as land crabs, small reptiles, small mammals and birds only if ant numbers are very high and if these animals are vulnerable (e.g. newly hatched chicks) or are walking across super-colonies (as is the case with the Christmas Island red crab) (TSSC 2010; K Abbott, Monash University, pers. comm. 2010; B Hoffmann, CSIRO, pers. comm. 2010).

Origin and distribution

The native range of the yellow crazy ant is unclear. Some authors suggest it is native to either Africa or Asia (Holway et al. 2002; Abbott et al. 2005) as collection records for both continents are pre-1900 (Abbott et al. 2005). The Global Invasive Species Database (GISD 2009) lists the native range of the species as Brunei Darussalam, Cambodia, China, India, Indonesia, Malaysia, Myanmar (Burma), Philippines, Singapore, Sri Lanka, Thailand and Vietnam. Wetterer (2005) proposed that yellow crazy ants are native to Asia, possibly including Christmas Island. Abbott et al. (2005) suggested this was unlikely as the centre of diversity for the genus is Africa and *A. gracilipes* is the only species distributed beyond Africa (GISD 2009). However, the records for Africa are restricted, possibly to north-eastern Tanzania (Abbott et al. 2005). Recently, evidence from climate modelling (Chen 2008) and studies of ant populations in Indonesia, where *A. gracilipes* appears unable to dominate or colonise undisturbed rainforest (Bos et al. 2008) or even mature cacao plantations (Wielgoss et al. 2010), cannot rule out that *A. gracilipes* may be native to South-East Asia (Drescher et al. 2007). Moreover, there is a growing body of evidence that *A. gracilipes* is native to this region, i.e. Indonesia, Malaysia and Borneo (not India and definitely not Africa) (B Hoffmann, CSIRO, pers. comm. 2010). In addition, it appears likely that *A. gracilipes* may eventually be split from the genus *Anoplolepis* (B Hoffmann, CSIRO, pers. comm. 2010).

The native range of the species has been obscured by a long history of human-assisted dispersal, as yellow crazy ants are readily moved to new areas within sea cargo. To this day, these ants are regularly detected in shipping containers and other freight. Currently, yellow crazy ants have a pantropical distribution and continue to expand into additional countries and islands (Figure 4). Many of the countries in tropical Asia mentioned previously are also listed by various authors as part of the introduced range of the species, including Brunei, Cambodia, China, India, Indonesia, Malaysia, Myanmar, New Guinea, Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam, as well as parts of Africa including South Africa and Tanzania (Dar es Salaam and Zanzibar), Central and South America (Brazil, Panama, Mexico), and Australia (GISD 2009; Wetterer 2005).

Yellow crazy ants have been introduced to numerous oceanic islands in the Caribbean (McGlynn 1999), Indian Ocean (Agalega, Cocos Islands, Christmas Island, Madagascar, Mauritius, Rodrigues, Réunion and Seychelles) and the Pacific, including Japan (Amami Oshima, Bonin, Okinawa and Minami-Daito islands), Polynesia (Austral Islands, Cook Islands, Gambier Islands, Hawaii, Line Islands, Marquesas Islands, Niue, Samoa, Society Islands, Tokelau Islands, Tonga, Tuamotu Islands, Tuvalu, and Wallis and Futuna), Micronesia (Caroline Islands, Gilbert Islands, Mariana Islands, Marshall Islands, Palau, Rotuma and Santa Cruz Islands), Melanesia (Fiji, New Caledonia, Solomon Islands, Tokelau, Vanuatu and the Galapagos archipelago) (Abbott et al. 2005; Haines & Haines 1978; Holway et al. 2002; Lewis et al. 1976; Matsui et al. 2009; McGlynn 1999; O'Dowd et al. 1999; Veeresh & Gubbaiah 1984; Wetterer 2005).

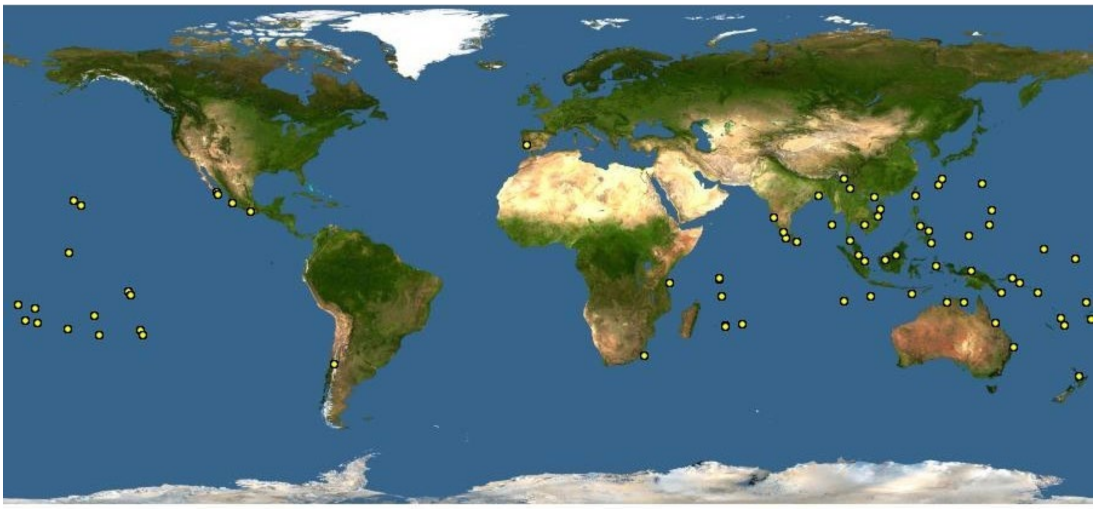


Figure 4. Global distribution of yellow crazy ants (Global Biodiversity Information Facility n.d.)

The yellow crazy ant is often referred to as a 'tramp ant', i.e. an ant 'that is widely dispersed (or reliant on dispersal) by commerce and other human-assisted activities' (GISD 2009; Passera 1994).

Preferred habitat

Preferred climate is tropical, with some populations persisting in subtropical climates. The species is abundant in the tropical lowlands of Asia, and islands of the Indian Ocean and Pacific Ocean between the tropics of Cancer and Capricorn. Wetterer (2005) reports it occurring up to latitude 26–27° N (northern India, southern China and southern islands of Japan) and found few records at higher latitudes, either north or south. The latter were either confined to urban areas or were otherwise short-lived or failed populations (Brisbane, Australia; Auckland, New Zealand; Valparaiso, Chile; Durban, South Africa; and Zayul, Tibet).

Further verification is required for locations reported from higher altitudes in Tibet and China (Abbott et al. 2005). Global climate change is predicted to increase the range of favourable environmental conditions for *A. gracilipes* at higher latitudes (Chen 2008).

A. gracilipes is reported from low to mid elevations in Hawaii up to 2000 m (Holway et al. 2002; Mau & Kessing 1992). However, Hoffman and Kay (2008) suggest it is unable to colonise areas above 900 m. Most collection records are from elevations lower than 1200 m (Wetterer 2005; Abbott et al. 2005).

Preferred habitats include moist riverine and lowland tropical forest (Abbott et al. 2005; GISD 2009). For example, in India, it exists in moist habitats (Veeresh 1987) but is absent from hot, dry parts of the North-Western Provinces, the Punjab and Central India (Bingham 1903).

In northern Australia, yellow crazy ants were initially believed to prefer rainforest, but recent research confirms they can thrive in harsh, rocky, dry areas in Arnhem Land, Northern Territory. The presence of acacias and other plants that supply extra-floral carbohydrates appears to be a primary influence on persistence. Some references state that the species can survive in grasslands and savannah (GISD 2009).

Yellow crazy ants typically colonise moist, shady, disturbed habitats such as rainforest margins/gaps and agricultural land, particularly agroforestry. Coffee, cacao, coconut, citrus and cinnamon plantations are all reported to be readily invaded (GISD 2009; Bos et al. 2008; Young 1996). However, the species can colonise relatively undisturbed (i.e. uncleared) habitats such as monsoon rainforest on islands (e.g. on Christmas Island) (GISD 2009). It can readily invade urban areas, making it a troublesome household and building pest (GISD 2009).

Yellow crazy ants forage day and night, generally when temperatures are 21–35 °C (Haines & Haines 1978; Abbott et al. 2005). However, in the Solomon Islands, foraging was observed to be most intense at dusk, when humidity and temperature were relatively high (Greenslade 1972). Unlike some ant species, use of conspicuous foraging trails is not common (Fotso Kuate et al. 2008). High midday temperatures of more than 44 °C prevent workers foraging and activity also declines below 25 °C (Abbott et al. 2005). Rain and strong winds may also limit foraging (Mau & Kessing 1992). Increased foraging activity and nest building have been observed in the dry season (GISD 2009). However, Vanderwoude and Abbott (2006) found that during prolonged dry periods, workers remain in the nest where they either use stored food or cannibalise their brood and other workers to survive. Baiting during this time is therefore ineffective.

High rainfall may be an important factor determining distribution, as events associated with brood production depend on the onset of the rainy season in Papua New Guinea, the Seychelles and Christmas Island (Baker 1976; Haines & Haines 1978; Abbott et al. 2005).

Nests are usually made in the soil, in cracks and crevices, under leaf litter and in bamboo sections on the forest floor (GISD 2009). On Christmas Island, the ants readily take over the burrows of red land crabs and also nest in the hollow base of fallen palm leaves, but they are also arboreal, nesting in canopy tree hollows and epiphytes (O'Dowd et al. 1999). In coconut plantations they nest at the base and crown of the tree (CSIRO 2010; Young 1996; Zipcode Zoo 2010).

History as a pest elsewhere

The yellow crazy ant is listed by the International Union for the Conservation of Nature's Invasive Species Specialist Group (IUCN-ISSG) among 100 examples of some of the 'world's worst invasive species' (GISD 2009; Lowe et al. 2000) and is considered to be one of the most destructive invasive ant species (Wetterer et al. 2009). It has caused substantial environmental harm on numerous islands in Polynesia, Melanesia and Micronesia, including Papua New Guinea (Sarnat 2008; PAPP 2009), and has achieved a pantropical distribution.

The yellow crazy ant is a 'quarantine pest' in the United States (APHIS 2006) and the Republic of Korea (*Country report: the Republic of Korea* 2007), but is not listed as an invasive species in North America (invasive.org 2010). It was first recorded in Hawaii in 1952 where it has since become one of the most dominant invasive ant species (Krushelnycky et al. 2005). Invasive ants are considered the most significant invertebrate predators on Hawaii (Gillespie & Reimer 1993).

It has been reported as a pest in East Africa, Papua New Guinea, Indonesia, Malaysia (Borneo), Japan, Réunion, Mauritius, Rodrigues, Agalega and India (Drescher et al. 2007; Way 1953; Young 1996; Matsui et al. 2009; Veeresh 1987; Bos et al. 2008; AntWeb 2010). Its impact in the Seychelles is well documented (Lewis et al. 1976; Haines & Haines 1978; Haines et al. 1994; Feare 1999; Hill et al. 2003; Gerlach 2004). Gerlach (2004) reported predation on Hawksbill turtle hatchlings (*Eretmochelys imbricata*) on Bird Island, Seychelles.

Predation of invertebrates by yellow crazy ants is widely reported, including small isopods, myriapods, molluscs, arachnids, land crabs and insects (O'Dowd et al. 1999; Vanderwoude et al. 2006; Jeffery 2005; Gerlach 2004; K Abbott, Monash University, pers. comm. 2010; B Hoffmann, CSIRO, pers. comm. 2010). Gillespie and Reimer (1993) reported predation and displacement of endemic spiders in Hawaii. Gerlach (2004) reported a significant reduction in native ant species and paussine beetles caused by yellow crazy ants, but no change to other invertebrates. Hence, the general trend appears to be a decline in species diversity and abundance; however, few papers quantify the impacts (B Hoffmann, CSIRO, pers. comm. 2010; Abbott et al. 2005). Impact is probably dependent on super-colony density (Abbott et al. 2005).

Invasive ants can affect native ant–plant mutualisms, such as seed dispersal and pollination, and alter species composition (Drescher et al. 2007). Native ants are reported to be displaced by yellow crazy ants in India (GISD 2009). Similarly, Abbott (2004, 2006, 2007), Bos et al. (2008) and Savage et al. (2009) found that native ant diversity is reduced in the vicinity of yellow crazy ant super-colonies—for example, by up to 50 per cent on islands in the Tokelau Archipelago. Species affected range in size from the tiny *Monomorium minutula* to the larger *Anochetus graffaei* (head width 0.9 mm) (Abbott et al. 2007). Only two of the 40 resident ant species were able to coexist with yellow crazy ants on Christmas Island (*Paratrechina longicornis* and *Paratrechina minutum*) (Abbott et al. 2007). Two dominant predatory ants *Oecophylla smaragdina* and *Leptogenys processionalis* were eliminated by yellow crazy ants in India (Veeresh & Gubbaiah, 1984).

Populations of yellow crazy ants in Hawaii have been shown to actively defend flowers from other nectivores (Lach 2005).

Gerlach (2004) reported *A. gracilipes* preying on blind snakes (*Ramphotyphlops braminus)* on Bird Island, Seychelles. Endemic geckoes and skinks are at risk on Christmas Island (Commonwealth of Australia 2006).

Haines et al. (1994) reported yellow crazy ants preying on newborn domestic animals such as pigs, chickens and rabbits.

There is evidence that yellow crazy ants can kill young birds (Matsui et al. 2009). However, it is not known whether this is direct predation or defensive. On islands, where birds are often ground-nesting and there is a lack of predators, bird populations have been negatively affected. For example, on Minami-daito Island, Japan, yellow crazy ants inflicted fatal injuries on fledglings of bull-headed shrike (*Lanius bucephalus*) and Daito white-eye (*Zosterops japonicas daitoensis*) (Matsui et al. 2009). Reproductive success in the Daito scops owl (*Otus elegans interpositus*) was not affected, but nesting behaviour was altered with adults interchanging nesting sites more frequently in ant-infested sites (Matsui et al. 2009).

High densities of yellow crazy ants on Bird Island, Seychelles, are associated with high densities of coccid scale insects on the native tree *Pisonia grandis*, causing some tree mortality and a reduction in the number and density of invertebrate species on foliage and on the ground (Hill et al. 2003).

Yellow crazy ants can affect the health of coffee, coconut and sugarcane crops by nesting at the base of these plants, exposing the roots to disease and reducing yields (GISD 2009; Mau & Kessing 1992; Feare 1999; Haines et al. 1994; Wood et al. 1988). They have been recorded as a pest of mangoes in India (Srivastava, 1997). Coconut plantations infested by yellow crazy ants experienced yield reductions of 77 per cent in Papua New Guinea, due to infestation by the coconut spathe moth (*Tirathaba rufivena*). Yellow crazy ants are believed to reduce populations of various predators that normally control spathe moth (Young n.d.). Similarly, damage to Hawaiian macadamia crops caused by *Nezara viridula* (green vegetable bug) is greater when yellow crazy ants dominate, compared to areas patrolled by *Pheidole megacephala* (big-headed or coastal brown ant) (Jones et al. 2001).

On Mahé, Seychelles, the abundance of the sap-sucking insect *Ceraplastes rubens*, associated with sooty mould on citrus and cinnamon, sometimes increased a hundredfold in the presence of yellow crazy ants (up to 90 per cent of leaves were infected) (Haines & Haines 1978).

A. gracilipes has traditionally been used as a biological control agent in Papua New Guinea against pod weevil in cacao crops as well as in coconut and coffee agroforestry systems (see following section). However, the negative impacts of yellow crazy ants would far outweigh any potential benefit from biocontrol, even within horticultural systems. The fact that this ant will tend all sap-sucking bugs makes it a pest in horticultural settings (B Hoffmann, CSIRO, pers. comm. 2010).

Although yellow crazy ants do not bite, formic acid sprayed when they are disturbed can cause skin burns and eye irritation to farm workers (GISD 2009; Haines & Haines 1978; Haines et al. 1994; K Abbott, Monash University, pers. comm. 2010).

Yellow crazy ants are considered troublesome household, building and village pests in some places (GISD 2009; Lewis et al. 1976; Vanderwoude et al. 2006; Walsh & Walters 2010).

Use

Yellow crazy ants have been used successfully as a biological control agent. *A. gracilipes* limits pod weevil (*Pantorhytes szentivanyi*, *Crematogaster* sp., *Pheidole* spp. and *Camponotus* spp.) in cacao crops in Papua New Guinea (McGregor & Moxon 1985). It is also used as a biocontrol agent in coconut and coffee plantations (GISD 2009).

Pest potential in Queensland

Current impact in Australian territory

Christmas Island

The impact of yellow crazy ants on the biodiversity of Christmas Island has been profound. Originally introduced some 60 years ago, the ant population has increased dramatically in recent years (CBD 2003). The Australian Government has spent $3.4 million controlling crazy ants over 2400 hectares of forest between 1999 and 2009 (Department of Environment and Heritage 2004a). Between 15 million and 20 million of the island's iconic red land crabs have been killed by crazy ants (Wikipedia 2010b). This has caused 'a rapid and catastrophic' change within the rainforest ecosystem, as land crabs are a 'keystone' species within the island's ecosystem (O'Dowd et al. 2003).

The extinction of the Christmas Island pipistrelle (*Pipistrellus murrayi*) was reported this year (IUCN SSC, March 2010) and is attributed to an increase in crazy ant abundance, which reduced red crab numbers, causing an increase in the abundance of giant millipedes, which prey on roosting pipistrelles.

The red crab also provides biotic resistance to other invaders such as the giant African snail (*Achatina fulica*) and some weed species. Thus, a reduction in red crab numbers has facilitated secondary invasions (Wikipedia 2010b).

Since the crabs are the island's primary detritus (leaf litter etc.) consumers, a reduction in their numbers has caused significant changes to forest structure, increasing tree seedling survival rates and reducing the breakdown of leaf litter. This has had flow-on effects on other species such as the Christmas Island thrush (*Turdus poliocephalus erythropleurus*), altering its foraging success (Davis et al. 2008; Department of Environment and Heritage 2005).

The broadscale farming of scale insects by yellow crazy ants has caused an increase in sooty mould infections, severely reducing canopy health and resulting in tree mortality (O'Dowd et al. 2003). The Tahitian chestnut (*Ingocarpus fagifer*) in particular has been adversely affected and may become eligible for listing as a 'vulnerable' species (Commonwealth of Australia 2006). Changes to the island's forests have caused loss of essential breeding habitat for the endangered Abbott's booby (*Papasula abbotti*) (Department of Environment and Heritage 2004b) as well as significant declines in populations of various skinks, blind snakes, geckos and bats. Endemic snails and a number of insects appear to have become extinct.

Once yellow crazy ants attained super-colony status on Christmas Island, there was noticeable predation on turtle hatchlings and coconut crabs (Jeffery 2005).

Cocos (Keeling) Islands

Yellow crazy ants have been on North Keeling for a number of years but, as yet, have not formed destructive super-colonies (Reid & Hill 2005). The species is a potential threat to the endangered endemic buff-banded rail (*Gallirallus philippensis andrewsi*) (Department of the Environment, Water, Heritage and the Arts 2010). If super-colonies develop, the island's pisonia forest may be at risk, together with dependent fauna (Commonwealth Attorney-General's Department 2008).

Northern Territory

In Arnhem Land, crazy ants occupy 2500 km^2 (Young et al. 2001) and are considered a serious threat to invertebrate fauna of the monsoon rainforests (Young et al. 2001). Invertebrates at risk include the endangered Gove crow butterfly (*Euploea alchathoe enastri*) (Braby & Wilson 2006). However, this study was unable to find detailed information on their impact.

New South Wales

Forty percent of crazy ant quarantine interceptions in Australia to date occurred in New South Wales ports. Only one naturalised population has been detected in New South Wales, at Yamba in 2004, and this was eradicated by 2010 (New South Wales Department of Environment and Conservation 2008).

Western Australia

Yellow crazy ants have been intercepted in shipping freight arriving at Freemantle (GISD 2009).

Current distribution and impact in Queensland

Yellow crazy ants were first detected in 2001 in Cairns. Since then, more than 20 additional sites have been found, in and around Cairns, Townsville, Hervey Bay, Caboolture and Brisbane (Table 1). The total area of infestation involves at least 320 hectares. Populations at some of these sites have been eliminated, whereas others are subject to ongoing control.

Table 1. Locations where yellow crazy ants have been found in Queensland (current at March 2010)

Location	Detection date	Infestation area (ha)	Site description
Cairns – Portsmith	Apr 2001 Apr 2004	5	Industrial
Hamilton	Nov 2002	n/a	Port area
Port of Brisbane	Nov 2002	n/a	Port area
Edmonton – Creek	May 2004	40	Residential and forest
Caboolture	Dec 2004	0.4	Timber yard and industrial
Urangan (Hervey Bay)	Mar 2005	77	Timber roof truss factory and industrial
Slacks Creek	Mar 2005	4.5	Timber yard
Wacol	Mar 2005	n/a	Correctional centre
Banyo	Jul 2005	1.4	Timber importer
Gordonvale	Jul 2005	n/a	Rural residential
Townsville	Jul 2005	n/a	Port area
Hamilton	Aug 2005	n/a	Timber yard
Cairns – Portsmith	Dec 2005	n/a	Industrial
Cairns – Portsmith	Feb 2006	1.5	Port area
Cairns – Worree	Mar 2006	5	Industrial – transport company
Tingalpa	Apr 2006	3.2	Timber staircase factory
Kedron	Oct 2006	7.5	Industrial
Chermside	Feb 2008	17	Timber joinery
Arundel	Mar 2008	10.1	Timber yard – vacated
Woodridge	Mar 2008	2.5	Timber roof truss factory
Eagle Farm	Mar 2008	1.5	Timber joinery
Pinkenba	Mar 2008	12	Industrial – transport company
Bentley Park	May 2008	44.12	New housing development and forest
Townsville – Mount Saint John	Jun 2008	16	Industrial – timber yard and vacant land
Edmonton	Aug 2008	16.52	Cane paddock, school, roadside
Acacia Ridge	Aug 2008	15	Timber yard
Eagle Farm	Apr 2009	5	Industrial – transport company
Townsville – Douglas	Apr 2009	1.2	Hospital/university housing accommodation
Rocklea	Apr 2004 May 2007	4.7	Industrial – transport company and old container park
Townsville – Garbutt	Mar 2010	5.9	Industrial – timber truss plant

n/a = not available
Source: Department of Employment, Economic Development and Innovation (2010).

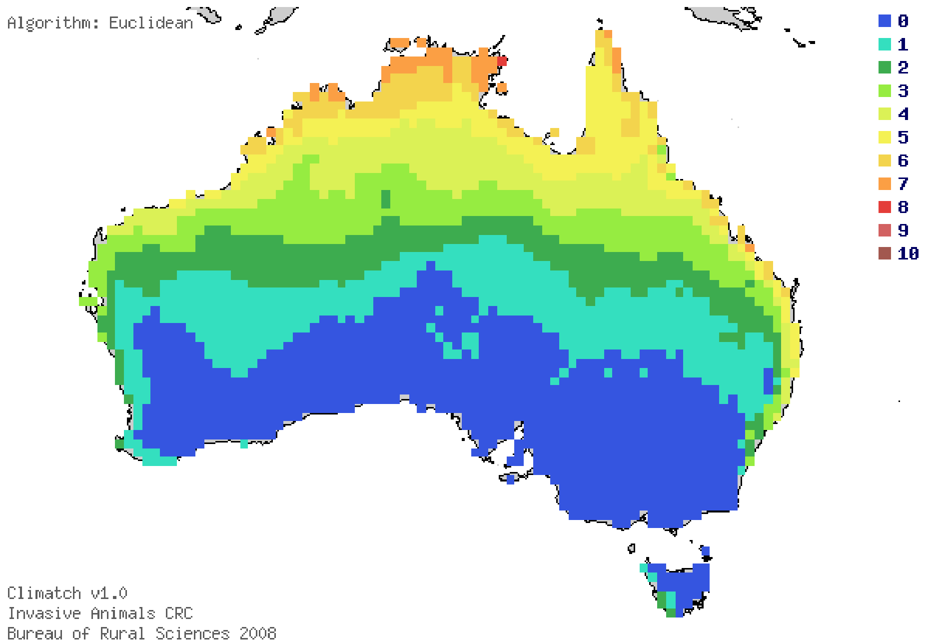
The total area of land with populations of yellow crazy ants in Queensland is relatively small. As such, the species is in its very early stages of population development, with minimal impacts.

Of the total number of quarantine border detections in Australia prior to 2005, Brisbane accounted for 40 per cent (Scanlan & Davis 2005).

Potential distribution and impact in Queensland

Climate-modelling software called Climatch (Bureau of Rural Sciences 2009) was used to predict areas of Queensland where climate appears similar to that experienced within the native range of the species (assumed to be Indonesia, Malaysia/Borneo). Coastal Queensland appears most suitable (Figure 5). The detection of a number of small populations of yellow crazy ants along the Queensland coast (and in Arnhem Land, Northern Territory) is consistent with this prediction.

Figure 5. Area of Australia where climate appears suitable for survival of yellow crazy ants. Red and orange are highly suitable, yellow is marginally suitable, and green and blue are unsuitable. Map produced using Climatch computer software (Bureau of Rural Sciences 2009)



Little is known about factors that influence the success of yellow crazy ant colonies on the Australian mainland (B Hoffmann, CSIRO, pers. comm. 2010). Research suggests that the availability of plant-based carbohydrates may play an important role in population development (Holway et al. 2002; O'Dowd et al. 2003). While the impacts of the species overseas may provide useful insights into its potential impact in Australia, most significant impacts are associated with relatively small islands. These islands often have depauperate ecosystems (simple ecosystems characterised by relatively low biodiversity). For example, the impacts of crazy ants on Christmas Island may be somewhat unique, due to unusually high ant numbers and the presence of a very influential 'keystone' species, the Christmas Island red crab (B Hoffmann, CSIRO, pers. comm. 2010). Mainland ecosystems are far more complex than on islands and ecologists often argue that complexity confers resilience to invasion. However, Hoffmann and Saul (2010) suggest biotic resistance may not be sufficient to mediate the spread of yellow crazy ants in northern Australia, despite the presence of highly competitive native ant communities. Hence, the potential impact of crazy ants on mainland Australian ecosystems is difficult to predict.

Since yellow crazy ants have well-documented negative impacts on tropical islands around the world, they can be expected to have a significant impact on Queensland's offshore islands. Other invasive ant species such as *Pheidole megacephala, Tetramorium* sp. and *Monomorium* sp. have already caused widespread mortality of *Pisonia grandis* populations on the Capricornia Cays and in the Coral Sea Cays by farming *Pulvinaria urbicola* (Olds 2006). These islands host breeding populations of globally threatened sea turtle species (loggerhead, hawksbill, green and leatherback).

The yellow crazy ant is one of six national priority species of invasive tramp ants likely to threaten the biodiversity of Australia or its territories (Commonwealth of Australia 2006). It is also listed as a 'key threatening process' on Christmas Island and in New South Wales.

In New South Wales, the following species may become 'threatened' as a result of yellow crazy ant invasions (New South Wales Department of Environment and Conservation 2008):

- ants such as *Rhytidoponera* spp., *Pheidole* spp. and *Paratrechina* spp.
- eastern sedgefrog *Litoria fallax*
- eastern grass skink *Lampropholis delicata*
- a burrowing skink *Ophioscincus truncates*
- a range of other ground-dwelling invertebrates and vertebrates.

In addition to potential impacts on a number of rare and threatened species, yellow crazy ants are perhaps most likely to cause a general decline in abundance, and perhaps diversity, of a range of other invertebrates. The degree to which this may happen is difficult to predict and may be heavily influenced by competing native ant species.

Considering the impact of yellow crazy ants on various crops overseas, they can be expected to have some impact on similar crops in Queensland. Perhaps their most significant impact will be their effects on the abundance of various sap-sucking insects (e.g. scale insects). Major effects on human health are not expected, unlike fire ants.

Yellow crazy ants could become troublesome pests in towns and cities. While their bites are not dangerous, they can spray formic acid, which can irritate people's skin and eyes (Figure 6).

Figure 6. Skin irritation ('burn') caused by formic acid sprayed by yellow crazy ants

A number of Pacific Islands have produced risk assessments for yellow crazy ants, e.g. Samoa (Nuulua Island) (Vanderwoude et al. 2006) and Tokelau (PAPP 2009). A detailed and comprehensive pest risk assessment is available for New Zealand (Abbott et al. 2005). Guidelines produced by the IUCN-ISSG recommended the production of a Pacific Ant Prevention Plan (PAPP) to guide quarantine activities in the region (PAPP 2009).

Likelihood of additional incursions

Additional incursions of yellow crazy ants into Queensland are inevitable, considering the previous history of incursions here and elsewhere.

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