FIELD EVALUATION OF SYNERGY® ANT BAIT FOR DIRECT NEST TREATMENT OF TROPICAL FIRE ANT (*SOLENOPSIS GEMINATA*) AND OTHER NUISANCE ANT SPECIES ON A GOLF RANGE IN NORTHERN AUSTRALIA

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Summary

Tropical fire ant is present in northern Australia, occurring in urban, agricultural and natural environments. Synergy® Ant Bait was evaluated for direct nest treatment of tropical fire ant (*Solenopsis geminata* F.) and some native nuisance species on a golf range in Darwin (Australia). Synergy® was applied directly to nests of tropical fire ant, meat ant (*Iridomyrmex sanguineus* Forel), pale tyrant ant (*Iridomyrmex pallidus* Forel) and *Monomorium* sp. (*rothsteini* gp) at rates of 1 to 16g per nest and colony viability evaluated over a period of several months. Almost all nests were eliminated within 37 days and all but two large meat ant nests were inactive by 68 days after application. These two remaining meat ant colonies were considered moribund as there were very few worker ants active and excavation of the main nest resulted in little or no defensive response from the colony. Synergy® used as a direct nest treatment provided very effective control of nests of tropical fire ant and several species of nuisance ants in managed turf on a golf range in northern Australia.

Keywords: Ants, pyriproxyfen, hydramethylnon, *Solenopsis geminata*, control

INTRODUCTION

Darwin (Australia) lies north of the Tropic of Capricorn and experiences typical tropical monsoon weather during the period December to March. Tropical fire ant (*Solenopsis geminata* F.) is an invasive species originating from central and south America and is now widespread in the tropics (Plowes *et al.* 2007, Wetterer 2010). It may have been present in northern Australia for at least 100 years (Wetterer 2010), although the first confirmed record is from 1939 (Lach and Thomas 2008). Outside of its home range, it is a significant and aggressive pest of urban, agricultural and natural environments and due to its potent sting, of human health concern (Risch and Carroll 1982, Plowes *et al.* 2007, Chin 2008, Plentovich *et al.* 2009, 2010, Wetterer 2010). Unlike its congener, the red imported fire ant (*Solenopsis invicta* Buren), tropical fire ant does not construct solid elevated mounds; rather it constructs low soil mounds of loose soil with extensive radiating runways (Plowes *et al.* 2007) which results in extensive areas of disturbed soil and damaged turf thatch. In the US up to $30M is spent annually on control of red imported fire ant on golf courses (Camerino *et al.* 2011) and ants are generally a significant nuisance in recreational turf (Lopez *et al*. 2000, Potter 2002, Shetlar 2003, Maier and Potter 2005, Puckett *et al*. 2007) . On the golf range used in this study the presence of tropical fire ant results not only in player discomfort through occasional stings but also reduced visual amenity and a physical playing hazard. The presence of some other native species also contributes to the degradation of the playing surface.

Aside from a few key conservation areas or areas of significance to indigenous Australians in northern Australia, where eradication has been or is currently being attempted (Hoffmann and O'Connor 2004, Hoffmann *et al.* 2011, Hoffmann pers. comm.), there is currently no concerted effort to eradicate or even control tropical fire ant. Hoffmann and O'Connor (2004) succeeded in eradicating two small colonies in Kakadu National Park, a significant conservation reserve in northern Australia, using Amdro™ Granular Ant Bait (hydramethylnon). Similarly, two small infestations in northern Western Australia were eradicated using combined treatments of liquid nest injection and baiting with either Amdro™ or Distance® Ant Bait (pyriproxyfen). In Hawaii hydramethylnon-based baits have had variable success from complete elimination of a small mainland infestation (Hoffmann *et al.* 2011) through to short-term control (non-detection on bait cards) for up to 12 months on offshore islands (Plentovich *et al*. 2010, 2011).

Synergy® is a new ant bait containing both hydramethylnon and pyriproxyfen, now approved in Australia for the control of a range of invasive and nuisance ants. The bait has proved to be both attractive and efficacious against a range of species including Argentine ant (*Linepithema humile* (Mayr)) (Krushelnycky *et al*. 2011, Webb 2011) and African bigheaded ant (*Pheidole megacephala* F.) (Webb 2014). This study was conducted to determine the required rates of Synergy® for direct nest treatment of tropical fire ant and some other nuisance ant species in recreational turf. Rates ranging from 1 to 16g per nest were applied to nests of tropical fire ant, meat ant (*Iridomyrmex sanguineus* Forel), pale tyrant ant (*Iridomyrmex pallidus* Forel) and *Monomorium* sp. (*rothsteini* gp.), and colony viability assessed over a period of 2 months. The golf range adjoins a mixed agriculture farm, in which other studies (as yet unpublished) were conducted and some observations are gleaned from these studies.

MATERIALS AND METHODS

Synergy® is a blended granular product containing two granule types, both loaded with two active ingredients, pyriproxyfen at 2.5 gai/kg and hydramethylnon at 3.65 gai/kg, manufactured by Sumitomo Chemical Australia, Epping, Australia. The two granules are either corn-based or protein-based. The corn granule is typical of most granular products currently used for control of red imported fire ant containing soybean oil but with added human food-grade ingredients, known to be attractive to ants (Webb 2013). The protein granule contains various food-grade proteins and carbohydrates and is extruded and cut to the required dimensions.

The golf range at Berrimah near Darwin (NT) is approximately 13ha in size and comprises an area of sparse grass cover which is regularly mowed (Figure 1). Scattered throughout the property are nests of various species of ants, predominantly, tropical fire ant, meat ants, pale tyrant ant and *Monomorium* sp.. Other species such as black ants (species of *Iridomyrmex and Paratrechina)* and a range of small cryptic species are present but in low densities and not considered further here. The zone between the golf range and the adjoining horticulture farm consists largely of an unsealed access road, a row of palm trees, bare ground and sparse grass cover.

Figure 1: Layout of farm and golf range at Berrimah

Table 1: Ant activity ratings used to classify the activity status of nests.

	Activity status
1	>10 ants present on the surface, or present on the surface within 1 minute following mild surface disturbance (tapping with small shovel).
2	<10 ants present on the surface or present on the surface within 1 minute following mild surface disturbance (tapping with small shovel).
3	>10 ants present in excavated hole within 1 minute following excavation to 20cm deep
4	<10 ants present in excavated hole within 1 minute following excavation to 20cm deep
5	No activity on the surface or in excavated hole within 1 minute

On the morning of 26 July 2009, 42 to 54 nests each of tropical fire ant, meat ant and *Monomorium* sp. on the golf range were identified and marked for treatment. Nests were only included if there was obvious activity on the surface surrounding the main access hole to the nest. A smaller number of nests of pale tyrant ant were also identified and flagged but these were not very common on the golf range although more common on the adjoining agricultural land. Nests were selected to ensure they were independent of surrounding nests – this was particularly difficult for meat ants which have a very wide foraging range. One particularly large meat ant nest (ca. 3.5 m in diameter) (not used in this trial) and its foraging trails covered an area of approximately 200 m^2 adjoining the main road, Vanderlin Drive, with radiating runways to small eucalypt trees along the roadside which supported populations of honeydew secreting leafhoppers. Most meat ant nests used in this trial were small and ranged in size from 0.5 to 1 m in diameter. Generally speaking, nests and obvious foraging ranges of tropical fire ants and *Monomorium* sp. were confined to just a few square metres. Tropical fire ant nests were typically small and comprised of loose soil covering turf thatch whilst those of *Monomorium* sp. were small cleared patches (ca. 20 cm in diameter) with a single central or radial entrance hole surrounded by small pebbles. Pale tyrant ant typically constructed small conical earth mounds of ca. 5-10 cm diameter. On the morning of 27 July 2009, each nest was assigned a treatment rate from 2 g to 12 g (ie. 2 g, 4 g, 8 g or 12 g) and treated. Additional nests discovered and flagged that morning were assigned rates of 1g or 16 g/nest but there were insufficient numbers of all but *Monomorium* sp. to allow for 10 replicates at these rates.

Bait was applied by hand using a scoop calibrated to contain 2 g of bait and bait was scattered evenly across the surface of the visible nest and the surrounding area out to a diameter of 1 m. Weather conditions at the time of application were warm and sunny (ca. 28-32 °C) and moderate cloud cover.

On 3 September 2009 (37 days after treatment (DAT)), all marked and treated nests were inspected for ant activity. Where no activity was evident on the surface, the top of the nest was tapped with a small shovel to elicit a response. In most cases there was no apparent activity following this mild disturbance and the main entrance hole was no longer evident and mound material dispersed. If ants did not respond to tapping on the top of the nest, then nests were excavated to determine the presence of ants. Nests were excavated down to approximately 20 cm. Where there was no obvious ant activity on the surface following tapping, activity was scored on the basis of response to excavation. A cut off point of 10 ants was used for each category of activity (Table 1). Two nests (both meat ant nests) were still active on 3 September 2009 (37DAT) with ants present on the surface only after tapping. All other nests were excavated at that time. On 4 November 2009 (68DAT), all nests (including these two) were subjected to further excavation to determine ant activity. In the adjoining farmland, five nests of each of the four species were marked for use as untreated controls and monitored for activity during the period of this trial. No statistical analysis was applied because the vast majority of nests on the golf range were considered inactive by the first assessment and no useful information is likely to be gleaned from such analysis.

RESULTS

All nests used as untreated controls in the adjoining agricultural block remained active at the end of the study with clear activity on the surface. Results for nest activity for the treated nests are summarized in Figure 2.

Tropical Fire Ant

Most tropical fire ant nests were within or near the central area of the golf range which is periodically irrigated. Only three of 47 nests showed activity at 37 DAT (one at 4 g/nest and two at 12 g/nest) and only following excavation. The typical low soil mounds were generally absent and soil compacted by foot-traffic, mowing, rainfall or irrigation. By 68 DAT the remaining three nests were considered inactive. As there were only two nests treated at 1 g/nest there is insufficient data to determine if this was an adequate application rate but all rates of 2 g and above provided complete nest mortality by 68 DAT and most by 37 DAT.

Meat Ant

Eight of 42 nests showed activity of some sort at 37 DAT (three at 2 g/nest, one at 4 g/nest, one at 8 g/nest and three at 12 g/nest) but only 2 of these nests showed activity above ground following the mild disturbance of surface tapping. All others required excavation. By 68 DAT all but these same two nests were considered inactive and both required excavation to determine the level of activity. In both cases the nests appeared moribund with no brood evident and just a few ants present. It would appear likely that a further assessment would have found these two nests to be dead. These were also the largest nests treated originally (ca. 1 m diameter).

Monomorium sp. (*rothsteinii* group)

All 54 nests were considered inactive at 37 DAT with no activity following mild disturbance or excavation. Inactive mounds typically had no entrance hole and the pile of pebbles had been dispersed. There was no apparent difference in efficacy between rates from 1 g to 12 g/nest.

Pale Tyrant Ant

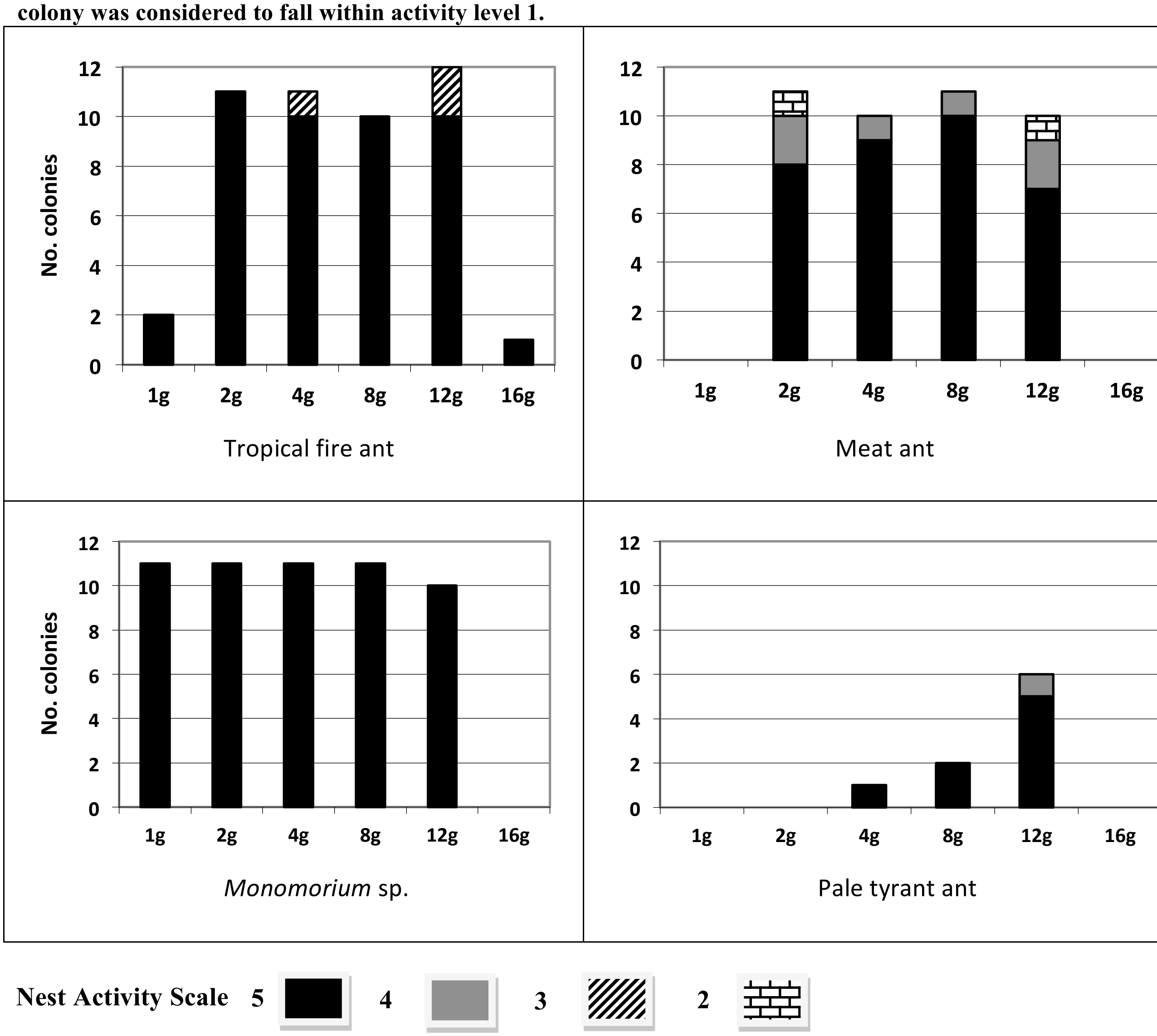
Only a small number of nests were available for treatment. However, all but one of the 9 nests was considered inactive at 37 DAT with no activity following mild disturbance or excavation. The low conical earth mounds were mostly absent at this first assessment, and were probably dispersed by wind or some other form of mechanical disturbance. The final nest was inactive by 68 DAT.

DISCUSSION

All four ant species included in this trial were clearly susceptible to baiting with Synergy® across a wide range of rates from as little as 1g per nest for tropical fire ant and *Monomorium* sp. and most colonies succumbed within 37 days. With a few exceptions (three tropical fire ant nests, one pale tyrant ant nest and eight meat ant nests for which ant activity was still evident in some form at 37 DAT), all nests were considered inactive at that time. At the 68 DAT assessments all nests were considered inactive, with the exception of just two meat ant nests and both of these were considered moribund. The nest viability evaluation process involved excavation, and for those few nests that were still active at 37 DAT, the physical damage caused by excavation most likely exacerbated the decline evident at 68 DAT. Nevertheless, the fact that there was no above ground activity even after tapping the nest with a shovel indicates that these nests had minimal protective response to disturbance and were likely moribund at 37 DAT. The only nests not excavated at 37 DAT were the two meat ant nests, which showed above ground activity after surface disturbance.

Unlike the adjoining agricultural land where tropical fire ant nests can be extensive with runways covering up $10m^2$, most colonies on the golf range were relatively small. This is likely to be the result of regular disturbance through mowing activities and deliberate attempts to physically damage or remove the colonies. It is possible that these constant physical challenges may have enhanced the speed of nest elimination by baiting, relative to less disturbed nests in the adjoining agricultural land. The use of nests in the adjacent agricultural land as untreated control nests was problematic in that there can be no certainty that the differing land use was not a contributing factor. It is also possible that with the intensive baiting on the golf range - a total of 151 separate colonies and an aggregate bait volume of 955g over 13 ha – there may have been competitive interactions between colonies for the bait resource. As a result there can be no guarantee that each treated colony actually harvested the exact amount delivered to it. Irrespective of these concerns, there was a very high success rate overall with 92% of all colonies considered dead at 37 DAT and all but two meat ant nests considered dead by 68 DAT.

Figure 2. Activity status of ant nests 37 days after treatment. Refer to Table 1 for nest activity scale. No colony was considered to fall within activity level 1.



Nests of pale tyrant ant and *Monomorium* sp. were monodomous and relatively small and the rates applied were sufficient to achieve elimination within 37 days (with the exception of one pale tyrant ant nest which had succumbed by 68 DAT). The response of meat ant nests to baiting was generally slower than for the other three species (81% of nests were dead at 37 DAT compared with an aggregate of 96% for the other three taxa). At least two of the meat ant nests were large and this might account for the delayed response to baiting in these two nests, which nevertheless ultimately succumbed to baiting. Meat ant nests are known to grow very large, sometimes with multiple satellite mounds up to 100 m away (Greaves 1973, Greaves and Hughes 1974, Mobbs *et al*. 1978, Greenslade and Halliday 1983, McIver 1991, Webb *et al.* 2013) and control measures have met with variable success as a result (Webb *et al.* 2013). Higher application rates and/or multiple applications may be required for large and polydomous colonies of meat ants.

Tropical fire ant has been shown to be susceptible to baiting with granular products such as Amdro™ (Hoffmann and O'Connor 2004, Plentovich *et al.* 2010, 2011, Hoffmann *et al.* 2011). Both granules incorporated into Synergy are independently attractive to tropical fire ant (Webb unpubl. data) and both matrices were also attractive to Argentine ant (Kruschelnycky *et al.* 2011, Webb 2011) and the corn component of Synergy was also effective in controlling African bigheaded ant (Webb 2014).

There is no published information available on control of the other three species examined in this study, with the exception of Webb *et al.* (2013) for the meat ant *I. sanguineus* in Western Australia. In that study, baiting with both pyriproxyfen and hydramethylnon-based baits provided varying levels of colony control with Amdro™ providing an initial reduction in colony viability and Distance® ant bait providing longer term and more persistent reductions. James *et al.* (1996) and Stevens *et al.* (2002) studied the effects of baiting on another common species of meat ant (*Iridomyrmex purpureus* (Smith)), in citrus orchards in southern Australia. Baits containing hydramethylnon and fipronil were effective in reducing the number of foraging workers. James *et al.* (1996) also evaluated direct nest treatment with hydramethylnon-based baits for various sized *I. purpureus* nests achieving control for 91 days and 35 days respectively for 1 and 2 m^2 nests but no apparent control of a larger nest. Clearly meat ants (various species) are susceptible to baiting but colony size may influence the speed of control and ultimately whether the entire colony succumbs.

Pale tyrant ant is a common arid zone species in Australia (Andersen 2003) but there is very little known about its biology. It has not been recorded as a significant nuisance species in urban environments although it is known to be a pest of suburban lawns in Cairns in northern Queensland (Australia) (Webb 2013). Similarly, there is not much known about the taxonomically uncertain *Monomorium* sp.(*rothsteini* gp), again other than it being recorded in broader ecological studies of arid and semi-arid environments (eg. Andersen *et al.* 2013). It is not known to be of any broad economic importance. Other species of *Monomorium* considered to be urban pests are known to be attracted to corn and oil based granular baits and indeed granules containing either hydramethylnon or pyriproxyfen have been shown to be effective on both *Monomorium pharaonis* (Linnaeus) and *Monomorium destructor* (Jerdon) in the field (Vail and Williams 1995, Vail *et al.* 1996, Oi *et al.* 1996, 2000, Hsieh and Su 2000, Lee 2000, Lee *et al.* 2003, Lim and Lee 2005, Webb and Hoffmann 2013).

There are very few published studies with the aim of direct nest application of baits, although direct application of liquid insecticides is a common practice (Williams and Lofgren 1983, Collins and Callcott 1995, Rashid *et al*. 2005). Direct nest applications of bait offer the benefits of reduced bait usage, more targeted application and potentially less non-target effects. However, the downside is the increased time taken in identifying nest locations and the chance that some nests may be missed, which might be significant for more cryptic species. The work of James *et al.* (1996) on *I. purpureus* showed that direct nest treatment with hydramethylnon-based baits for various sized *I. purpureus* nests achieved control of at least small colonies. Hu (2008) found that application of bait directly onto *S. invicta* mounds led to higher bait removal rates than when bait was placed in 30cm and 120cm bands around the mounds, but no data on nest mortality was provided. Drees *et al.* (1992) were able to show reproductive effects on *S. invicta* nests directly treated with fenoxycarb-based bait and Lopez *et al.* (2000) achieved good control of individual *Lasius neoniger* mounds on US golf greens using hydramethylnon and spinosad protein-based granular baits as spot treatments.

Direct nest application of Synergy to tropical fire ant and other nuisance ant species was successful in eliminating colonies of these species from a golf range in Darwin (northern Australia). Spot treatment of nests can be an effective method of application of ant bait where colonies are clearly evident such as on managed recreational turf surfaces but use of this technique in eradication programs may be limited.

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