AN EVALUATION OF THE EFFICACY OF HYDRAMETHYLNON-BASED BAITS ON AFRICAN BIG-HEADED ANT (*PHEIDOLE MEGACEPHALA*) IN AUSTRALIA.

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Summary

Hydramethylnon-based baits are commonly used for the control or eradication of tramp ants. Four small unreplicated trials were conducted in different localities (Lord Howe Island, Sydney and Darwin) to demonstrate the effectiveness of hydramethylnon-based baits on African big-headed ant. Three trials were whole suburban property treatments using the same bait and the other trial was conducted in peri-urban bushland comparing multiple bait treatments. Hydramethylnon-based baits were effective in either temporary elimination or a substantial reduction in abundance in all trials but ant abundance rebounded in the two longer-term trials.

Keywords *Pheidole megacephala*, African big-headed ant, Hydramethylnon, Campaign®, Amdro®, Control,

INTRODUCTION

African bigheaded ant (*Pheidole megacephala*) (F.) (ABHA) is a common tramp ant around the globe. It is present across most of continental Australia including off-shore islands such as Lord Howe Island (Hoffmann et al. 2017, Wetterer 2007). ABHA was first detected in Australia over 100 years ago (Hoffmann 2011) and are known locally as the coastal brown ant.

Hydramethylnon-based baits have been used widely and successfully in the control or eradication of a range of ants including African big-headed ant (*Pheidole megacephala*) (ABHA) (Apperson et al. 1984, Causton et al. 2005, Hoffmann 2011, Hoffmann et al. 2011, Hoffmann and O'Connor 2004, Hoffmann and Parr 2008, Hooper-Bui and Rust 2000, Klotz et al. 2000, Krushelnycky and Reimer 1998), despite well-known instability under UV irradiation (Chakraborty et al. 1993, Malipudi et al. 1986, Vander Meer et al. 1982, Webb and Jovic 2019). It is likely that the encapsulation of the active within the bait granule may protect it from the rapid degradation seen for the unprotected active ingredient (Webb and Jovic 2019).

In Australia, Amdro® (7.3g/kg hydramethylnon) is registered for use against a range of tramp and pest ants including ABHA. Campaign® is a similar unregistered product which is used under permit for little fire ant (*Wassmannia auropunctata*) in north Queensland. This report brings together several smaller unreplicated trials which utilised Campaign and Amdro for the control of ABHA in various locations. These trials were either whole property treatments or trials involving various products used on residential properties or in semi-natural parkland.

MATERIALS AND METHODS

The products used in these trials were Campaign Ant Bait and Amdro Granular Ant Bait – both 7.3g/kg hydramethylnon. Campaign is manufactured by Sumitomo Chemical Australia and supplied under various permits issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) in Canberra for use against invasive ants. Amdro is manufactured by BASF and registered by the APVMA for use on various invasive ants including ABHA. The approved rate for both products is 2.5kg/ha.

Bait Application method

Bait was broadcast by hand at the registered rate of Amdro (2.5kg/ha) evenly over the treatment areas using a swath width of 5m (the arc of an arm's throw) usually travelling first in a north-south direction and then overlapping in an east-west direction to ensure even coverage.

Ant Assessment rating

As ant numbers often exceeded the capacity to count them, a rating system was employed, consistent with other similar studies (eg. Webb and Hoffmann 2013, Webb 2013) where 0 = no ants, 1 = 1-5 ants, 2 = 6-25 ants, 3 = 26-50 ants, 4 = 51-100 ants and 5 = > 100 ants. All assessments were conducted at 1 hour after placement of lure stations to allow enough time for discovery and recruitment to lure stations. In all trials, lure stations were 14 x 11 cm pieces of paper with ca. 1 g tinned fish or fish-based cat food together with ca. 1 g honey as the lure. Ratings were based on the estimated number of ants on each lure station. At three of the 4 trials other species of ant were present at lure stations, along with the target species (see Appendix).

Figure 1: View of trial site at Neds Beach, Lord Howe Island, showing sandy soils favoured by ABHA.

Figure 2: Location of trial site at Neds Beach, Lord Howe Island. Yellow squares represent the 0.25ha plots used. The second from the left was used for Amdro and the third from the left for Campaign. Only the green transects were used in this trial. The three green transects on the far right of the photo were used as untreated control transects. At the time of trial establishment the orange line was the northern boundary of ABHA presence.

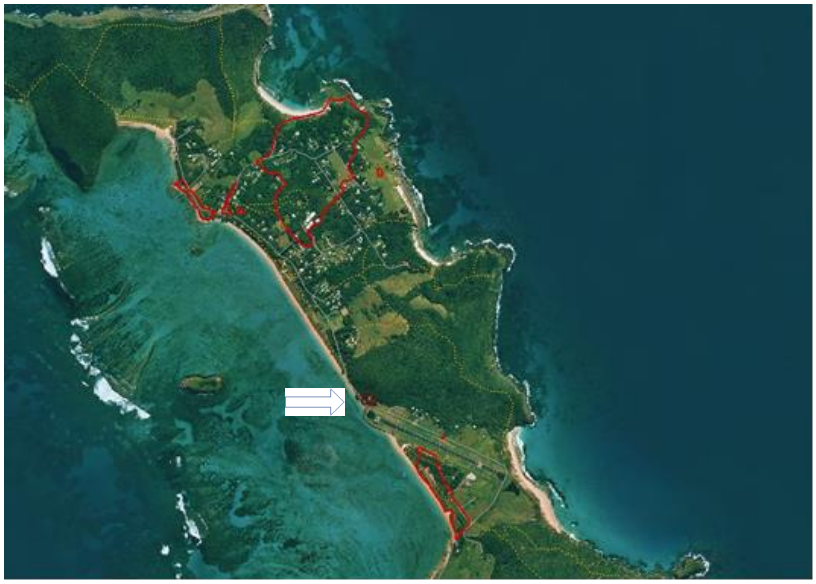

Figure 3: Location of residential trial site near the airport on Lord Howe Island marked by the white arrow. Red lines designated the extent of the infestation on the island in 2006 (courtesy of the Lord Howe Island Board).

Table 1: Trial locations, timing and trial design

Trial No.	Location	Bait application	Trial format	Treatments
1	NSW, Lord Howe Island	13 March 2006, 4 April 2006	Single unreplicated treatments	Campaign, Amdro, Untreated control (UTC)
2	NSW, Lord Howe Island	16 May 2006	Single unreplicated treatment	Campaign, UTC
3	NSW, Sydney, Cronulla	16 April 2007	Single unreplicated treatment	Campaign, UTC
4	NT, Darwin	19 October 2007	Single unreplicated treatments	Campaign, Amdro

Trial locations and trial design

Trial 1: Lord Howe Island

Webb (2014) reported on a trial at Neds Beach on Lord Howe Island which included two unreplicated treatments of Campaign and Amdro. These data are included here with additional commentary. The site was typical habitat for ABHA with well drained sandy soil (Fig. 3). Five adjoining blocks of 50 x 50m (0.25ha) were marked over the most seriously infested area allowing for five different treatments. Only Amdro and Campaign are reported here (blocks 2 and 3 respectively from the LHS of the Figure 2) but the full trial assessment is available in Webb (2014). The walking track acted as the centre line through each of the blocks. Within each block two 30m transects were marked perpendicular to the track and lure stations positioned every 3m either side of the track (ie. 40 lures/treatment). At the end of each transect there was a 10m buffer to the edge of the treated area. Three untreated transects were positioned at the top of the hill. Bait was applied twice at 2.5kg/ha on 13 March 2006 and then again on 5 April 2006. A range of other species was also present at the trial site (Appendix 1).

Trial 2: Lord Howe island

A residential property adjoining the airport on Lord Howe Island (Fig. 3) was found to be heavily infested with ABHA and was treated at the request of the owner. The property was located on sandy soil and heavily vegetated with palm trees and other trees and shrubs. The property was treated with Campaign at the rate of 2.5kg/ha on 16 May 2006. Fifteen lure stations were placed randomly around the property. Five lure stations were placed immediately out-side the property acted as untreated controls. An inspection was carried out on 30 May 2006 by the local Lord Howe Island Board ranger and virtually no ants were detected. A formal assessment was carried out on 16 November 2006 using the 20 lure stations placed in the same locations as the pre-treatment assessment.

Trial 3: NSW, Cronulla

A suburban block of ca. 800m^2 at Cronulla (NSW) was found to be heavily infested with ABHA and was treated at the request of the owner. The property was located on sandy soil and heavily vegetated with cultivated shrubs and trees. Campaign was applied at 2.5kg/ha across the entire property on 16 April 2007. A pre-treatment assessment was carried out immediately prior to treatment using seven lure stations placed randomly around the property. Subsequently, ant abundance was evaluated on 25 April 2007 (9 days after treatment) and 25 May 2007 (39 days after treatment). Also, seven lure stations were placed in an adjacent park which was heavily infested and assessed at the same times. No other ant species were present at the lure stations.

Trial 4: NT, Darwin

During October 2007 several suburban properties in Darwin (Northern Territory) were identified with various levels of infestation of ABHA and the owners requested treatment. Properties were treated with various baits including Campaign and Amdro as part of an overall assessment of various registered and experimental bait products. Only single properties were treated with these two baits. No untreated control was available. These two sites contained a wide array of species other than the target species (Appendix 1).

RESULTS

Trial 1: Neds Beach, Lord Howe island

ABHA abundance was high in both the Amdro and Campaign plots and for each of the transects in each plot, approaching the maximum rating (5) on average which signifies > 100 ants at each lure station. Abundance in both plots declined over 9 weeks (Fig. 4) with 73% of lure stations in the Campaign treatment recording no ants and 55% of those in the Amdro treatment recording no ants. For both treatment plots, lure stations on the northern side of the track towards the cliff edge recorded very few ants (mean rating of < 0.2 for both treatments). Those on the southern side, adjoining infested properties, varied from no ants up to a rating of 4 (51-100 ants) (mean ratings of

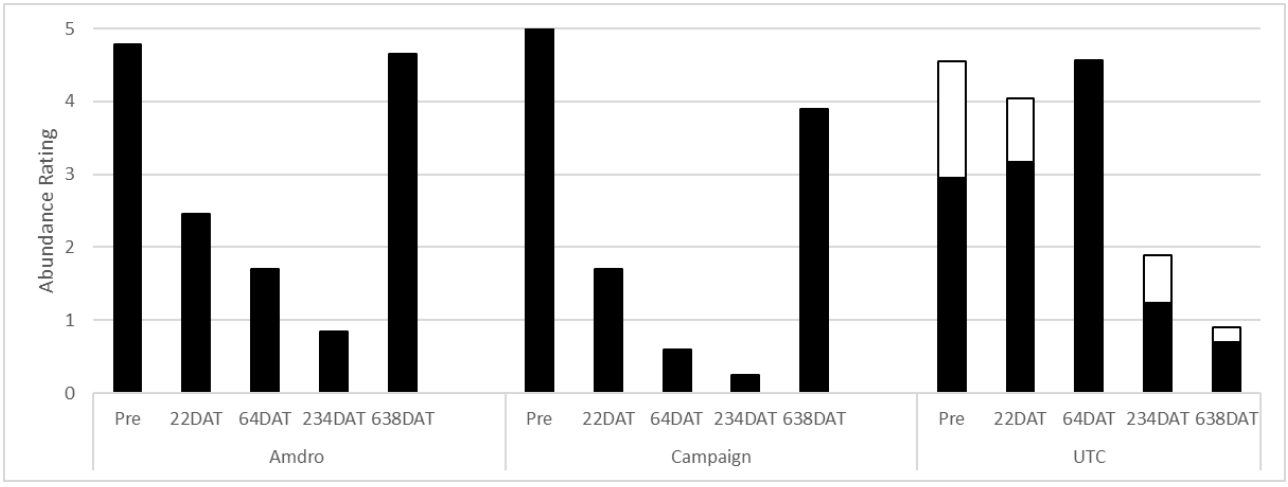

Figure 4: Abundance of ABHA and other species in treated and untreated plots over 91 weeks (1.75 years) at Ned's beach, Lord Howe Island. Columns are the means of two transects for the Amdro and Campaign plots and three transects for the untreated control. African bigheaded ant (black bars), Other species (white bars).

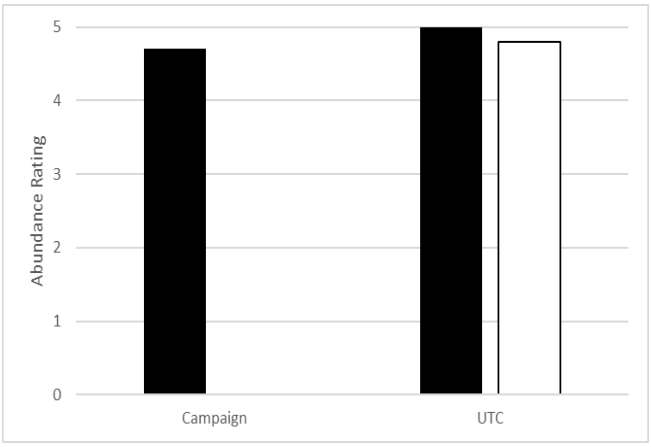

Figure 5: Abundance of ABHA on the Davis property on Lord Howe Island. Pre-treatment assessment (black bars), post-treatment assessment at 24 weeks (white bar).

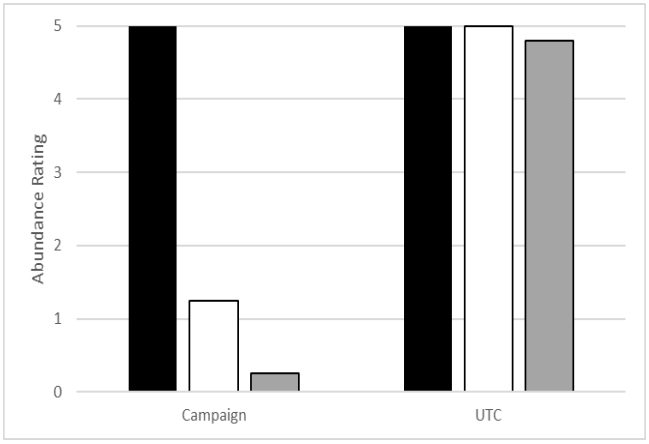

Figure 6: Abundance of ABHA on the Cronulla property and adjoining untreated park. Pre-treatment assessment (black bars), post-treatment assessments at 9DAT (white bars) and 39DAT (grey bars).

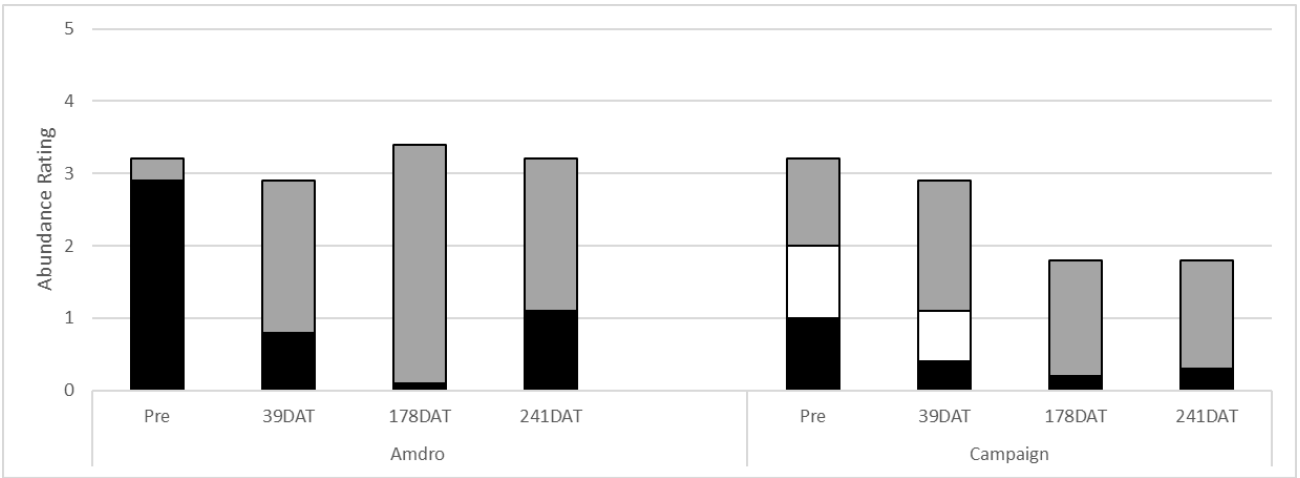

Figure 7: Abundance of ABHA and other species on the Darwin properties treated with Amdro and Campaign. ABHA (black bars), pale tyrant ant (white bars) and other species (grey bars).

1.55 and 0.4 for Amdro and Campaign treatments respectively). At the 33 week assessment (November 2006), ant abundance had declined further in both plots (below a rating of 1) with ants confined mostly to the southern side of the track. This was co-incident with a decline in abundance in the control transects (mean of 1.25). Thirteen months later (December 2007), ant abundance in treated blocks had recovered but not to the pre-existing levels – with average ratings of 3.7 and 4.1 in the Campaign and Amdro plots respectively. The abundance in the untreated transects continued to decline from the previous assessment.

Trial 2: Davis Property, Lord Howe Island.
At the time of treatment, the property was heavily infested with ABHA which were foraging in the yard and inside the house and were observed foraging up in the canopies of the palms. At the pre-treatment assessment, the average abundance ratings in the treated and untreated areas were high (mean of 4.8 and 5 respectively) (Fig. 5). The inspection two weeks after treatment indicated that few ants were active but no quantitative assessment was conducted. The formal assessment, 6 months later, found no ants active at lures in the treated area except for a few *Iridomyrmex* sp. individuals. Abundance of ABHA remained high at lure stations placed in the untreated area.

Trial 3: Cronulla property, Sydney
The abundance of ABHA declined rapidly at lure stations within the property over the period of the trial (Fig. 6). Conversely, there was little change in abundance on the lure stations in the untreated area.

Trial 4: Darwin properties, NT
A complex array of ant species was present at the two sites in Darwin, particularly the property treated with Campaign where 14 taxa were present at lures (Appendix 1). Only three species were present at lures in the property treated with Amdro – ABHA, *Tapinoma melanocephalum* (F.) and an unidentified species of *Monomorium.* ABHA was dominant at lure stations at the Amdro treated property but co-dominant with pale tyrant ant *Iridomyrmex pallidus* Forel at the Campaign-treated property. In both treated properties, the abundance of ABHA declined over 178 days (25 weeks) (Fig. 7). On the property treated with Campaign the abundance of pale tyrant ant also declined over that period indicating that both ABHA and pale tyrant ant were affected by the bait. Other species became more prevalent at lure stations replacing both ABHA and pale tyrant ant. Abundance of ABHA increased again at the 34 week assessment for the Amdro treated property.

DISCUSSION

This study brings together several smaller unreplicated trials where hydramethylnon-based baits were used to control ABHA. These trials all had different locations, ant species diversity, trial designs and therefore likely outcomes. Two trials were ad-hoc whole property treatments (Lord Howe Island and Cronulla) and two were structured as multi-treatment but unreplicated trials (Lord Howe Island and Darwin). None of these trials can stand alone as proof of efficacy of Campaign or Amdro against ABHA, but they all point to similar outcomes for hydramethylnon-based baits. The larger trial on Lord Howe island showed that ABHA abundance declined over 33 weeks for both Campaign and Amdro but rebounded over the thirteen months till the final assessment at 91 weeks after application. Recovery occurred faster close to the adjoining infested properties rather than the cliff edge and beach. It is inferred that re-invasion occurred from these adjoining properties and highlights the need to treat large areas to successfully suppress or eradicate ABHA.

The reason for the decline in abundance of ABHA in the three untreated transects is unclear. Such collapses of invasive ant populations for no obvious reason do occur but are often related to changes in food abundance, competition from other species, pathogens and low genetic diversity (Cooling *et al.* 2011, Cooling and Hoffmann 2015, Gruber et al. 2012, Haines and Haines 1978, Wetterer 2012). However, the decline in ABHA at Ned's Beach seemed to be confined to just the untreated area. One would expect this decline to be over a larger area, including the adjoining treated areas. ABHA was clearly not replaced by other species, as measured by lure stations at least, and no other hypothesis could be tested.

For the Darwin trial, the assessments were complicated by the presence of many other species. For the Campaign treatment, bait was harvested by both ABHA and pale tyrant ant (*Iridomyrmex pallidus*) and both declined in abundance over time. For the Amdro treatment, ABHA was the dominant species and the decline in abundance was more pronounced. An increase in abundance was observed at the 34 week assessment for the Amdro treatment. The two single properties (Lord Howe Island and Cronulla) treated with Campaign resulted in eradication or near-eradication of ABHA while remaining abundant in adjoining untreated areas. Both these trials were of short duration (24 and 5.5 weeks respectively) and it is not known if and how quickly these properties were re-infested from adjoining infested land.

Hoffmann successfully used Amdro to eradicate or control ABHA from locations in northern Australia (Hoffmann and O'Connor 2004, Hoffmann 2010, 2011). More recently and subsequent to the work here, ABHA was eradicated from Lord Howe Island (Hoffmann pers. comm.) and elsewhere (Plentovich et al. 2009) using Amdro®. These are small often isolated outbreaks where ABHA is the dominant species present and the entire

infested area was delineated and treated. Population reduction but not eradication is the more common outcome where ABHA is more widespread and only a portion of the infestations has been treated. Where eradication is too difficult, moderation of abundance is the desired outcome. Several studies in Hawaii and elsewhere in agricultural and environmental settings have attempted to reduce ABHA abundance and moderate their negative interactions with agricultural pests such pineapple mealybug (*Dysmicoccus* spp.) or reduce their direct impact on species of ecological significance (eg. nesting seabirds) (Gaigher et al. 2012, Peck et al. 2013, Plentovich et al. 2009, Reimer and Beardsley 1990, Taniguchi 2011, Zerhusen and Rashid 1992). This is typical of control attempts in urban and peri-urban areas, such as those treated during these studies where eradication is not the goal, is not achievable and re-invasion commonly occurs. The four small trials included here demonstrate that small infestations can be reduced or even eliminated temporarily. However, re-invasion from adjoining infested areas will ultimately result in a resurgence in abundance and require retreatment.

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Appendix 1: Other ants co-incident with ABHA identified from trial sites. TERC is Tropical Ecology Research Centre (CSIRO) at Berrimah, Northern Territory and references unidentified species in their collection.

Ant Taxa	Trial 1	Trial 2	Trial 3	Trial 4
Camponotus sp.				x
Iridomyrmex spp.		x	x	x
Iridomyrmex pallidus Forel				x
Meranoplus sp.				x
Monomorium sp.				x
Monomorium nr. *fieldi* Forel				x
Monomorium sp. *nigrium* Forel gp.	x			
Nylanderia sp. *obscura* (Mayr) gp.	x			
Nylanderia vaga (Santschi) sp. gp TERC sp. 4				x
Oecophylla smaragdina F.				x
Opisthopsis haddoni Emery				x
Paraparatrechina sp. *minutula* (Forel) gp.	x			
Pheidole longiceps Mayr sp. gp. TERC sp. 2				x
Plagiolepis nr. a*lluaudi* Emery				x
Rhytidoponera victoriae (Andre)	x			
Tapinoma melanocephalum (F.)	x			x
Trichomyrmex destructor (Jerdon)				x