Relative Attractiveness of Baits to *Paratrechina longicornis* (Hymenoptera: Formicidae)

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ABSTRACT Exotic ant incursions are becoming more frequent around the globe, and management with toxic baits is a suitable strategy for most species. Crazy ants, (Latreille) (Hymenoptera: Formicidae), however, are notoriously difficult to attract to commercial baits, which are generally tailored to the preferences of fire ants. We tested *P. longicornis* preferences for various food types and commercial ant baits. Baits trialed were commercially available products Amdro, Maxforce, Xstinguish (nontoxic monitoring version), Presto, and tuna (in spring water), sugar water (25%), boric acid (1% in 25% sugar water), and deionized water. Tuna and Xstinguish, along with sugar water and sugar water + boric acid, were the most attractive baits to *P. longicornis* foragers. The granular baits (Maxforce, Amdro, and Presto) were not as attractive to *P. longicornis* foragers. A decrease in temperature from summer (30°C) to autumn (23°C) trials did not seem to affect the food preferences of *P. longicornis*. Although *P. longicornis* recruitment was substantially lower during trials where there was concurrent high native ant abundance and diversity, *P. longicornis* still recruited to preferred baits in numbers higher than any other species. Given that tuna is impractical for management programs, the effectiveness of boric acid, sweet liquid baits in eliminating *P. longicornis* colonies should be compared with that of the toxic version of Xstinguish. If both are effective at eliminating colonies, we recommend sweet liquid baits containing boric acid be used for small-scale incursions (one or two nests), but a more practicable solid bait, such as Xstinguish, be used for larger scale incursions (numerous nests).

KEY WORDS *Paratrechina longicornis*, crazy ants, bait preference, ant management

Exotic ant invasions can be ecologically destructive and have major economic and social impacts (Holway et al. 2002). A frequent management strategy is to attract the ants to toxic baits, but bait acceptance is crucial to their success. Foraging ants must be attracted to the bait, must feed on the bait sufficiently, and must carry it back to the nest and share it with other members of the colony (Davis and van Schagen 1993, Klotz and Williams 1996, Collins and Callcott 1998, Lee 2000). Ant preferences for different food types (e.g., proteins, carbohydrates, and lipids), different-sized particles, and seasonal variation in these preferences will determine how appropriate toxic baits are for use against particular ant species.

Paratrechina longicornis (Latreille) (Hymenoptera: Formicidae) is notoriously difficult to control with bait (Hedges 1996a, 1996b; Lee 2002). Hedges (1996a) reported *P. longicornis* would not feed for long enough on commercial baits to ensure effective control. However, commercial ant baits are usually tailored to the preferences of red imported fire ant, (*Solenopsis invicta* Buren), and it is likely that oil-based baits are not preferred by *P. longicornis*, given observations by other researchers (see below) and the preferences of other *Paratrechina* species (Stanley 2004). There is little research on the food and bait preferences of *P. longicornis*, although indoor surveys in Malaysian residential areas found honey (80% of workers) was strongly preferred by *P. longicornis* over peanut butter (20% workers) (Lee 2002). Lee and Tan (2004) reported that baiting is seldom effective, particularly with paste and granular commercial formulations, against *P. longicornis* in Singapore and Malaysia and recommended sugar-based, liquid, or gel formulations for control of *P. longicornis* (Lee 2002). Tuna (in oil) baits used in Biosphere 2 (in which *P. longicornis* was the dominant ant) were consistently more attractive to *P. longicornis* than the pecan cookie baits (primarily carbohydrate) put out at the same time (Wetterer et al. 1999; J. Wetterer, personal communication). Observations during incursions in New Zealand have revealed that *P. longicornis* prefer sweet baits over protein baits but that they recruit well to the protein-based Xstinguish bait (T. Ashcroft, personal communication). Other species of *Paratrechina* have been observed to recruit well to protein and sugar water baits, but they largely ignore Maxforce and Amdro granules (Harris et al. 2002, Krushelnycky and Lester 2003). However, no formal testing of bait attractiveness has been carried out for *P. longicornis.*

This research trialed the relative attractiveness of various food types and baits to *P. longicornis,* with the

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Table 1. Baits used in trials for relative attractiveness of food types to *P. longicornis*

Bait	Primary nutrient class of bait matrix	Bait formulation	Quantity (g)	Manufacturer
Amdro (+0.73% hydramethylnon)	Lipid	Granules	5	Ambrands (BASF Corporation), Australia
Boric acid + sugar water (1% boric acid)	Carbohydrate	Liquid	3	
Deionized water (no toxin)	Water	Liquid	3	
Maxforce (+1% hydramethylnon)	Protein	Granules	5	Bayer Environmental Science, USA
Presto (+0.01% fipronil)	Protein	Granules	5	BASF Australia, Australia
Sugar water (25% sucrose) (no toxin)	Carbohydrate	Liquid	3	
Tuna (no toxin)	Protein	Solid	5	South Australian Fisheries Company Limited (SAFCOL)
Xstinguish (nontoxic version)	Protein and carbohydrate	Paste	5	Bait Technology Ltd., New Zealand

Liquid baits were a standard of three grams equating to one soaked cotton dental swab (38 by 10 mm). In trials 1, 3, 4, and 5 tuna was used instead of Presto (fish meal matrix) due to the unavailability of this product. Boric acid is analytical reagent boric acid (99.5%). For more information on product details, see Stanley (2004). Formulations of commercially available baits are not accessible due to commercial sensitivity.

ultimate aim of determining its food preferences and the appropriateness of various commercial ant baits for *P. longicornis* management. The attractiveness of seven bait types to *P. longicornis* was tested in summer and autumn field trials in southeastern Queensland, Australia. Recruitment of *P. longicornis* workers to the baits in the presence of other ant species also was investigated.

Materials and Methods

The research was undertaken at Kingfisher Bay Resort and Village (KBRV), Fraser Island, Queensland, Australia. Fraser Island is a vegetation-covered sand island located ≈290 km north of Brisbane (27° 37′ 27 S, 153° 05′ 32 E). Kingfisher Bay is on the western side of the Fraser Island, 15 km east of Hervey Bay on mainland Australia. KBRV is a minimal-impact ecoresort set within native vegetation (canopy trees are primarily native pines and eucalypts). The climate is subtropical.

The boundaries of the *P. longicornis* infestation at KBRV were identified in the first weeks of March 2005 by using observations (aggression assays) and honey baits. There is only one large supercolony spread over several hectares and included areas of high *P. longicornis* numerical dominance (low abundance of other ant species) as well as areas where high numbers of *P. longicornis* frequently co-occurred with native ants. Site 1 was identified as an area where complete numerical dominance of *P. longicornis* was expected and was used for a summer and an autumn trial. Site 2 was a site where *P. longicornis* co-occurred with native ants and was used in an autumn trial. Site 2 was ≈50 m down a heavily vegetated incline from site 1, but it offered completely different environment. Although site 2 was completely shaded with trees up to 30 m in height, site 1 had few tall trees, much drier leaf litter and provided only partial shade.

Overall, five separate trials were performed. Trials 1 (summer) and 2 (autumn) tested the attractiveness of the baits to *P. longicornis* at a site where *P. longicornis* was dominant (site 1). Trials 3 and 4 were performed in autumn, but 3 wk apart, and they investigated how bait attractiveness and recruitment of *P. longicornis* might differ at a site where there were a variety of behaviorally dominant native ant species present (site 2). Trial 4 investigated whether *P. longicornis* might avoid interacting with native ant species by foraging at night. Because few ants (of all species) foraged on baits at night in trial 4, a smaller trial (trial 5) was carried out the next day to investigate whether low numbers were a result of the time of day effect or whether ant density in the area had decreased in the 3 wk since trial 3.

Baits trialed were the commercially available products Amdro, Maxforce, Xstinguish (nontoxic monitoring version), and Presto as well as tuna (in spring water), sugar water (25% sucrose), boric acid (1% in 25% sugar [sucrose] water), and deionized water (Table 1). This ensured all major food types (e.g., proteins, carbohydrates, and lipids) were available. Seven baits were used in each trial, and tuna was used when Presto was unavailable (trials 1, 3, 4, and 5) to ensure a fish-based bait type was included in the trials.

Daytime trials were timed to coincide with afternoon peak foraging activities (W.A.R., unpublished data), and ambient temperatures were recorded during each sampling round. During each trial, replicate bait stations (trials 1, 3, and 4, $n = 32$; trial 2, $n = 31$; and trial 5, $n = 11$) were positioned at least 10 m apart within the trial site. At each bait station, each of the bait types were placed on one of seven white petri dishes positioned in random order in a circular or oval pattern with at least 30 cm between dishes. The position order of baits at each station was determined using the PLAN procedure in SAS (SAS Institute 1992). Recruitment (number of workers in petri dish) to each of the seven baits was recorded at each bait station at least three times (three sampling rounds). Four sets of observations for each bait station (four sampling rounds) were made during trials 1, 3, and 5. Each sampling round took ≈30 min, although the night trial (trial 4) took longer to complete and was reduced to three sampling rounds. A storm also reduced the number of sampling rounds completed for trials 2 to three sampling rounds.

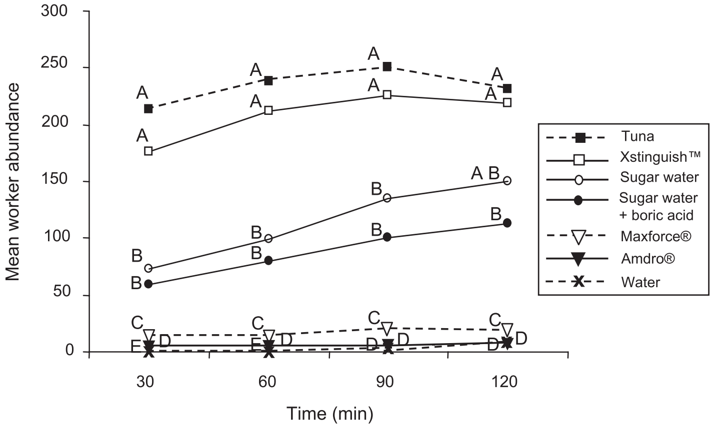

Fig. 1. Mean abundance of *P. longicornis* workers on baits during bait preference trial 1: summer, *P. longicornis* numerically dominant ($n = 32$ bait stations). Standard errors omitted to retain clarity. Means with the same letter at each time are not significantly different according to Tukey's honestly significant difference multiple comparisons procedure.

Recruitment was recorded by estimating the number of ants on each bait. During trial 1, a digital image was taken of the petri dish for each bait type at every fifth bait station. The digital images were enlarged, and the actual abundance of ants on each bait was determined. A regression analysis of actual versus estimated numbers was performed, and the slope of the line used to correct the estimated abundance before analysis. For trials 2, 3, 4 and 5, counts were calibrated in situ against a standard score sheet that contained a range of the digital images and counts from the first trial. The same observer (W.A.R.) made all abundance estimates across all trials. When ant species other than *P. longicornis* was present on a bait, and the species could not be identified in situ (by W.A.R.), workers were collected and identified using the Fraser Island Voucher collection held in the University of the Sunshine Coast invertebrate bioassessment program.

Using relative abundance of *P. longicornis* as an indication of preference, the Cochran–Mantel–Haenzel (C-M-H) statistic was used to test for concordance in the order of preference of bait type across the replicate bait stations. The C-M-H test is not influenced by large numbers and uses rank order within each bait station; hence, it automatically partitions differences between bait stations. A repeated measures analysis of variance (ANOVA) (bait stations treated as blocks) was used to determine whether abundance changed across time, across baits, and whether there was an interaction of time × bait. Significant effects were determined using Tukey's multiple comparisons procedure. Ant abundance was transformed using $Y' = \log 10(Y + 1)$ to reduce the effects of skewness in abundance. Furthermore, because of the potential for lack of sphericity in the repeated measures (because abundance can be high on some baits and expected to vary through time), the effect of time and the interaction effect was adjusted using Greenhouse–Geisser correction.

Results

Trial 1: Summer, *P. longicornis* Numerically Dominant. At site 1 where *P. longicornis* dominates the ant community, *P. longicornis* foragers were present at all bait stations. With the exception of two Amdro baits and one water bait, *P. longicornis* foragers were observed on all baited petri dishes ($n = 224$) at least once during the 2-h period. Concordance between bait preferences was extremely high and consistent across the different sampling rounds ($\chi^2 = 169.8$, df = 6, $P < 0.0001$).

There was a significant difference in the number of *P. longicornis* foragers across the four observation times ($F = 30.99$; df = 3, 558; $P < 0.0001$) and across the seven bait types ($F = 471.2$; df = 6, 186; $P < 0.0001$), and the two effects were not independent ($F_{\text{time} \times \text{bait}} = 2.26$; df = 18, 558; $P < 0.005$). The posthoc analyses found consistent trends in preference across time (Fig. 1). There was high forager recruitment to both the Xstinguish and tuna baits, and these baits were preferred over the sugar water baits (sugar water and sugar water + boric acid) through the first three sampling rounds; however, sugar water was not statistically different to the Xstinguish and tuna baits by the last sampling round (Fig. 1). Although Maxforce had slightly higher worker abundance than Amdro, the granular baits along with the water had very low, almost nil, forager recruitment (Fig. 1). Increases in forager recruitment to the sugar water baits were maintained throughout the trial, but recruitment leveled off or decreased at the tuna and Xstinguish baits (Fig. 1), possibly because workers could remove large chunks of these baits from the petri dishes.

Trial 2: Autumn, *P. longicornis* Numerically Dominant. Temperatures averaged 23°C during this trial, compared with 28–31°C during trial 1 in summer. *P. longicornis* foragers were present at 181 of 217 baited petri dishes ($n = 31$ bait stations), but they were not observed at all on 45% of the water baits, and 32, 29,

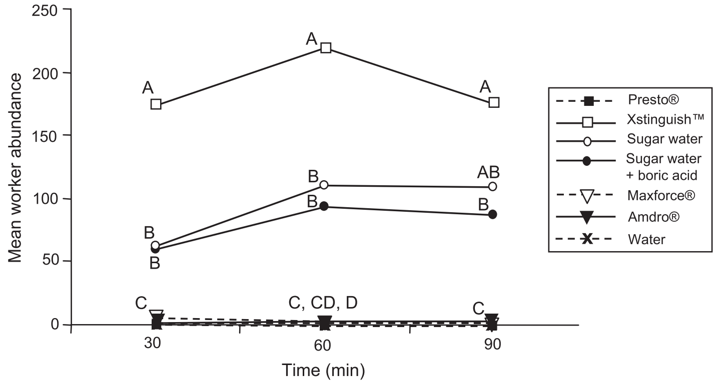

Fig. 2. Mean abundance of *P. longicornis* workers on baits during bait preference trial 2 (n = 31 bait stations). Standard errors omitted to retain clarity. Means with the same letter at each time are not significantly different according to Tukey's honestly significant difference multiple comparisons procedure.

and 23% of the Presto, Amdro, and Maxforce baits, respectively. *P. longicornis* foragers were present on all but one of the other three baits (Xstinguish, sugar water, sugar water + boric acid). There was strong concordance among bait preferences, which was consistent across the different sampling rounds (χ^2 = 155.8, df = 6, $P < 0.0001$). There was a significant difference in the number of *P. longicornis* foragers across the three observation times (F = 10.16; df = 2, 360; $P < 0.0001$) and across the seven bait types (F = 453.3; df = 6, 180; $P < 0.0001$), and the two effects were not independent ($F_{\text{time} \times \text{bait}}$ = 4.86; df = 12, 360; $P <$ 0.0001). Posthoc analyses found consistent trends in preference across time (Fig. 2); Xstinguish attracted more foragers than any other bait, whereas sugar water and sugar water + boric acid were also more attractive to foragers than the granular baits and water (Fig. 2). Presto was no more attractive to foragers than deionized water (Fig. 2). Overall, forager abundance was comparable with that in trial 1, even though trial 2 did not go the full four sampling rounds. Hence, the change in season (this trial being 6 wk later in the season than trial 1 and ambient temperature ≈6°C lower) did not seem to affect the numbers of active foragers.

Trial 3: Autumn, *P. longicornis* Co-Occurs with High Abundance of Native Ant Species. The Xstinguish used in the first 24 bait stations during trial 3 had been left over from a previous trial, and although sealed, the product was probably stale (evidenced by the attendance of flies for at least the first eight of those stations). After the first count (40 min), fresh bait was applied at these 24 stations. The statistical analyses presented here are therefore from the final eight stations only. Each sampling round in this trial took ≈40 min (rather than the usual 30 min) because of the time taken to collect other ant species feeding on the baits. *P. longicornis* was the most common of the 19 ant species that visited the baits, and it was observed visiting between 10 and 29 of the 32 petri dishes for each bait type.

The concordance among bait preferences by *P. longicornis* was again high across all sampling rounds (χ^2 = 17.9, df = 6, $P < 0.01$). *P. longicornis* decreased in abundance on tuna baits but increased on boric acid, sugar water, and Xstinguish during the four sampling rounds (Fig. 3).

There was no significant difference in the number of *P. longicornis* foragers across the four observation times (F = 2.53; df = 3, 102; P = 0.1), but there was

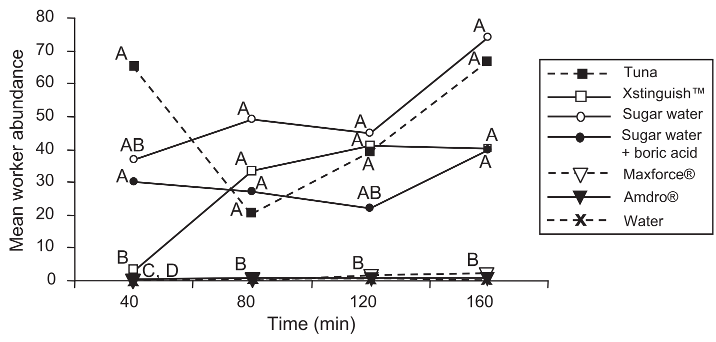

Fig. 3. Mean abundance of *P. longicornis* workers on baits during bait preference trial 3 (n = 8 bait stations). Standard errors omitted to retain clarity. Means with the same letter at each time are not significantly different according to Tukey's honestly significant difference multiple comparisons procedure.

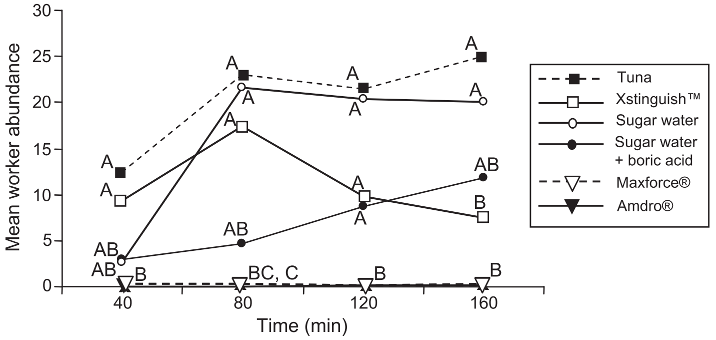

Fig. 4. Mean abundance of *P. longicornis* workers on baits during bait preference trial 5 (n = 11 bait stations). Standard errors omitted to retain clarity. Means with the same letter at each time are not significantly different according to Tukey's honestly significant difference multiple comparisons procedure.

a difference across the seven bait types (F = 16.4; df = 6, 34; P < 0.0001), and there was no interaction ($F_{\text{time} \times \text{bait}}$ = 1.03; df = 18, 102; P = 0.43). The posthoc analyses found that the granular baits were not preferred by *P. longicornis* foragers, but numbers were not as high on Xstinguish as in the previous two trials relative to the sugar or tuna baits (Fig. 3). On the sugar water, sugar water + boric acid, and tuna baits, *P. longicornis* was the most abundant ant, averaging 60–80% of all individuals. *P. longicornis* made up ≈40% of all ants recorded on Xstinguish but <10% on Amdro and Maxforce. The number of records (presence/absence) of *P. longicornis* relative to all other ant species was in similar proportions to the abundance.

Trial 4: Late Autumn Night Trial, *P. longicornis* Co-Occurred with Low Abundance of Native Ant Species. Ant abundance during the night trial (trial 4) was considerably lower than in trials 1–3. Temperatures averaged 17–19°C during this trial, compared with 21–24°C during the diurnal autumn trials at the same site. *Crematogaster cornigera* Forel, *Aphaenogaster longiceps* (Smith), and *P. longicornis* were the most common species; each of these species was observed on 30 different baits during the trial. Several species including the native *Paratrechina vaga* (Forel), *Tapinoma* sp., and a third native, *Pheidole* sp., were not recorded during the day trial in the same location. *Pheidole megacephala* (F.) was noticeably absent during the night trial apart from its presence on one Maxforce bait.

P. longicornis foragers also were recorded in low numbers; not enough foragers were present to find significant bait preferences. During this trial they occurred at only 17 of the bait stations and only on 30 different baits. During the first sampling round, there was an average of 6.6 *P. longicornis* foragers on 16 baits; during the second sampling round, an average of 7.7 foragers on 19 baits; and during the final sampling round, an average of 10 foragers on 20 baits. The few foragers that were present were almost absent from the water, Maxforce, and Amdro baits, which is consistent with the earlier trials, but they were also low in numbers on tuna in this trial. When considering all ants from all species, there was significant concordance in preferences (χ^2 = 46.4, df = 6, P < 0.0001). Xstinguish was the most attractive bait and water the least attractive across all species.

Trial 5: Late Autumn Trial, *P. longicornis* Co-Occurred with Low Abundance of Native Ant Species. Because ant abundance was so low during the night trial (trial 4), we set out 11 bait stations at the same site the next day to see whether ant abundance during the day was comparable with the previous trial conducted there (trial 3). The air temperature was 24°C throughout this trial, the same as experienced throughout trial 3 (3 wk earlier). However, the numbers of *P. longicornis* foraging during trial 5 were about half those observed during trial 3 (Fig. 4). Two Xstinguish and two tuna baits were consumed by a lace monitor, *Varanus varius,* between the second and third counts of this trial, and the numbers for these baits were affected; hence, counts 3 and 4 from all baits on these bait stations were removed from the analysis. Concordance among bait preferences was again very strong for *P. longicornis* (χ^2 = 36.5, df = 6, P < 0.0001).

There was a significant difference in the number of *P. longicornis* foragers across the four observation times (F = 6.01; df = 3, 180; P < 0.005) and across the seven bait types (F = 17.1; df = 6, 60; P < 0.0001), and the two effects were not independent ($F_{\text{time} \times \text{bait}}$ = 2.45; df = 18, 180; P < 0.0001). The posthoc analyses found consistent trends in preference with tuna, Xstinguish, sugar water, and sugar water + boric acid preferred by *P. longicornis* throughout the 2-h trial (Fig. 4).

Discussion

Bait Attractiveness. Of the seven baits available, tuna and Xstinguish were the most preferred by *P. longicornis* foragers, followed by sugar water and sugar water + boric acid. Wetterer et al. (1999) also found that tuna (in oil) was consistently highly attractive to *P. longicornis* during surveys in Biosphere 2, and Lee (2002) recommends sugar-based, liquid or gel formulations for control of *P. longicornis.* The granular baits (Maxforce, Amdro, and Presto) were not successful at all in attracting *P. longicornis* foragers, particularly in the trials where *P. longicornis* was the dominant ant species (trials 1 and 2). Although small numbers (<1% of active *P. longicornis* foragers) were observed on the granular baits in the trials where other ant species were present (trials 3–5), it is likely that recruitment was not sufficient to ensure adequate bait uptake and spread through the colony, and no granules were observed being removed by *P. longicornis* foragers. Lee and Tan (2004) report that baiting with paste and granular commercial baits is seldom effective against *P. longicornis* in Singapore and Malaysia. High moisture content of baits is likely to be a key factor in the attractiveness of baits to *P. longicornis,* as with Argentine ant, *Linepithema humile* (Mayr), which is highly attracted to the moist matrix of Xstinguish (Klotz et al. 1996, Harris et al. 2002; R. Harris, unpublished data).

Other species of *Paratrechina* recruit well to Xstinguish bait. The two undescribed Australian species of *Paratrechina* present in New Zealand have been observed foraging on the nontoxic version of Xstinguish (Harris et al. 2002). Bait attractiveness trials on Palmyra Atoll showed *Paratrechina bourbonica* (Forel) had a preference for sugar water followed by Xstinguish (Krushelnycky and Lester 2003). *P. bourbonica* also largely ignored Maxforce and Amdro granules in the same study (Krushelnycky and Lester 2003).

Temporal Factors Affecting Recruitment. Repeating the summer bait attractiveness trial (no native ant species co-occurrence), 6 wk later in autumn, did not seem to affect either the abundance of *P. longicornis* foragers at the baits, or the relative attractiveness of specific baits. The temperature did decrease from ≈30°C during the summer trial to ≈23°C during the autumn trial.

There was a reduction in *P. longicornis* foraging activity during the night trial (trial 4). However, because *P. longicornis* has been observed foraging in large numbers throughout 24-h periods during summer at both these sites (W.A.R., unpublished data), it is most likely that the reduction in foragers during this night trial was due to reduced reproduction in the colony during late autumn, rather than reduced foraging at night. This was confirmed by reduced foraging activity during trial 5 (the next day), a late autumn repetition of the trial 3 diurnal trial.

Effects of Co-Occurrence with Other Ant Species on Bait Attractiveness. In regions where the native ant fauna is depauperate and cryptic, native ant species would not be expected to exclude *P. longicornis.* Although *P. longicornis* recruitment was substantially lower during trials where there was high native ant abundance and diversity (trials 3–5), there was still reasonable recruitment to preferred baits (≈50 foragers at each bait after 160 min).

Xstinguish was attractive to ant species other than *P. longicornis.* In areas where there are numerous conspicuous and highly abundant native ant species, the use of a toxic version of Xstinguish could have nontarget impacts. However, commercial baits, such as Amdro and Maxforce, proved to be similarly attractive to native ant species. Nontarget impacts of toxic Xstinguish bait used in management operations also would need to be quantified for reptiles and other animals, which were attracted to the bait.

The influence of competitive exclusion on the management of *P. longicornis* incursions through the use of toxic baits will depend on the set of ant species present at the incursion site and their relative competitive abilities. *P. longicornis* is an aggressive, competitive species that can recruit large numbers of workers rapidly to food resources (Clark et al. 1982, Lee 2002, Lester and Tavite 2004). In Tokelau, Lester and Tavite (2004) found that *P. longicornis* competitively excluded other ant species, including *Tetramorium bicarinatum* (Nylander) and *Pheidole oceanica* Mayr, from foraging on tuna baits. However, *P. longicornis* can be displaced when more highly aggressive species, such as *S. invicta,* recruit to the resource (Banks and Williams 1989).

Application of Bait Preferences Trials to Effective Management of *P. longicornis* Incursions. Xstinguish, tuna and sugar water (and sugar water + boric acid) were all highly preferred by *P. longicornis.* Although tuna is attractive and may indicate a preference for protein, it is not practical for use as a control tool in terms of toxin incorporation and bait delivery. It is also highly attractive to nontarget animals, including birds and reptiles. Sugar water is generally a highly preferred food item to ants, but it is also a broad-spectrum attractant. Care is required in situations where potential nontarget species, such as honey bees, *Apis mellifera* L., are present. Bait delivery in liquid form is more difficult than solid bait delivery, and it requires containerization, but it can be used efficiently during small-scale incursion events (one or two nests). Xstinguish combines both a protein and carbohydrate (sugar) attractant (Stanley 2004) and was consistently more attractive to *P. longicornis* than the sugar water. The attractiveness of Xstinguish to *P. longicornis* workers in this study confirms observations made during incursions in New Zealand (T. Ashcroft, personal communication). Because Xstinguish is produced as a commercial ant bait, and it can be applied without the need of bait stations or containers, it could be readily used in both small and large-scale incursions.

Post hoc analyses indicate that the presence of a toxin in the sugar water (sugar water + 1% boric acid) did not deter *P. longicornis* foragers in these trials. However, although never statistically significantly different within a trial and a time, the sugar water with boric acid was always slightly less preferred than sugar water alone. Nevertheless, there was always large numbers of foragers present on sugar baits containing the boric acid. Exterm-An-Ant (8% boric acid + 5.6% sodium borate in a sweet solution) has been used to successfully attract large numbers of *P. longicornis* foragers in previous incursions at New Zealand ports (V. Van Dyk, personal communication), even though research indicates that concentrations of borates >1% are repellent to some ant species (Klotz and Williams 1996, Hooper-Bui and Rust 2000). It is possible that the highly attractive nature of the Exterm-An-Ant matrix overrides the repellent nature of boric acid.

The effectiveness of boric acid-based baits in killing *P. longicornis* colonies has not been tested. Although observations during New Zealand incursions suggest that Exterm-An-Ant is effective at controlling *P. longicornis* (V. Van Dyk, personal communication), baits with high concentrations of boric acid (>1%) have been shown to kill ants too rapidly and prevent recruitment (Klotz and Williams 1996, Hooper-Bui and Rust 2000). Baits with low concentrations of boric acid (≤1%) are extremely effective at killing laboratory colonies of *Monomorium pharaonis* (L.), *Tapinoma melanocephalum* (F.), *S. invicta*, and *L. humile* (Klotz and Williams 1996, Klotz et al. 1997, Ulloa-Chacon and Jaramillo 2003). Given the attractiveness of sugar water + 1% boric acid baits to *P. longicornis* in this study, the effectiveness of this bait in eliminating *P. longicornis* colonies requires testing.

Because of lack of registration in Australia, the Xstinguish used in these trials was the nontoxic form of the bait. Although the nontoxic form of Xstinguish was highly attractive to *P. longicornis* foragers relative to the toxic baits Amdro and Maxforce, it is possible that the toxic version of Xstinguish may repel *P. longicornis.* However, in numerous small- and large-scale trials, no difference in the recruitment of Argentine ants has been observed between the toxic and nontoxic versions of the Xstinguish baits (Harris 2002; Harris et al. 2002; V. Van Dyk, personal communication). Furthermore, *P. longicornis* workers have been observed to recruit well to the toxic version of Xstinguish bait during incursion events in New Zealand; no evidence of repellency has been observed (T. Ashcroft, personal communication). Hedges (1996a) reported *P. longicornis* would not feed for long enough on commercial baits to ensure effective control. However, there was no evidence during this study that foraging on preferred baits noticeably declined over the 2–3-h trials. The effectiveness of Xstinguish in eliminating *P. longicornis* colonies remains to be tested. The relative effectiveness of Xstinguish compared with boric acid, sweet liquid baits also remains untested. Given the attractiveness of Xstinguish to *P. longicornis* in this study and the effectiveness of Xstinguish at controlling Argentine ants (Harris et al. 2002) and other ant species (V. Van Dyk, personal communication), we predict high levels of control would be achieved should efficacy trials be undertaken.

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