

# Do isolated trees encourage arboreal ant foraging at ground-level? Quantification of ant activity and the influence of season, in Veracruz, Mexico

Aaron D. Gove\*, Jonathan D. Majer

*Department of Environmental Biology, Curtin University of Technology, P.O. Box U 1987, Perth, WA 6845, Australia*

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## Abstract

Removal rates of dead fruit flies were used in a tropical dry grassland of Veracruz, Mexico to indicate whether foraging by ants would be higher under isolated trees than in open grassland, and if foraging rates would differ seasonally. It was hypothesised that foraging rates would be higher under trees during the dry season, when arboreal food resources were minimal, and when arboreal ants were inclined to forage at ground-level. However, arboreal ant species were more abundant in pitfall traps beneath isolated trees during the wet season months of May and July and they never made up more than 3% of ants sampled at ground-level. Neither the presence of trees nor the dry season increased bait removal rate; removal rate on the ground was significantly higher in the wet season and did not vary with habitat type. Canopy predation by ants decreased in the dry season, suggesting that the arboreal species' response to the dry season was to reduce activity levels overall, rather than to compensate with increased foraging on the ground. Because of the lack of arboreal ant activity at ground-level, and the high baseline level of ground ant activity in open habitats, isolated trees may have only a limited role in increasing biological control by ants in ground-level crops, such as pasture.

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## 1. Introduction

Isolated trees are often left after clearing in order to provide shade for stock and crops and to provide resources such as building materials and firewood. These trees increase landscape heterogeneity and thereby can increase the conservation of insect species diversity in simplified landscapes (Majer and Delabie, 1999; Dunn, 2000; Gove et al., 2005; Reyes-Lopez et al., 2003). It has been suggested that these trees could act as a source of predatory ants, which may act as important agents in the biological control of agricultural pests (Majer and Delabie, 1999; Dunn, 2000).

Ants have been successfully employed as biological control agents in a broad variety of settings (reviewed in

Way and Khoo, 1992; Perfecto and Castiñeiras, 1998). Carroll and Risch (1990) suggested that ants are valuable biological control agents because: they are common and abundant, and therefore, do not need special introduction; their recruiting behaviour makes them density-responsive and hence capable of responding efficiently to pest outbreaks; their population size is held relatively constant due to their ability to cannibalise brood; ant colonies are capable of storing food and are therefore able to forage consistently over time, whether or not food is immediately required.

The role of isolated trees in maintaining natural enemies has not been studied, but other non-crop vegetation, such as hedgerows and non-tilled field-margins, are recognised as effective means of conserving natural enemies of crop pests (e.g., Thomas et al., 1991; Lagerlöf and Wallin, 1993; Nentwig et al., 1998; Sutherland et al., 2001; reviewed in Landis et al., 2000).

\* Corresponding author. Tel.: +61 8 9266 7041; fax: +61 8 9266 2495.  
E-mail address: [a.gove@curtin.edu.au](mailto:a.gove@curtin.edu.au) (A.D. Gove).

In tropical environments, trees offer the only means of introducing some of the most active and aggressive ant species, such as *Azteca* and *Crematogaster* species, to agricultural landscapes (Van Mele and van Lenteren, 2002; Vandermeer et al., 2002; Peng et al., 2004; Philpott and Foster, 2005). These ants will be of most use in biological control if they forage outside of their nest-trees and within the crops. This movement may exhibit a seasonal component and would be predicted to be most pronounced when resources within such trees are relatively low. For example, Hahn and Wheeler (2002) found that arboreal ants extended their foraging range to lower tree trunks during the dry season. Levings (1983), Byrne (1994) and Delabie et al. (2000) also suggest that arboreal ant species forage at ground-level during the dry season or when canopy conditions are otherwise unfavourable. Provision of biological control may therefore have a seasonal component, with greatest benefit occurring during the dry season. Seasonal shifts towards ground-level foraging may be more pronounced in isolated trees, as lack of an interconnected canopy inhibits foraging within alternative sections of the canopy. The seasonal tropics, in which trees may be deciduous, serves as a good location in which to examine whether such patterns exist.

The objective of this study is to evaluate the influence of isolated trees on insect predation rates in a tropical dry grassland. The objective is developed by answering three specific questions: (1) Could isolated trees play a beneficial role by favouring the presence of aggressive and predatory ants? (2) Are insect removal rates higher under isolated trees than in open grassland? (3) Is removal rate influenced by season, and is it higher during the dry season when arboreal food resources are minimal?

## 2. Materials and methods

The study took place in stabilised dune grassland within the Centro de Investigaciones Costeras La Mancha, Veracruz, La Mancha (19°35'N, 96°23'W). The climate was warm sub-humid, with a rainy season occurring from June to September. Average annual precipitation was approximately 1200 mm and mean monthly temperature ranges from 20.3 to 26.7 °C, with the cooler months corresponding with the dry season (K. Mehlreter, unpublished data).

Within the study site, three smaller habitat types were distinguished and within each of these, 12 replicates were selected.

**Grassland.** The grassland was dominated by the grasses *Schizachyrium scoparium* and *Trachypogon gouninii* and covered an area 300 m × 2000 m.

**Isolated tree.** The studied focal tree species, *Diphysa robinoides*, occurred frequently as an isolated tree dispersed throughout the grassland described above. Mean distance between these trees was 20.6 m (10–35 m range), while their

average height was 4.7 m (3–6.25 m range). This tree is a deciduous species which loses all leaf-cover during the dry season.

**Matorral.** Within sections of the grassland described above, patches of scrubland were also interspersed. The shrub layer was dominated by *Randia aculeata*, *Opuntia stricta*, *Acacia farnesiana*, *Chrisobalanus icaco* and *Attalea butyracea*. The canopy was generally 5–10 m high, and dominated by *D. robinoides*, *Enterolobium cyclocarpum*, *Bumelia celastrina* and *Piscidia piscipula*. Nine separate matorral patches were examined (mean area 0.62 ha, range 0.13–1.74 ha).

Composition of ants in pitfall traps set beneath the trees and surrounding open grassland was examined. Pitfall traps consisted of disposable plastic drinking cups (70 mm diameter), approximately half-filled with ethylene glycol, and set flush with the ground surface. Pitfall traps were left open for 96 h. Isolated tree traps were placed 1 m to the north and south of each tree trunk. The surrounding open grassland was sampled with a similar configuration, with the pair of traps, separated by 2 m, beginning 5 m to the north of the drip line of the nearest sampled tree. Trees had an average radius of 3.4 m, meaning that the open grassland traps were on average, 8.4 m from the tree trunk. The ant assemblage this far from isolated trees has been shown to be significantly different to that of the assemblage beneath the tree (Gove et al., 2005) and is therefore considered a separate treatment. Sampling occurred bi-monthly for 1 year (September 2000–May 2001), and only species which were considered to be arboreal are considered here. Species were defined as arboreal on the basis of observed nesting sites within trees.

Locally captured fruit flies (*Drosophila* sp.), killed by freezing, were used as bait to compare ground-level predation associated with isolated trees with predation rates occurring within the open grassland and matorral patches. Five flies were placed on a leaf, at ground-level, 1.25 m north of each of 12 isolated *D. robinoides* individual trees. Depots of five fruit fly baits were also placed at each of 12 open grassland sites, 6.25 m to the north of the drip-line of each isolated tree. Baits were placed under matorral trees following the same configuration as that used under isolated trees. Baits were counted and recorded 5, 10, 15, 30, 60, 120 and 180 min after their initial placement at depots. The main predation event was considered to have occurred when all five baits had been removed. Ground-level bait trials were performed throughout the day (800–1700 h), and a replicate for each of the three habitat treatments was run concurrently.

Bait removal trials were repeated three times: February 2001 (dry season, complete lack of canopy cover), May 2001 (early wet season, new plant growth), and July 2001 (wet season, complete canopy cover).

Predation rates within the tree canopy of isolated trees were also compared between seasons. The same 12 isolated *D. robinoides* trees used in the study of ground-level predation were employed. Four individual fruit fly

individuals were glued as lightly as possible to stems, approximately 2 m above ground-level at approximately equal distance around the circumference of the tree. Baits remaining were counted and recorded after 1, 3, 6 and 24 h. A predation event was considered to have occurred when all four fruit flies had been removed. The experiment was carried out in March 2001 (dry season, complete leaf-loss) and July 2001 (wet season, full canopy cover).

The effect of habitat type and month on numbers of arboreal ant individuals in ground-level pitfall traps was tested using a generalised linear model with a Poisson error term and a log link function.

Persistence of fruit fly baits under the different treatments was compared using a Cox proportional hazards model (Fox, 2001; Muenchow, 1986), which is a particular form of failure-time or survival analysis. In the study of ground-level predation, the “failure event” for each aggregation was the time at which all five baits had been removed. Covariates considered were habitat type, month, and the habitat–month interaction term. Significant variables were selected using a forward stepwise procedure (entry,  $P \leq 0.05$ ; removal,  $P \geq 0.10$ ), with the contribution of variables to the model being tested using the likelihood ratio.

A similar model was used to test whether season had a significant effect on bait removal rate in the tree canopy. In this case, the failure event was the time until removal of the four fruit flies in a single tree.

### 3. Results

Numbers of arboreal ant individuals in pitfall traps were quite low; mean numbers of individuals in open grassland, isolated trees and matorral were respectively 0.17, 2.24 and 1.57 individuals per sample (Fig. 1). Numbers of arboreal individuals in pitfall traps displayed a habitat–month interaction ( $\chi^2 = 36.69$ ,  $P < 0.001$ ), with ants occurring under trees more frequently during May and July (wet season). However, arboreal ants represented a very minor portion of the ant activity at ground-level, making up less

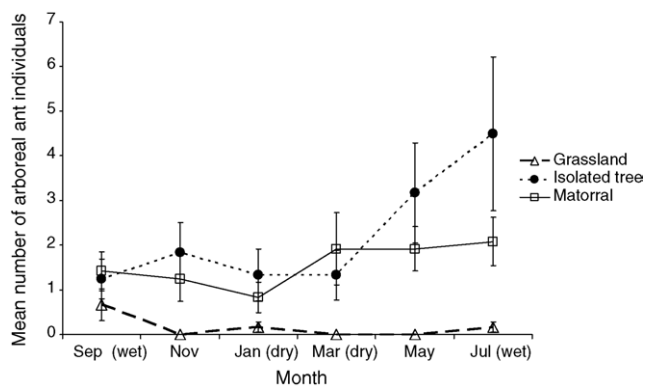


Fig. 1. Mean numbers of arboreal individuals caught in ground-level pitfall traps. Error bars represent 1 S.E.

Table 1

Number of arboreal ant individuals caught in ground-level pitfall traps, September 2000–July 2001

| Species                                    | Number of individuals |               |          |
|--|-----------------------|---------------|----------|
|  | Grassland             | Isolated tree | Matorral |
| <i>Azteca</i> sp. 1                        | 0                     | 0             | 9        |
| <i>Azteca</i> sp. 2                        | 0                     | 7             | 1        |
| <i>Azteca</i> sp. 3                        | 0                     | 0             | 3        |
| <i>Camponotus linnaei</i>                  | 0                     | 0             | 5        |
| <i>Cephalotes minutus</i>                  | 0                     | 0             | 3        |
| <i>C. scutulatus</i>                       | 0                     | 0             | 5        |
| <i>Crematogaster torosa</i>                | 1                     | 89            | 20       |
| <i>Dolichoderus lutosus</i>                | 0                     | 4             | 33       |
| <i>Leptothorax echinatoidis</i>            | 4                     | 2             | 3        |
| <i>Myrmelachista</i> sp. 1                 | 1                     | 15            | 23       |
| <i>Pachycondyla harpax</i>                 | 0                     | 3             | 0        |
| <i>Pseudomyrmex ita</i>                    | 0                     | 0             | 3        |
| <i>P. simplex</i>                          | 5                     | 5             | 0        |
| <i>P. caeciliae</i>                        | 0                     | 4             | 1        |
| <i>P. cubaensis</i>                        | 0                     | 0             | 2        |
| <i>P. brunneus</i>                         | 0                     | 1             | 0        |
| <i>P. ejectus</i>                          | 1                     | 30            | 1        |
| <i>P. pallidus</i>                         | 0                     | 1             | 0        |
| Total arboreal                             | 12                    | 161           | 113      |
| Percentage of all ants caught <sup>a</sup> | 0.26                  | 2.78          | 2.67     |

<sup>a</sup> All ants caught in pitfall traps, including terrestrial species.

than 3% of total ants caught at ground-level in any habitat. *Crematogaster torosa* was the most common arboreal ant at ground-level (110 individuals in pitfall traps). Other common species were *Myrmelachista* sp. 1 (39 individuals), *Dolichoderus lutosus* (37 individuals) and *Pseudomyrmex ejectus* (32 individuals) (Table 1).

All five fruit fly baits were removed from a single depot in as little as 5 min at open grassland and isolated trees and 10 min in matorral. Over the whole study, three depots in the open grassland, were not preyed upon after 3 h. Predation did not occur at two depots under isolated trees, and five depots in the matorral. The ground-nesting ants *Forelius pruinosus* and *Monomorium cyaneum* were the ant species most often observed removing baits in the open grassland and beneath isolated trees. Baits in the matorral were removed by a broader range of ants, including *Azteca* spp., *Pheidole* spp., *Solenopsis* spp. and *Camponotus planatus*.

Month was the only significant variable in the prediction of ground-level bait removal rate ( $\chi^2 = 10.781$ , d.f. = 2,  $P = 0.005$ ). Survival time was lowest in all three habitats in the wet season (Fig. 2). Bait removal rates below trees were lowest in February, the driest part of the year. At this time, bait survival under isolated trees was intermediate between that of the matorral and open grassland. Bait removal rate was consistently lowest in the matorral, although this pattern was not significant ( $\chi^2 = 2.994$ , d.f. = 2,  $P = 0.229$ , Fig. 2). The month–habitat interaction was not significant ( $\chi^2 = 6.137$ , d.f. = 4,  $P = 0.189$ ).

Arboreal baits were removed more rapidly in the wet season ( $\chi^2 = 6.85$ , d.f. = 1,  $P = 0.009$ ). In July (wet season), all 12 trees had baits removed within 6 h, while in March

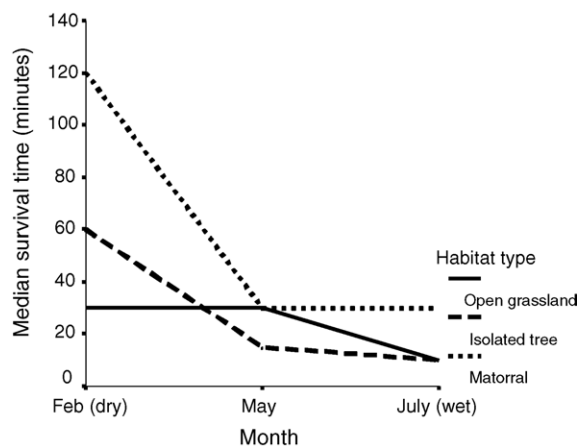


Fig. 2. Median survival time of fruit fly baits (time for complete removal of baits at 50% of depots) within three different habitat types over three periods (February, dry season; May, early wet season; July, wet season).

(dry season), baits were removed from only three trees after 6 h, and only 10 trees after 24 h. The most commonly observed ant species at arboreal fruit fly baits were the dominant arboreal species, *Azteca* spp., *C. torosa* and *Myrmelachista* sp. 1.

#### 4. Discussion

As a consequence of the low number of arboreal ants foraging at ground-level, and of the high level of open grassland ant activity, no beneficial influence of isolated trees on ant foraging at ground-level was demonstrated. This suggests that isolated trees may not contribute to the biological control of potential pests at ground-level in this setting. Introduction of arboreal ant colonies may be of increased benefit where crops are either trees or shrubs, and foraging at canopy-level, rather than ground-level is required (e.g., Majer, 1976; Van Mele and Cuc, 2000, 2001; Peng et al., 2004; Philpott, 2005).

The activity of many ant species is increased with insolation (e.g., Retana et al., 1991; Andersen, 1995; Bestelmeyer, 2000; Cerdá and Retana, 2000; Cerdá et al., 1998a,b). Many ground foraging species are also opportunistic, and capable of occupying highly disturbed sites (e.g., Majer et al., 1984; Mackay et al., 1991; Perfecto, 1991; Belshaw and Bolton, 1993; Andersen, 1995; Bestelmeyer and Wiens, 1996; Dunn, 2004) so, in this area at least, it would appear that there is limited need to introduce new tree-dependent ants to disturbed habitats such as pastures.

Both Risch and Carroll (1982) and Nestel and Dickschen (1990) found that activity of a generalised predatory ant species, *Solenopsis geminata*, was increased with simplification of the agricultural system. Retana et al. (1991) and Armbrrecht and Perfecto (2003) also found that bait removal rate did not benefit from increased vegetation complexity. In our study, bait removal was at its slowest in the matorral

patches. More complex agroecosystems do, however, possess higher ant species richness than their simpler counterparts (Risch and Carroll, 1982; Roth et al., 1994; Perfecto and Vandermeer, 1996; Armbrrecht and Perfecto, 2003; Perfecto et al., 2003; Gove et al., 2005). Perfecto and Castiñeiras (1998) suggest that diverse ant communities can offer better protection against pest outbreaks than communities dominated by fewer species, while Beattie (1985) suggested that plants that attract a diversity of ants would be advantaged due to the variety of herbivores that would be controlled. Isolated trees do augment species richness of simplified landscapes (Majer and Delabie, 1999; Dunn, 2000; Gove et al., 2005), and this diversity may represent a level of insurance for unknown pest outbreaks of the future.

Bait removal was significantly lower in the dry season, which is in agreement with the notion of reduced ant activity during dry seasons (e.g., Levings, 1983; Kaspari and Weiser, 2000; Levings and Windsor, 1985). The results here suggest that ants are sufficiently ubiquitous, disturbance and insolation tolerant, and generalised in their foraging that the presence of trees is not required in order promote their ground-level foraging.

We conclude that while isolated trees may increase habitat heterogeneity, and therefore increase biodiversity conservation, such trees may only play a limited role in introducing predatory ants to agricultural habitats, particularly where ant foraging may be required at ground-level, such as in the case of pastures.

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