

## CHALLENGES FOR SUCCESSFUL MANAGEMENT OF *PACHYCONDYLA CHINENSIS* (HYMENOPTERA: FORMICIDAE)

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**Abstract** *Pachycondyla chinensis* (Emery), the Asian needle ant, is an invasive, stinging ant established in the United States. It is known to displace both native and invasive ant species such as *Linepithema humile* (Mayr), the Argentine ant. It can be medically important to people who are allergic to arthropod stings and may cause anaphylaxis in hypersensitive individuals. Successful management of *P. chinensis* has proven to be difficult using traditional treatment methods with liquid insecticides or bait products. Although *P. chinensis* readily consumed toxic bait products in a laboratory study, it was not effectively managed in the field during seasonal periods of peak activity. Perimeter and targeted treatments using liquid insecticides were variable. Although targeted treatments were more successful, *P. chinensis* colonies were not eliminated. The potential reasons for inadequate population reduction are based on *P. chinensis* behavior and nest site distribution.

**Key words** Formicidae, treatment strategies, Ponerinae, Asian needle ant.

### INTRODUCTION

*Pachycondyla chinensis* (Emery), commonly known as the Asian needle ant is an invasive species in some areas of the United States. It usually does not enter structures in large numbers, but rather its urban pest status is based on its ability to sting which may cause mild to severe allergic reactions including anaphylaxis (Nelder et al., 2006). Sting reactions are well documented in Korea and other areas in the native range of this species (Kim et al., 2001; Cho et al., 2002). *Pachycondyla chinensis* also has an ecological pest status based on its ability to displace key native species in woodland habitats (Paysen 2007; Guénard and Dunn, 2010). In a study in an urban setting, the Argentine ant, *Linepithema humile* (Mayr), which normally displaces other species within a habitat, was itself displaced by the Asian needle ant. Although *L. humile* colonies are often larger and more aggressive than *P. chinensis* colonies, they were displaced early in the season before populations reached an overwhelming capacity (Rice and Silverman, 2013). *Pachycondyla chinensis* forms small colonies in rotting logs often associated with termite colonies, or in the soil beneath stones, wood debris, or structural objects including logs, rocks, subterranean tree roots, landscape objects, bricks, lumber, or other human-made debris. Paysen (2007) found *P. chinensis* nests around buildings and landscaping in urbanized areas, on the forest edges, and interior forests. However they are not known to nest in open areas and consequently do not compete with the red imported fire ant, *Solenopsis invicta* Buren. In forest areas, *P. chinensis* workers forage on the ground and on tree trunks. With generally small populations of several hundred to several thousand, nests tend to be small and discrete, but if circumstances provide a large area of contiguous, suitable habitat, colonies may fill the void. They opportunistically feed on decaying fruit, and prey on live arthropods, and dead organisms including terrestrial invertebrates, birds and mammals. Recruitment of

*P. chinensis* does not result in trails of workers going to a food source as with *L. humile* or *Tapinoma sessile* Say. They forage individually or recruit cohorts by tandem carrying to a food source (Guénard and Silverman 2011). For this reason, control using bait may be effective in some instances, but success has been variable. In studies reported here based on Mo (2013), targeted application of ant bait was often not a reliable strategy for control, nor were targeted applications of liquid insecticides. These variable results are likely because of the cryptic nature of *P. chinensis* nest entrances. This paper provides a discussion of considerations and challenges of *P. chinensis* management in light of results of laboratory and field trials with an emphasis on why success may be elusive.

## MATERIALS AND METHODS

### Choice / No Choice Bait Laboratory Study

A choice/no choice bait study was conducted using field-collected *P. chinensis* challenged with seven bait products including granular, gel and liquid formulations. Detailed procedures, analysis, and results for the study are found in Mo (2013). The products included were Advion® fire ant bait, Advion® Insect Granule, Advion® ant gel (DuPont™, Nemours and Company, Wilmington, Delaware, USA), Advance® 375A Select Granular Ant Bait (BASF Corporation, St. Louis, Missouri, USA), Optigard® Ant gel Bait (SYNGENTA CROP Protection, Greensboro, North Carolina, USA), Maxforce® Complete Brand Granular Insect Bait, and Maxforce® Quantum Ant Bait (Bayer Environmental, Research Triangle Park, North Carolina, USA).

A choice test was performed by providing food and bait in a treatment dish in which ants were offered termites and a bait product. Control ants were offered termites only. Five replicates were performed using five colonies. In a no-choice test, ants were offered only bait in the treatment and only termites in the control. Six replicates were performed using four colonies. Ants within each replicate were from the same colony. Bait products were refreshed every three days. Every day food and water were refreshed and mortality was recorded for 14 days.

Analysis of variance was performed on arcsine square root transformed data in the study comparing the daily mortality of each treatment (PROC GLM, SAS institution 9.3 2011). Fisher's Least Significant Difference test was used to compare the difference in mean daily mortality between each two treatments.

### Bait Field Study

Evaluation of bait products in the field was conducted in urban areas where actively foraging ants and potential nesting sites were located. Detailed procedures, analysis, and results for the study are found in Mo (2013). Each site was identified by non-overlapping foraging resources. Pitfall traps were placed in the ground to monitor *P. chinensis* populations at each site. Population change was calculated by comparing weekly *P. chinensis* pitfall trap catches with the number collected before treatment was applied.

### Perimeter/Targeted Applications Compared with Perimeter- Only Treatments

A comparison of perimeter and targeted (P/T) insecticide spray applications, and perimeter-only (P-only) spray treatments against *P. chinensis* was conducted around homes in the area of Clemson, SC in August and September. In the P/T replicates, sites targeted beyond the perimeter were located within 6 m of the treated structure. Tempo Ultra SC (Bayer Environmental, Research Triangle Park, North Carolina, USA) at 16ml/93m<sup>2</sup> was applied 0.3 m up the foundation wall and up to 3 m out using a Solo (Solo™, Newport News, VA, USA) back-pack sprayer at 25 psi. Three homes were identified for each treatment including the control. Pre- and post treatment data were collected using pitfall traps at 0, 1, 2, 3 and 5 weeks. A pitfall trap consisted of a 2x15 cm test tube filled about one third its length with

propylene glycol and fitted into a PVC sleeve. Traps were placed flush with the soil at 6 m intervals around the perimeter of each structure and adjacent to previously identified nest sites. This placement resulted in 14-20 pitfall traps per replicate.

Data were evaluated using analysis of variance with a least significant means test applied where appropriate at  $P = 0.05$ .

## RESULTS

### Choice/No Choice Bait Laboratory Study

In both choice and no-choice laboratory tests, the control groups were provided food (termite workers) and water daily, and had survival rates of 90-95%. Food also was provided in the choice test in each treatment dish. A detailed discussion of laboratory results can be found in Mo (2013).

Advion® fire ant bait, Advance, and Maxforce® Complete achieved 100% mortality within the 14 day period in both the choice and no-choice studies. Advion® gel provided approximately 90 and 96% mortality in the both studies and was not significantly different from products reaching 100% mortality after 14 days. When there was a choice of a natural food source, Optigard® was less effective than in a no-choice test in which it was not significantly different from Advion® gel. Optigard® was not significantly different from Maxforce® Quantum in the choice test achieving a mortality of 43%. Advion® granule was the least effective bait in both choice and no-choice tests at 22 and 34% respectively, and was not significantly different from the control.

### Bait Field Study

Field results at 10 weeks showed the most effective bait products in the field differed from the most effective bait products in the laboratory tests. Only Advion® gel reduced the field population over 10 weeks. Advion® fire ant bait achieved 70% reduction in the field population during the first three weeks; however the population increased during week 5 and 6. After reapplication, the population was reduced again. Advance® was effective in the first seven weeks and had no effect on the population reduction in the last three weeks even after reapplication. Maxforce® Complete was not as effective as in the laboratory, and the field population increased during most weeks of the study. Optigard® and Maxforce® Quantum had similar trends in population change during the 10 weeks. The population increased during weeks when there also was an increase at control sites and decreased in weeks when there was a decrease in the *P. chinensis* population at control sites.

### Perimeter/Targeted Applications Compared with Perimeter-Only Treatments

Both P/T and P-only treatments had significantly reduced pitfall trap counts compared with controls at weeks one and two, but were not significantly different from each other. There were 72 and 74%, and 64 and 71% reduction in the number of *P. chinensis* collected in pitfall traps at weeks one and two for P/T and P-only treatments, respectively. By weeks 3 and 5 there were no significant differences between these two treatments and the control.

## DISCUSSION AND CONCLUSIONS

Results for the laboratory and field bait studies were variable in achieving mortality of *P. chinensis*. Bait products, which cause high mortality of *P. chinensis* in laboratory studies, were not consistently effective in the field during seasonal periods of peak activity. Rice et al. (2012) reported effective control of *P. chinensis* using hydramethylnon bait in both clumped and scattered application. By 28 days after treatment, *P. chinensis* was increasing, although the control sample was decreasing.

Over a ten week period, management with bait products in our field study varied weekly. Advion fire ant bait, Advion gel, and Advance were more efficacious than other products tested in this

study, but no product achieved acceptable results over the study period and results were variable week to week, although products were reapplied according to label directions.

The results of the spray applications against *P. chinensis* also did not achieve sufficient, sustained control over the study period. Significant differences compared to the control were documented only for weeks one and two after treatment.

The studies discussed here offer insight about the many potential considerations and challenges which may hamper successful *P. chinensis* control. We speculate that among the most important is that *P. chinensis* has many often disjunct nest sites. Without recruitment by trailing disconnected or very large populations may not locate bait or be affected by insecticide applications that do not directly target each nest.

Bait products may be depleted before reapplication can occur with a larger *P. chinensis* population or when other arthropods are attracted to the site of application. In the bait field study crickets, pill bugs and millipedes were found weekly in many pitfall trap samples. When bait products are applied and reapplied according to label rates the amount of product may not be sufficient to reduce populations, even when they are moderately-sized and contiguous. During periods of heavy rainfall or climatic periods of high temperature and humidity, baits may quickly become unpalatable. This would not be as problematic if recruitment strategies for *P. chinensis* were more similar to *L. humile* or *S. invicta*, but rapid, large-scale recruitment to a food source does not occur.

Inadequate, sustained control with applications of liquid insecticides, even when many nest sites are targeted, may be due to similar factors. Because nest sites are not always contiguous and because interaction of ants from one nest site to another is not dependable, a treated area may have limited impact on untargeted sites. In the P/T treatments of our study we did not treat targeted nest sites beyond 6 m from the structure leaving open the possibility of recolonization of treated sites over time. Insecticides also are impacted by climatic and weather-related causes which can reduce their effectiveness.

A combination of integrated strategies may improve treatment success especially if careful inspection is conducted prior to treatment. *Pachycondyla chinensis* will move their nest very rapidly after a disturbance (personal observation). Insecticide applications should be made at the time of inspection to impact the most ants. After activity is reduced, introducing attractive bait with timely reapplication may offer longer-term control of *P. chinensis*. Regular inspection is necessary after treatment to time reapplication and prevent resurgence in the population. It also may be advantageous to begin treatment early in the season before *P. chinensis* populations increase. After successful control is achieved, reducing preferred nesting habitat will be important to prevent possible immigration of *P. chinensis* from untreated areas.

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### REFERENCES CITED

- Cho, Y.S., Y-M. Lee, C-K. Lee, B. Yoo, H-S. Park, and H-B. Moon. 2002.** Prevalence of *Pachycondyla chinensis* venom allergy in an ant-infested area in Korea J. Allergy and Clinical Immunology 110:54-57

- Guénard, B. and R. R. Dunn. 2010.** A new (old), invasive ant in the hardwood forests of eastern North America and its potentially widespread impacts. *PloS ONE*. 5(7): e11614
- Guénard, Benoit and Silverman J. 2011.** Tandem carrying, a new foraging strategy in ants: description, function, and adaptive significance relative to other described foraging strategies. *Naturwissenschaften* 98: 651-659
- Kim, S.S., H.S. Park, H.Y. Kim, S.K. Lee, and D.H. Nahm. 2001.** Anaphylaxis caused by the new ant, *Pachycondyla chinensis*: demonstration of specific IgE and IgE-binding components. *J. Allergy and Clinical Immunology*. 107:1095-9.
- Mo, Y. 2013.** Temporal food preference and effectiveness of selected bait products against *Pachycondyla chinensis* (Emery) (Hymenoptera: Formicidae). M.S. Thesis. Clemson University
- Nelder, M.P., E.S. Paysen, P.A. Zungoli, and E.P. Benson. 2006.** Emergence of the introduced ant *Pachycondyla chinensis* as a public-health threat in the southeastern United States. *J. Med. Entomol.* 43: 1094-1098
- Paysen, E. 2007.** Diversity and abundance of ants at forest edges in the Great Smoky Mountains National Park. PhD Dissertation. Clemson University.
- Rice, E. S., J. Shik, and J. Silverman. 2013.** Effect of scattered and discrete hydramethylnon bait placement on the Asian needle ant. *J. Econ. Entomol.* 105(5): 1751-1757
- SAS Institute. 2011.** SAS/STAT® 9.3 user's guide. SAS Institute, Ca