Hindawi Publishing Corporation
Psyche
Volume 2011, Article ID 526175, 9 pages
doi:10.1155/2011/526175

*Research Article*

# Colony Structure and Nest Location of Two Species of Dacetine Ants: *Pyramica ohioensis* (Kennedy & Schramm) and *Pyramica rostrata* (Emery) in Maryland (Hymenoptera: Formicidae)

**Richard M. Duffield[1] and Gary D. Alpert[2]**

[1] *Department of Biology, Howard University, Washington, DC 20059, USA*
[2] *Museum of Comparative Zoology, Harvard University, Cambridge, MA 02138, USA*

Correspondence should be addressed to Richard M. Duffield, rduffield@howard.edu

Received 9 March 2011; Accepted 13 April 2011

Academic Editor: Abraham Hefetz

Copyright © 2011 R. M. Duffield and G. D. Alpert. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The discovery of numerous *Pyramica ohioensis* and *P. rostrata* colonies living in acorns, as well as the efficient recovery of colonies from artificial nests placed in suitable habitats, opens a new stage in the study of North American dacetine ants. Here we present detailed information, based on 42 nest collections, on the colony structure of these two species. *P. ohioensis* colonies are smaller than those of *P. rostrata*. Both species are polygynous, but nests of *P. ohioensis* contain fewer dealate queens than those of *P. rostrata*. This is the first report of multiple collections of *Pyramica* colonies nesting in fallen acorns, and of the use of artificial nesting cavities to sample for dacetines in the soil and leaf litter. We describe an artificial cavity nest design that may prove useful in future investigations.

## 1. Introduction

The ants of the genus *Pyramica* are distributed worldwide and are diverse and abundant in both warm temperate and tropical forest communities (Bolton lists 350 valid species) [1]. In the United States, *Pyramica* is represented by 32 native species and 9 introduced species [2–5]. Two additional undescribed species from the Southwest have been discovered recently (Cover and Alpert, [6]). *Pyramica* species are widely known as specialist predators of Collembola [3, 7–16], however, little is known about other aspects of their biology. These diminutive, cryptobiotic ants forage in leaf litter and rotten wood and are most frequently collected by litter sifting, Berlese funnel extraction, or Winkler samples. Collections of colonies are comparatively infrequent and thus our understanding of *Pyramica* colony demographics and life histories is limited.

This study began as a trial of the use of artificial nests to sample soil and leaf litter ants in a Maryland oak-hickory forest. Sets of artificial nests designed to evaluate preferences for cavity volume and diameter of the nest entrance were placed at the study site in the spring and retrieved at the end of the summer. Although a variety of ant species colonized the artificial nests, the most interesting result was the recovery of several colonies of dacetine ants belonging to the genus *Pyramica*. Based on this finding, it was assumed that *Pyramica* was nesting in natural preformed cavities in the same general area where the artificial nests were placed. *Pyramica ohioensis* and *P. rostrata* were eventually discovered colonizing acorns. Once the appropriate conditions were recognized, several *Pyramica* colonies were consistently recovered on each collecting trip.

*Pyramica ohioensis* (Kennedy & Schramm) (Figure 1) can be recognized by a combination of unique characters including J-shaped hairs on the lateral clypeal margin pointing posteriorly, absence of a gap between the basal lamella and the first basal tooth. All curved hairs on the ventral margin of the scape are pointing toward the apex. State records: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Missouri, New Jersey, North Carolina, Ohio, Oklahoma, Tennessee, Texas, and Virginia.

Figure 1: *Pyramica ohioensis*.

Figure 2: *Pyramica rostrata*.


Figure 3: Artificial Nest: middle section with top and bottom pieces underneath.

*Pyramica rostrata* (Emery) (Figures 2 and 6) can be recognized by a combination of characters including J-shaped hairs on the lateral clypeal margin pointing anteriorly, having a small gap between the basal lamella and the first basal tooth, and curved hairs on the ventral margin of the scape pointing toward the base. State records: Alabama, Arkansas, District of Columbia, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New Jersey, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, and Virginia.

This is the first report of multiple collections of *Pyramica* colonies in acorns. Although hollowed-out stems have been used in other studies in the tropics, we believe that our artificial nests also represent the first application of artificial nesting cavities to sample *Pyramica* species. We describe a design of artificial nests that may prove useful in future investigations of species of ants which form small colonies.

## 2. Materials and Methods

*2.1. Artificial Nest Design.* Each artificial nest consisted of three pieces of pine (Figure 3), 5.0 cm × 3.4 cm × 0.5 cm. The middle insert had two holes (diameters 0.63 cm and 1.26 cm, 0.2 cm from each edge) drilled through it to create nesting cavities. Entrance holes of different diameters were drilled into each cavity from the side: 1.56 mm, 1.95 mm, and 2.35 mm. Glass cover slips were glued over the top and bottom of each cavity to facilitate inspection of the artificial nest and to retain inhabitants when the nests were retrieved and opened. The layers were tied together with monofilament fish line. Each trap was given an accession number which identified the diameter of the cavity, the diameter of the entrance hole, and the trap number.

*2.2. Artificial Nest Placement.* The ant nests were randomly placed at the study site in groups of five (referred to as a trap line). Traps varied by cavity volume and/or entrance diameter. Each trap was attached to a 3–5 m piece of monofilament and spaced evenly. Each trap and trap line was buried in the leaf litter.

*2.3. Study Site.* The artificial nests were placed in the woods associated with the Croydon Creek Nature Center, Rockville, Montgomery County, Maryland. The GPS coordinates are 39°05′23′′ N; 77°07′42′′ W. The woods are dominated by multiple species of oak, hickory, beech, maple, and tulip. Deep ravines cut through the woods.

*2.4. Retrieval of Artificial Nests.* Each trap was placed individually into a resealable plastic bag. The nests were refrigerated at 3°C until they were processed.

Each cavity was then inspected for the presence of ants or other organisms. If the trap cavity contained an ant colony, the entrance hole was plugged and later inspected with a dissecting microscope.

Each ant colony was placed in 70% ethyl alcohol. Much care was taken to remove all larvae, pupae, and adult ants from the nesting cavity. Ant material was placed in two dram screw cap vials with poly-seal lids. Each sample was labeled with the appropriate collection information and accession number.

*2.5. Acorn Collection.* After it was discovered that multiple *Pyramica* colonies occupied the trap nests, a concerted effort was made to find natural colonies. In the same woods where the trap lines were placed, within 0.25 of a mile, a colony of *Pyramica* was discovered in a decomposing acorn. As work proceeded, *Pyramica* colonies were recovered repeatedly from acorns.

When acorns were found on the ground, the top leaf litter was brushed aside exposing the organic horizon. Acorns that had entrance holes and that were embedded in the top of the organic soil horizon proved to be the best candidates for finding *Pyramica* colonies. Acorns that were in an advanced stage of decomposition were ideal. In order to locate these acorns, the top layer of soil was disrupted by running fingers over it in a claw-like motion. Many times, acorns were dislodged that were not otherwise visible. Acorns were cracked open but not split into two disconnected halves. Colonies of of *Temnothorax* were easy to detect. Sometimes the clumped, white larvae were seen first or frequently the workers would rush out of the acorn when disturbed. If the acorn contained a *Ponera* colony and if the light-tan-colored pupae were present, they were the first objects observed. Often it was possible to observe the shiny appearance of disturbed workers scurrying around. If an acorn was split open and contained a *Pyramica* colony, the workers remained motionless. The open acorns would have to be held in direct sunlight to see the cryptic slow moving *Pyramica* workers. Secondly, larvae were uniformly spread around the cavity and were very small so that they were not noticeable except under a microscope. Although the workers were cryptic, the light colored spongiform gland/tissue on the petiole and gaster [17] helped to recognize workers.

*2.6. Processing Acorns.* When an acorn was located that contained a *Pyramica* colony, it was placed in a 50 mL screw-cap plastic conical centrifuge tube. Most of the acorn samples were preserved with 70% ethyl alcohol. A few colonies were kept alive so that the ants within could be observed and photographed.

*2.7. Processing Ant Samples.* The acorn collections were processed by the same procedure as with the artificial ant nest samples. For each sample, total number of workers, dealate queens, male and female alates, pupae, and larvae were counted and recorded.

*2.8. Deposition of Specimens.* All materials were identified by the second author [G. D. Alpert]. Voucher specimens have been placed in the Museum of Comparative Zoology, Harvard University. The remaining materials reside in the collection of the first author [R. M. Duffield].

## 3. Results

Of the 55 artificial nests (110 nesting cavities) placed in the woods, 18 cavities (16%) contained ant colonies or ants. Five different species of ants were recovered from the artificial nests. They included *Temnothorax curvispinosus* (6 colonies), *Temnothorax longispinosus* (1 colony), *Ponera pennsylvanica* (3 colonies), *Pyramica ohioensis* (Kennedy & Schramm) (2 colonies), and *P. rostrata* (Emery) (6 colonies).

Two of the artificial nests had both of the nesting cavities occupied by ant colonies. One had two *T. curvispinosus* colonies residing in it. The second nest had a *T. curvispinosus* colony on one side and a *Pyramica* colony on the other side. Six of the eighteen cavities occupied by ant colonies were 6 mm in diameter. *Pyramica* colonies occupied two 6 mm diameter cavities; six others colonized 1.2 cm diameter cavities.

A total of 29 *P. rostrata* colonies were recovered: 6 from artificial nests and the rest from acorns. The demographic data of each colony are presented in Table 1. We did not want to mix the colony data recovered from the artificial nests with the acorn data. Since there were more samples for each species from acorns, these were the data that were analyzed.

*3.1. Demographic Data for P. rostrata Colonies Recovered from Acorns.* Analysis of colonies recovered from acorns provided the following data: mean number of workers 82.9 $\pm$ S.D. 39.1; range 14–160, $N = 28$; mean number of queens 5.0 $\pm$ S.D. 4.8; range 0–24, $N = 28$; mean number of larvae 63.3 $\pm$ S.D. 38.0; range 0–140, $N = 28$. Eight colonies contained over one hundred adult workers. A total of 2,074 *P. rostrata* workers were collected during this study. While most of the *P. rostrata* colonies contained multiple queens, one contained no queen and two others contained single queens. Surprisingly, one colony contained twenty-four queens. Five of the colonies contained at least one male and/or female alate. These reproductives were primarily recovered from the artificial nests. Most of the recovered *P. rostrata* colonies contained larvae. The greatest number of larvae recovered from a single nest was 140. Larvae appeared to be one uniform age class. Seven colonies contained at least one pupa.

*3.2. Demographic Data for P. ohioensis Colonies Recovered from Acorns.* The demographic data of each of the 14 *Pyramica ohioensis* colonies recovered from acorns is given in Table 2. Analysis of colonies provided the following data: mean number of workers 55.5 $\pm$ S.D. 23.5; range 19–111, $N = 14$; mean number of queens 2.6 $\pm$ S.D. 1.7; range 1–6, $N = 14$; mean number of larvae 39.4 $\pm$ S.D 18.9; range 0–83, $N = 14$. The number of adult individuals per colony ranges from 10 to 83. Only one colony contained over one hundred adult ants. A total of 763 workers of *P. ohioensis* were collected during this study. Five of the colonies contained single queens while the rest contained multiple queens. The greatest number of queens in a single colony was six. Three colonies contained at least one alate. Five of the colonies contained one or more pupae. The largest number of larvae recovered was eighty-three.

The number of workers per colony versus the number of larvae was positively correlated at 63% for *P. rostrata* and 67% for *P. ohioensis*. This may be a reflection of the number

Table 1: Demographic data for *Pyramica rostrata* colonies recovered in this investigation [Montgomery Co., Maryland].

| Nest | Collection number/Ant species | workers | queens | Male alates | Female alates | Larvae | Pupae |
|---|---|---|---|---|---|---|---|
| A.N. | 2010-VIII-27-211 | 26 | 2 | — | — | — | 1 |
| A.N. | 2010-VIII-27-213 | 26 | — | 2 | 4 | | — |
| A.N. | 2010-VIII-27-511 | 53 | 12 | — | 2 | 14 | 3 |
| A.N. | 2010-VIII-27-613 | 34 | 7 | 1 | — | 17 | 1 |
| A.N. | 2010-VIII-27-614 | 63 | 4 | 1 | — | 17 | 1 |
| A.N. | 2010-VIII-27-751 | 49 | 5 | — | — | 13 | 1 |
| A | 2010-IX-24-02 | 49 | 2 | — | 2 | 38 | — |
| A | 2010-X-09-01 | 160 | 3 | — | — | 122 | 3 |
| A | 2010-X-09-02 | 118 | 5 | — | — | 68 | 2 |
| A | 2010-X-10-01 | 14 | 3 | — | — | 11 | — |
| A | 2010-X-11-01 | 36 | 2 | — | — | 14 | — |
| A | 2010-X-11-02 | 63 | 6 | — | — | 15 | — |
| A | 2010-X-11-03 | 149 | 5 | — | — | 64 | — |
| A | 2010-X-11-04 | 132 | 10 | — | — | 124 | — |
| A | 2010-X-11-05 | 104 | 4 | — | — | 85 | — |
| A | 2010-X-11-06 | 72 | 3 | — | — | 37 | — |
| A | 2010-X-17-01 | 92 | 4 | — | — | 90 | — |
| A | 2010-X-17-02 | 54 | 5 | — | — | 91 | — |
| A | 2010-X-17-03 | 51 | 1 | — | — | 43 | — |
| A | 2010-X-17-04 | 113 | 2 | — | — | 54 | — |
| A | 2010-X-22-01 | 77 | 4 | — | — | 79 | — |
| A | 2010-X-22-03 | 65 | 8 | — | — | 24 | — |
| A | 2010-X-22-04 | 124 | 24 | — | — | 140 | — |
| A | 2010-X-23-01 | 45 | 4 | — | — | 40 | — |
| A | 2010-X-23-03 | 100 | 2 | — | — | 74 | — |
| A | 2010-XI-06-01 | 46 | 2 | — | — | 13 | — |
| A | 2010-XI-06-02 | 56 | 8 | — | — | 72 | — |
| A | 2010-XI-06-03 | 103 | 2 | — | — | 95 | — |
| C | Talbot [18] | 98 | 1 | | | 45 | |
| | Talbot [18] | 45 | — | | | 22 | |

A = acorn; A.N. = Artificial Nest; C = hickory nut; Collection number = [year-month-day-colony number].

Table 2: Demographic data on *Pyramica ohioensis* colonies recovered in this study [Montgomery Co., MD].

| Nest | Collection number/Ant species | Workers | Queens | Male alates | Female alates | Larvae | Pupae |
|---|---|---|---|---|---|---|---|
| A.N. | 2010-VIII-27-509 | 22 | 1 | — | 2 | 14 | 3 |
| A.N. | 2010-VIII-27-602 | 75 | 6 | — | — | 60 | 18 |
| A | 2010-IX-19-01 | 19 | 1 | — | — | 10 | — |
| A | 2010-IX-19-02 | 38 | 3 | — | — | 23 | — |
| A | 2010-IX-19-03 | 50 | 6 | — | — | 31 | — |
| A | 2010-IX-19-04 | 48 | 1 | — | 4 | 33 | — |
| A | 2010-IX-19-05 | 56 | 2 | — | — | 38 | — |
| A | 2010-IX-20-01 | 56 | 2 | — | — | 30 | 5 |
| A | 2010-IX-20-02 | 67 | 3 | — | 1 | 46 | 4 |
| A | 2010-X-02-02 | 111 | 2 | — | — | 59 | 1 |
| A | 2010-X-10-02 | 53 | 1 | — | — | 51 | — |
| A | 2010-X-10-03 | 77 | 5 | — | — | 83 | — |
| A | 2010-X-23-02 | 30 | 1 | — | — | 28 | — |
| C | 2010-X-30-01 | 61 | 4 | — | — | 41 | — |
| | Hill MS Thesis [23] | 72 | 2 | | | | |

A = acorn; A.N. = Artificial Nest; C = hickory nut; Collection number = [year-month-day-colony number].

of workers required to support development of a population of larvae since recruitment is based upon individual foragers returning with Collembola as prey.

However, the number of queens did not correlate strongly with either the number of larvae (17%, 25%) or the number of workers (.07%, 17%), *P. rostrata* and *P. ohionesis,* respectively. This preliminary data suggests that multiple queens are not laying viable eggs at the same time and that there may be a single reproductive queen. All the brood was synchronized in development as overwintering larvae. This colony reproductive system needs to be explored further to understand the role of polygyny in these two species.

*3.3. Overwintering Colonies.* During the collecting phase of this investigation, several tubes with acorns containing *Pyramica* colonies were left refrigerated [3°C] for more than three months (end of October through February 1, 2011). Each colony was then checked using a microscope at low magnification. The workers showed no movement at first but were active by the next day.

In retrospect, being able to refrigerate *Pyramica* colonies for months and revive the specimens at room temperature is not surprising. Temperate ants must survive periods of subfreezing temperatures with minimal losses. It may prove useful to store *Pyramica* colonies in natural cavities for laboratory experimentation. Colonies could be retrieved from storage as needed and thus reduce the burden of keeping live laboratory colonies.

## 4. Discussion

*4.1. Artificial Nests.* Although *P. rostrata* and *P. ohioensis* have been reported in Maryland and Virginia [19, 20], this is the first report of the recovery of multiple colonies of each species in artificial nests. As Deyrup and Cover [4] point out, when Creighton's Ants of North America [21] was published, dacetine ants were thought to be rare. It now appears that some dacetine ants, and in particular *Pyramica* species, are not uncommon. Rather, because of their cryptic appearances, diminutive size, and slow movements, colonies are frequently overlooked in the field. Although colonies are seldom collected, individuals in leaf litter samples have been reported throughout the world [22].

Since this is the first report of *Pyramica* colonizing artificial nests, it is premature to draw conclusions. At this juncture, we do not know how many different Nearctic species will colonize artificial nests. Artificial nesting cavities have been employed in several experiments performed in woodland settings. Herbers and Banschbach [24] successfully used hollowed-out wooden doweling to investigate nest choice by *Myrmica punctiventris* and *Temnothorax longispinosus*. The occupancy rate was as high as 27% per species. In another study on social organization of *M. punctiventris*, Herbers and Banschbach [25] used pieces of wooden doweling that had lengthwise holes. Friedrich and Philpott [26] used nests made from hollow twigs of differing internal diameters to study the impact of urbanization on cavity nesting ant communities in Ohio. Hollowed-out natural twigs were also used by Armbrecht et al. [27] to study the correlation between diversity of twig species versus the diversity of twig nesting ant species. They found a positive correlation. While other investigators have used artificial nesting cavities; we believe our nest design may be unique and favors some cavity nesting ant species over others.

*4.2. Nests in Acorns.* The decomposition of acorns follows a predictable series of steps from when the acorn first falls to the ground until it is incorporated into the humus of the forest floor [28]. This decomposition is aided by various insects and microorganisms, resulting in an empty outer shell. Depending upon the region, multiple species of weevil larvae (Curculionidae) and moth larvae (Tortricidae) feed on the seed inside the shell. The result is a partially empty hard shell with a small exit hole. Collection data document these degraded acorns are superb nest sites for a variety of ants including *Pyramica*. It is not clear how ants chose acorns for nesting. The volume of the cavity may be one parameter; others may include how the acorn decomposes and retains moisture, whether bacteria, fungi, or secondary plant substances are present, structural differences or biochemical differences.

Nest site selection by *P. rostrata* was originally described by L. G. Wesson and R. G. Wesson [8]. Several colonies were found in decaying logs. It is assumed that the nests were in preformed cavities. The authors report one colony in a rotten hickory nut. Talbot [18] also reported a *P. rostrata* colony from a hickory nut (*Carya* sp.) (Table 1). The Wessons [8] reported a colony found in a decayed stick in the leaf letter. Our data on *P. rostrata* suggest that the artificial nests may mimic natural cavities in rotten wood. Perhaps it is not the wood the ants are choosing but rather the environmental condition, that is, moisture content of the artificial nests. In retrospect, the reports of *P. rostrata* in hickory nuts could have given investigators a clue where else to look for *P. rostrata* colonies, namely, acorns. The data on colony demographics for *P. rostrata* recovered from acorns clearly documents the importance of acorns as natural nesting sites for this species.

Colonies of *P. rostrata* were also reported by L. G. Wesson and R. G. Wesson [8] living in the humus under the leaf layer. Another colony was found in a chamber in dry soil under a rock. Talbot [18] reports finding one colony in a chamber six inches below the surface (Table 1). It would appear that *P. rostrata* is either opportunistic or a generalist in choosing nest sites. As documented, this species constructs colonies in decaying logs, cavities in nuts and acorns, in the soil under a covering object, and in subterranean cavities.

Many myrmecologists have collected ants from acorns over the last half century, without finding *Pyramica* colonies. However, there is an anecdotal report by Coovert [29, page 95] that a colony of *P. ohioensis* was found in an acorn and state "Colony Organization: Futher data lacking." In our study, fourteen colonies of *P. ohioensis* were recovered (Table 2). Two colonies were recovered from artificial nests, eleven from acorns and one from a hickory nut. At this juncture, it may be assumed that its nest site requirements are similar to those of *P. rostrata*. The differences in the number of nests recovered for *P. rostrata* and *P. ohioensis* may reflect

Table 3: Numbers of workers per colony of North American *Pyramica* species.

| Species | Number of workers | Number of queens | Reference |
|---|---|---|---|
| *P. apalachicolensis* | >300 | | Deyrup and Lubertazzi [38] |
| *P. bunki* | 40 | | King and Porter [39] |
| *P. clypeata* | 50 | | King and Porter [39] |
| *P. clypeata* | 62 | | Brown [17] |
| *P. creightoni* | 50 | | King and Porter [39] |
| *P. deyrupi* | 50 | | King and Porter [39] |
| *P. dietrichi* | 80 | | Kennedy and Schramm [40] |
| *P. dietrichi* | 50 | | King and Porter [39] |
| *P. eggersi** | 50 | | King and Porter [39] |
| *P. memorailis* | 54 | 1 | Deyrup [41] |
| *P. ohioensis* | $x = 56$ $n = 12$ | 2.6 ± SD 1.7 | This study |
| *P. ohioensis* | 53 | | Brown [17] |
| *P. ornate* | 20 | | L. G. Wesson and R. G. Wesson [8] |
| *P. pergandei* | Up to 300 | | Brown [17] |
| *P. pergandei* | 700 | | Brown [37] |
| *P. pergandei* | 146 | 1 | Wilson [10] |
| *P. pilinasis* | 30 | 2 | L. G. Wesson and R. G. Wesson [8] |
| *P. pulchella* | 6–60 | | Smith [42] |
| *P. rostrata* | $x = 82$ $n = 22$ | 5.0 ± SD 4.9 | This study |
| *P. rostrata* | ~200 | 3–5 | Brown [17] |
| *P. rostrata* | 72 | | Brown [17] listed by Geraghty et al., [43] [Possibly incorrectly reported] |
| *P. talpa* | ~60 | | L. G. Wesson and R. G. Wesson [8] |

*exotic, introduced species in the United States. $n$ = number of colonies analyzed.

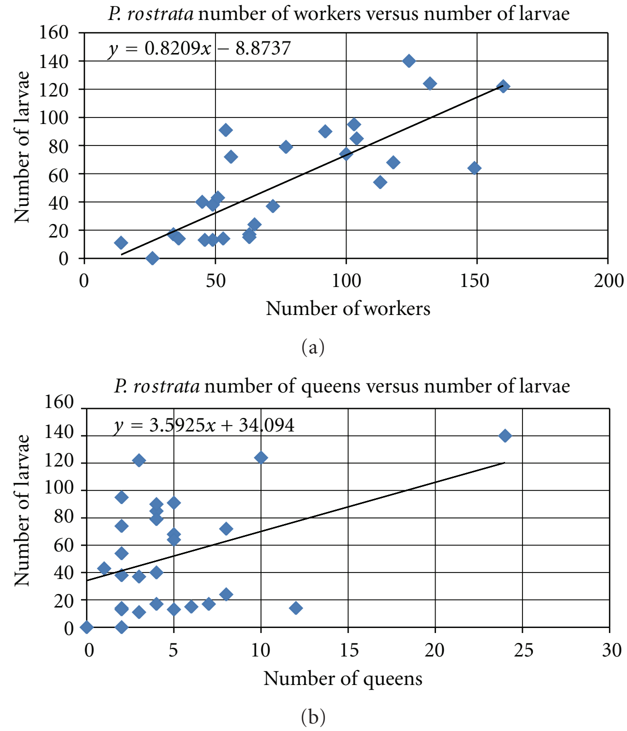



Figure 4: *P. rostrata* scatter plot of colonies ($N = 28$): (a) workers versus larvae; (b) queens versus larvae.

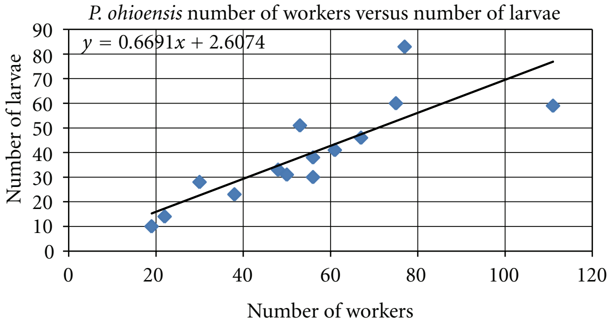
the density of each or may indicate *P. ohioensis* has slightly different nesting requirements and that our two collecting methods do not adequately sample for this species.

*4.3. Colony Structure.* Colonies of some species of ants occupy more than one physical nest (polydomy) rather than one (mondomy). For example, *Temnothorax longispinosus* under laboratory conditions exhibits colony fission and fusion [30, 31]. Polydomy or forms of polydomy have been documented in *T. curvispinosus* [32], *T. ambiguus* [33], *Myrmica punctiventris* [34, 35], and *Stenamma diecki* [35, 36].

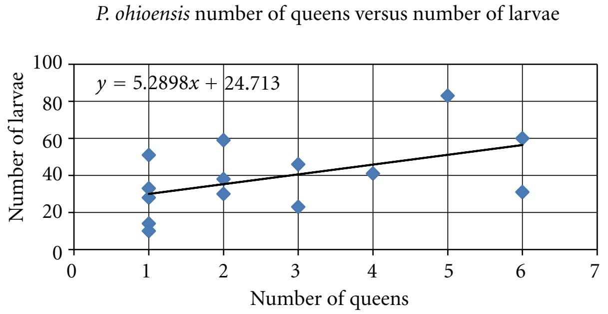
Worker number in a colony changes with the annual cycle. Our data represent the period after the reproductive alates have swarmed and just before winter hibernation. These are the first data sets based on multiple collections for each species. *Pyramica rostrata* colonies exhibited a mean of eighty-three workers per colony, compared to fifty-six workers per *P. ohioensis*. Our data are similar to those worker numbers per colony reported for other Nearctic species of *Pyramica* as listed in Table 3. The *Pyramica pergandei* colony reported by Brown [37] from Massachusetts that contained seven hundred workers is markedly larger than those listed in this study. Obviously we have much to discover about worker numbers in *Pyramica* colonies.

It is difficult to compare our *Pyramica* data to other data sets since so little exists for the Nearctic region, or that matter worldwide. Dejean (reported by Beckers et al. [44]) provides data on colony worker number for four African species: *Pyramica emarginata* [199 workers], *P. lujae* [57 workers], *P. serrula* [78 workers], and *P. truncatidens* [133 workers]. The number of workers per colony for the Japanese ground nesting "tramp species" *Pyramica membranifera*, is 198 ± SD 129, $N = 59$ [45]. Our data seems to fit in the range reported by these authors.

Larvae were present in most colonies of *P. rostrata* and *P. ohioensis*. In acorns *P. rostrata* colonies had a mean of 63.3 ± SD 38.0, $N = 28$ larvae and *P. ohioensis* has 39.4 ± SD18.9, $N = 14$. Figures 4 and 5 plot workers as a function of the number of larvae present for each colony recovered from acorns by species.




(a)




(b)

FIGURE 5: *P. ohioensis* scatter plot of colonies ($N = 14$): (a) workers versus larvae; (b) queens versus larvae.

*4.4. Polygyny.* The mean number of queens per colony for *P. rostrata* is 5.0 ± SD 4.9, $N = 28$, whereas *P. ohioensis* had a mean of 2.6 ± SD 1.7, $N = 14$ queens per colony. Thus it appears *P. ohioensis* forms smaller colonies and has fewer queens per colony.

Analysis of the twenty-eight *P. rostrata* colonies and fourteen *P. ohioensis* collected in the late summer documents that most colonies contain multiple queens; only three colonies did not. It is not clear whether these are true monogynous colonies where each colony was founded by a single queen and is retained as a single queen throughout the life of the colony. These colonies could have been established by a single queen and a group of workers leaving a larger polygynous colony.

Polygyny is an important component of ant biology and has evolved independently many times [46]. *Pyramica rostrata* and *P. ohioensis* are part of a growing list of polygynous species. It is not clear how many queens were inseminated, if one queen is doing the egg laying or if it is a shared responsibility. Given that the number of queens in both *P. rostrata* and *P. ohioensis* colonies does not correlate with the number of larvae or number of workers, it appears that only one queen is laying eggs. Polygynous colonies can be formed by swarming where a single queen or multiple queens leave the parent colony with a small group of workers and establish a new colony. Colonies could also be established by a single queen with extra queens added as the colony matures.

Five colonies of *P. rostrata* and three of *P. ohioensis* contained at least one male and/or female alate. The end of August seems relatively late in the year for alates to be present

FIGURE 6: *Pyramica rostrata* worker foraging in artificial nest.

in the colonies. Although one assumes that the female individuals would eventually leave the colony, they may not. Ito et al. [45] working with the polygynous species *Pyramica membranifera* recently reported thelytokous reproduction by queens. In laboratory investigations, they documented that some alate queens found in the colonies, shed their wings and established new polygynous colonies which produced workers.

*4.5. Utility of Artificial Nests.* This investigation demonstrates the limited effectiveness of a novel artificial nest to obtain colonies of two species of *Pyramica*. Additional work is necessary to determine whether other species of *Pyramica* will inhabit artificial nests, perhaps based on this design, if the nests are placed in a suitable habitat. The capture and subsequent maintenance of colonies of *Pyramia* in the laboratory will allow a number of important questions about the biology of *Pyramica* to be addressed. As pointed out by Deyrup and Cover [4], the natural history of these ants is poorly understood. We hope that our contribution will allow other investigators an opportunity to employ our methods to pursue investigations of this most fascinating group of ants.

## Acknowledgments

The authors would like to thank Donna Maglott for assistance in multiple aspects of this work. Discussions and a paper review by Stefan Cover improved the quality of this publication. They appreciate the comments and information provided by the reviewers which helped strengthen and improve the paper. This publication acknowledges the pioneering work on dacetines in North America by William L. Brown, Jr. and Edward O. Wilson.

## References

[1] B. Bolton, Version: 3, 2011, http://gap.entclub.org/.

[2] B. Bolton, "Ant genera of the tribe Dacetonini (Hymenoptera: Formicidae)," *Journal of Natural History*, vol. 33, no. 11, pp. 1639–1689, 1999.

[3] B. Bolton, "The ant tribe Dacetini. With a revision of the *Strumigenys* species of the Malgasy Region by Brian Fisher, and a revision of the Austral epopostrumiform genera by Steven O. Shattuck," *Memoirs of the American Entomological Institute*, vol. 65, pp. 1–1028, 2000.

[4] M. Deyrup and S. Cover, "Dacetine ants in southeastern North America (Hymenoptera: Formicidae)," *Southeastern Naturalist*, vol. 8, no. 2, pp. 191–212, 2009.

[5] J. A. MacGown and J. G. Hill, "A new species of *Pyramica* (Hymenoptera: Formicidae) from Mississippi, U.S.A," *Florida Entomologist*, vol. 93, no. 4, pp. 571–576, 2010.

[6] S. Cover and G. Alpert, unpublished collection data from Arizona and New Mexico, 2009.

[7] L. G. Wesson, "Contribution toward the biology of *Strumigents pergandei*: a new food relationship among ants," *Entomological News*, vol. 47, pp. 171–174, 1936.

[8] L. G. Wesson and R. G. Wesson, "Notes on *Strumigenys* from southern Ohio with descriptions of six new species," *Psyche*, vol. 46, no. 2-3, pp. 91–112, 1939.

[9] W. L. Brown Jr., "Supplementary notes on the feeding of dacetine ants," *Bulletin of the Brooklyn Entomological Society*, vol. 45, pp. 87–89, 1950.

[10] E. O. Wilson, "The ecology of some North American dacetine ants," *Annals of the Entomological Society of America*, vol. 46, no. 4, pp. 479–495, 1953.

[11] A. Dejean, "Etude eco-ethologique de la prédation chez les fourmis du genre *Smithistruma* (Formicidae-Myrmicinae—Dacetini). II. Attraction des proies prinicipales (Collemboles)," *Insectes Sociaux*, vol. 32, no. 2, pp. 158–172, 1985.

[12] A. Dejean, "Étude du comportement de prédation dans le genre *Strumigenys* (Formicidae-Myrmicinae)," *Insectes Sociaux*, vol. 33, no. 4, pp. 388–405, 1986.

[13] A. Dejean, "New cases of archaic foundatioin of societies in Myrmicinae (Formicidae): study of prey capture by queens of Dacetini," *Insectes Sociaux*, vol. 34, no. 3, pp. 211–221, 1987.

[14] A. Dejean, "Determination of the hunting strategy in the genus *Smithistruma* (Formicinae-Myrmicinae) by the kind of prey," *Behavioural Processes*, vol. 16, no. 1-2, pp. 111–125, 1988.

[15] K. Masuko, "Studies on the predatory biology of Oriental dacetine ants (Hymenoptera: Formicidae) II. Novel prey specialization in *Pyramica benten*," *Journal of Natural History*, vol. 43, no. 13-14, pp. 825–841, 2009.

[16] K. Masuko, "Studies on the predatory biology of oriental dacetine ants (Hymenoptera: Formicidae). III. Predation on gamasid mites by *Pyramica mazu* with a supplementary note on *P. Hexamerus*," *Journal of the Kansas Entomological Society*, vol. 82, no. 2, pp. 109–113, 2009.

[17] W. L. Brown Jr., "Revisionary studies in the ant tribe Dacetini," *The American Midland Naturalist*,, vol. 50, no. 1, pp. 1–137, 1953.

[18] M. Talbot, "Populations of ants in a Missouri Woodland," *Insectes Sociaux*, vol. 4, no. 4, pp. 375–384, 1957.

[19] J. F. Lynch, "Seasonal, successional, and vertical segregation in a Maryland ant community," *Oikos*, vol. 37, pp. 183–198, 1981.

[20] D. Kjar and E. M Barrows, "Arthropod community heterogeneity in a mid-Atlantic forest highly invaded by alien organisms," *Banisteria*, vol. 23, pp. 26–37, 2004.

[21] W. S. Creighton, "Ants of North America," *Bulletin of the Museum of Comparative Zoology of Harvard College*, vol. 104, pp. 1–585, 1950.

[22] P. S. Ward, "Broad-scale patterns of diversity in leaf litter ant communities," in *Ants Standard Methods for Measuring and Monitoring Biodiversity*, D. Agosti, J. D. Majer, L. E. Alonso, and T. R. Schultz, Eds., chapter 8, pp. 99–121, Smithsonian Institution Press, Washington, DC, USA, 2000.

[23] J. G. Hill, *Environmental variables affecting ant (Formicidae) community composition in Mississippi's Black Belt and Flatwood regions*, M.S. thesis, Mississippi State University, Starkville, Miss, USA, 2006.

[24] J. M. Herbers and V. Banschbach, "Size-dependent nest site choice by cavity-dwelling ants," *Psyche*, vol. 102, pp. 13–17, 1995.

[25] J. M. Herbers and V. S. Banschbach, "Plasticity of social organization in a forest ant species," *Behavioral Ecology and Sociobiology*, vol. 45, no. 6, pp. 451–465, 1999.

[26] R. Friedrich and S. M. Philpott, "Nest-site limitation and nesting resources of ants (Hymenoptera: Formicidae) in urban green spaces," *Environmental Entomology*, vol. 38, no. 3, pp. 600–607, 2009.

[27] I. Armbrecht, I. Perfecto, and J. Vandermeer, "Enigmatic biodiversity correlations: ant diversity responds to diverse resources," *Science*, vol. 304, no. 5668, pp. 284–286, 2004.

[28] P. W. Winston, "The acorn microsene with special reference to arthropods," *Ecology*, vol. 37, no. 1, pp. 120–132, 1956.

[29] G. A. Coovert, "The ants of Ohio," *Bulletin of the Ohio Biological Survey (New Series)*, vol. 15, no. 2, pp. 1–196, 2005.

[30] T. M. Alloway, A. Buschinger, M. Talbot, M. Stuart, and C. Thomas, "Polygyny and polydomy in three North American species of the ant genus *Leptothorax* Mayr (Hymenoptera: Formicidae)," *Psyche*, vol. 89, pp. 249–274, 1982.

[31] J. M. Herbers and C. W. Tucker, "Population fluidity in *Leptothorax longispinosus* (Hymenoptera: Formicidae)," *Psyche*, vol. 93, pp. 217–230, 1986.

[32] R. J. Stuart, "Spontaneous polydomy in laboratory colonies of the ant *Leptothorax curvispinosus* Mayr (Hymenoptera: Formicidae)," *Psyche*, vol. 92, pp. 71–81, 1985.

[33] J. M. Herbers and S. Grieco, "Population structure of *Leptothorax ambiguus*, a facultatively polygynous and polydomous ant species," *Journal of Evolutionary Biology*, vol. 7, no. 5, pp. 581–598, 1994.

[34] L. E. Snyder, *Colony subdivision and sex ratios in the ant Myrmica punctiventris: an analysis of queen worker conflict*, M.S. thesis, University of Vermont, Burlington, Vt, USA, 1988.

[35] V. L. Backus, C. DeHeer, and J. M. Herbers, "Change in movement and subdivision of *Myrmica punctiventris* (Hymenoptera, Formicidae) colonies in north temperate forests is related to a long-term shift in social organization," *Insectes Sociaux*, vol. 53, no. 2, pp. 156–160, 2006.

[36] V. L. Backus and J. M. Herbers, "Demography and reproduction in the cavity-dwelling ant *Stenamma diecki* (Emery) (Hymenoptera: Formicidae)," *Northeastern Naturalist*, vol. 16, no. 1, pp. 113–124, 2009.

[37] W. L. Brown Jr., "The ant genus *Smithistruma*: a first supplement to the world revision (Hymenoptera: Formicidae)," *Transactions of the American Entomological Society*, vol. 89, no. 3/4, pp. 183–200, 1964.

[38] M. Deyrup and D. Lubertazzi, "A new species of ant (Hymenoptera: Formicidae) from North Florida," *Entomological News*, vol. 112, no. 1, pp. 15–21, 2001.

[39] J. R. King and S. D. Porter, "Body size, colony size, abundance, and ecological impact of exotic ants in Florida's upland ecosystems," *Evolutionary Ecology Research*, vol. 9, no. 5, pp. 757–774, 2007.

[40] C. H. Kennedy and M. M. Schramm, "A new species of *Strumigenys* with notes on Ohio species," *Annals of the Entomological Society of America*, vol. 26, no. 1, pp. 95–104, 1933.

[41] M. Deyrup, "*Smithistruma memorialis* (Hymenoptera: Formicidae), a new species of ant from the Kentucky Cumberland Plateau," *Entomological News*, vol. 109, no. 2, pp. 81–87, 1998.

[42] M. R. Smith, "A revision of the genus *Strumigenys* of America North of Mexico based on a study of workers (Hymn.: Formicidae)," *Annals of the Entomological Society of America*, vol. 24, no. 4, pp. 686–710, 1931.

[43] M. J. Geraghty, R. R. Dunn, and N. J. Sanders, "Body size, colony size, and range size in ants (Hymenoptera: Formicidae): are patterns along elevational and latitudinal gradients consistent with Bergmann's Rule?" *Myrmecological News*, vol. 10, pp. 51–58, 2007.

[44] R. Beckers, S. Goss, J. L. Deneubourg, and J. M. Pasteels, "Colony size, communication and ant foraging strategy," *Psyche*, vol. 96, pp. 239–256, 1989.

[45] F. Ito, Y. Touyama, A. Gotoh, S. Kitahiro, and J. Billen, "Thelytokous parthenogenesis by queens in the dacetine ant *Pyramica membranifera* (Hymenoptera: Formicidae)," *Naturwissenschaften*, pp. 1–4, 2010.

[46] B. Hölldobler and E. O. Wilson, *The Ants*, Springer, Berlin, Germany, 1990.