

Research Article

Mites (Acari) Associated with the Desert Seed Harvester Ant, *Messor pergandei* (Mayr)

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Mites (Acari) associated with the seed harvester ant *Messor pergandei* were investigated in the Sonoran desert of Arizona. At least seven representatives of the mite genera *Armacarus*, *Lemanniella*, *Petalomium*, *Forcellinia*, *Histiostoma*, *Unguidispus*, and *Cosmoglyphus* are phoretically associated with *M. pergandei*. Most of these morphospecies show preference for specific phoretic attachment sites and primarily use female alates rather than male alates for dispersal. Five mite morphospecies were found in low numbers inhabiting the chaff piles: Tydeidae sp., *Procaeculus* sp., Anystidae sp., *Bakerdania* sp., and Tetranychidae sp. The phoretic *Petalomium* sp. was observed consuming fungus growing on a dead queen, but the roles of the other mite species remain mostly unresolved.

1. Introduction

The Sonoran Desert occupies the southwestern portion of Arizona and extends into California and Mexico. It is a harsh environment characterized by little rainfall, widely spaced shrubby vegetation, saguaro cacti, sandy soil, and high summer temperatures [1].

Seed harvesting by some desert ants is an adaptation to the lack of typical ant resources such as prey or honeydew from homopterans [2]. Harvester ants increase seed dispersal, protection, and provide nutrients that increase seedling survivorship of the desert plants [2–5]. In addition, ants provide soil aeration through the creation of galleries and chambers, mix deep and upper layers of soil, and incorporate organic refuse into the soil [6].

Messor pergandei (Mayr) (length: 2.5–7 mm) is one of the most conspicuous and thoroughly studied species of seed harvesters found in the southwestern United States. This species forms populous, long-lived colonies with an estimated 30,000 to 50,000 workers [7, 8]. Its nests have been estimated to span 15.5 m in underground diameter, and extending to a depth of 4 m [2]. Nests have conspicuous crater entrances (usually 2–3 per nest), which are surrounded

by chaff (refuse) piles [9]. Mating flights in this species occur primarily in February when temperatures reach approximately 22°C [10].

Mites (Acari) often attach to larger arthropods for dispersal (phoresy). Through this primarily commensal relationship, mites are able to exploit scattered habitats more successfully than they would be able to do without external assistance [11]. Often phoretic mites are so synchronized with their hosts that they are able to detect subtle changes in life cycle or other aspects of their host species. For example it has been documented that if the host's sex determines the mites' continued survival or transport to a habitat, the mites board the sexes differentially [12].

Previous work on ant associated mites has been limited primarily to descriptions of new species. The majority of ecological studies regarding myrmecophiles has focused on large arthropods (often Coleoptera), and most of the studies refer to the Acari recovered from the nest as simply "mites" or at another broad taxonomic level which provides little insight into the possible roles of the mites within the ant colonies [13–15].

The biology, behavior, and ecology of *M. pergandei* have been studied in detail, but no previous publications have

mentioned arthropod associates of this common desert ant species. Mites known to be associated with other *Messor* species are shown in Table 1. All of these records are Middle Eastern or European and most (except two scutacarid species) are large mesostigmatid mites. Earlier (1997, 2007) unpublished collections by S. W. Rissing and W. H. Schaedla from *M. pergandei* alates (unmated winged reproductives), included small numbers of *Petalomium* sp. (Heterostigmata: Pygmephoridae), *Cosmoglyphus* sp., *Forcellinia* sp. (Astigmatina: Acaridae), and *Lemanniella* sp. (Astigmatina: Lemanniellidae). The latter marked the first record of this family in the United States. What is unclear is whether this assemblage represents the complete set of mite species associated with *M. pergandei*.

The following study was implemented to: (1) generate a complete list of the phoretic mite species associated with *M. pergandei* alates, (2) determine the phoretic attachment sites of the mite species, (3) test if phoretic mites show preference for female rather than male hosts, and (4) suggest possible roles of the mites in the ant colonies.

2. Methods

2.1. Collection Dates and Localities. The majority of the mites from *M. pergandei* nests were collected at: USA., Arizona, Pinal County, Casa Grande, W McCartney Rd, East of I-10 (32.9398° N, 111.6641° W). A couple of collections occurred at a nearby site: N Cox Rd at W McCartney Rd, East of I-10 (32.9299° N, 111.6891° W). The dominant vegetation in the study area is the creosote bush, *Larrea* sp., with small numbers of saguaro, *Carnegiea gigantea* Britton & Rose. Collections were made from 12–22 February 2008. The two sites are located near to each other and match those of the Rissing and Schaedla collections.

2.2. Field Collection Methods. Alates were collected prior to the mating flights by excavating the upper chambers of the nests around the entrances (to a depth of approximately 30–60 cm). If alates were present, excavation continued until no further alates were found. Alates were deposited individually into empty 2 mL Eppendorf tubes labeled chronologically on the lids. Tubes with alates from different colonies were placed into separate plastic bags and labeled with a field number. If no alates were apparent after multiple excavation attempts at all entrances, the colony was assumed to not have any accessible alates.

After returning from the field, live alates were carefully examined for phoretic mites using a stereomicroscope (25–50x). Each ant's field number, sex, and the number and location of phoretic mites were recorded. Alates were returned to their original Eppendorf tubes and preserved in 95% ethanol. The numbers of ants with and without mites for each colony were recorded for prevalence calculations (number of infested hosts/number of hosts examined) [21].

Chaff accumulates as a contiguous mass outside of active nest entrances and can be easily peeled up from the sand. Chaff piles were collected from six nests (multiple entrances of the same nest were combined) prior to excavation for

alates and enclosed in 473 mL clear plastic deli containers for transport. Collapsible nylon Berlese funnels (using 40 watt bulbs) were hung in a garage for two days to extract any chaff-inhabiting mites into 100 mL Nasco Whirl-Paks half filled with 95% ethanol.

2.3. Recovery and Preservation of Mites from Ants and Chaff. All collections (ants and chaff products) were transported to the Acarology Laboratory at Ohio State University. Contents of the Eppendorf tubes holding the alates with phoretic mites were examined, mites were counted, and representatives were cleared in lactophenol then mounted on slides in Hoyer's-Strandtmann's medium. Berleseates from chaff were searched for mites, and exemplars of each morphospecies were also mounted on slides.

Mites were rarely observed still clinging to the host in the ethanol tubes. Therefore original mite attachment sites on host alates were determined by merging lab and field notes; the number of mites of each species recovered from a host was compared to field notes documenting the number at each bodily location. Specimens that were documented in the field, but not subsequently recovered in the lab were not included in the attachment site specificity summary (Table 5). Mites which were undocumented in the field, but later found in the tubes were categorized as specimens with "unknown" phoretic locations.

2.4. Mite Identification and Vouchers. Mites were identified using a published key to families of Astigmatina [22] and an unpublished key to the genera of Acaridae (O'Connor, pers. comm.), Savulkin's [23] generic key for pygmephoroids (Heterostigmata), and Walter et al.'s [24] key to families of soil Prostigmata. Attempts to identify the phoretic taxa to species failed, as none of these taxa matched available descriptions. Consequently, mites were identified to morphospecies (called "species" throughout the text).

Voucher specimens for all mite species are deposited in the Ohio State University Acarology Collection (OSAL) under the following names and accession numbers (total number of slides for each species in parentheses): *Armacarus* Messor sp1 (71)-OSAL0007082, *Lemanniella* Messor sp1 (28)-OSAL0007039, *Petalomium* Messor sp1 (36)-OSAL0007035, *Forcellinia* Messor sp1 (2)-OSAL0007105, *Histiostoma* Messor sp1 (2)-OSAL0092942, *Unguispus* Messor sp1 (1)-OSAL0007060, *Nanorchestidae* Messor sp1 (1)-OSAL0092938, Tydeidae Messor sp1 (7)-OSAL0102747, *Procaeculus* Messor sp1 (1)-OSAL0102748, Anystidae Messor sp1 (1)-OSAL0102750, *Bakerdania* Messor sp1 (1)-OSAL0102740, and Tetranychidae Messor sp1 (1)-OSAL0102749. A voucher specimen of *Messor pergandei* is deposited in the Ohio State University Insect Collection under accession number OSUC0359951.

2.5. Statistical Analysis. The proportions of infested male and female alates were analyzed using a logit model with the log odds ratio of the proportion of individuals infected (prevalence) and the proportion uninfected as the response variable and sex as a categorical predictor variable. Analyses

TABLE 1: A list of mite species associated with ants of the genus *Messor*. Generic names follow current taxonomic standing.

| <i>Messor</i> species | Mite family | Mite species | Association | Location | Reference |
|------------------------|--------------------|--|-------------|----------------|-----------|
| <i>M. barbarus</i> | Messoracaridae | <i>Messoracarus mirandus</i> Silvestri | On head | Italy | [16] |
| <i>M. capitatus</i> | Laelapidae | <i>Myrmozercon acuminatus</i> (Berlese) | In nest | Italy | [17] |
| | Laelapidae | <i>Myrmozercon brachiatus</i> (Berlese) | In nest | Italy | [17] |
| <i>M. excursionis</i> | Laelapidae | <i>Laelaps (Hypoaspis) intermedius</i> (Karawajew) (1) | In nest | Turkmenistan | [18] |
| | Scutacaridae | <i>Imparipes placidus</i> Khaustov & Chydyrov | In nest | Turkmenistan | [19] |
| | Circocyllibaniidae | <i>Cillibano transversalis</i> (Karawajew) (1) | In nest | Turkmenistan | [18] |
| <i>M. meridionalis</i> | Oplitidae | <i>Oplitis inopina</i> (Hull) | In nest | Iran | [20] |
| <i>M. structor</i> | Oplitidae | <i>Oplitis leonardiana</i> (Berlese) | In nest | Italy | [17] |
| | Oplitidae | <i>Oplitis philoctena</i> (Trouessart) | In nest | Italy | [17] |
| | Laelapidae | <i>Gymnolaelaps myrmophilus</i> (Michael) | In nest | Czechoslovakia | [20] |
| | Trachyuropodidae | <i>Trachyuropoda magna</i> (Leonardi) | In nest | Czechoslovakia | [20] |
| <i>Messor</i> sp. | Scutacaridae | <i>Imparipes ignotus</i> Khaustov & Chydyrov | In nest | Turkmenistan | [19] |

(1) The taxonomic status of the two Karawajew species is unclear, their descriptions are incomplete, and we have found no record of use of these names since the original description [18]. Karawajew does note that his *Laelaps intermedius* is intermediate between *L. myrmecophilus* Berlese and *L. myrmophilus* Michael. Both are currently placed in the genus *Gymnolaelaps*.

were conducted using the glm function in the base package of R software [25]. Due to low collections of mites on male alates (and many zeros in the data), the data were overdispersed relative to the binomial distribution. Likelihood ratio tests were used to compare the following models: M1 – intercept with overdispersion (null model) versus M2 – intercept + sex + overdispersion, and M2 versus M3 – sex + colony sex ratio (proportion of colony comprised of male or female alates) + overdispersion. We hypothesized that the effect of sex would be a significant variable predicting mite prevalence (M2). Alate sex ratio (M3) of the colony would not be significant unless mites were simply boarding hosts based on abundance of the sex within the colony.

3. Results

3.1. Colony Collections. A total of 330 alates (140 males, 190 females) was collected from 16 ant colonies. Numbers of alates ranged from 2 to 61 per colony. Most colonies produced both sexes, but sex ratios were usually skewed towards one sex or the other. Five colonies were collected with only males or females (Table 2). Phoretic mites were present on alates in 8 of the 16 colonies.

3.2. Mite Association with Female versus Male Alates. A total of 90 male and 150 female alates was collected from the 8 mite infested colonies and 88 total alates had phoretic mites (see Table 2). Average infestation rates across the 8 infested colonies were 6.7% for males ($N = 6$) and 54.7% for females ($N = 82$). The mean number of mites per male alate in infested colonies was 1.67 (range 1 to 2, SD = 0.41, median = 1); female alates had a mean of 7.15 (range 1–30, SD = 7.10, median = 5).

A total of 98% of the mite specimens was collected from female alates. The results of the generalized linear regression analysis showed the effect of sex (M2) to be of borderline

TABLE 2: Total number of male (M) and female (F) alates collected per colony of the ant *Messor pergandei* and abundance of associated phoretic mites.

| Colony | Total M | Total F | # M with mites | # F with mites |
|----------------|---------|---------|----------------|----------------|
| 1 | 15 | 6 | 2 | 6 |
| 2 | 9 | 48 | 0 | 11 |
| 3 | 7 | 30 | 0 | 6 |
| 4 | 2 | 1 | 0 | 0 |
| 5 ¹ | 1 | 3 | 0 | 2 |
| 6 | 0 | 10 | --- | 7 |
| 7 | 0 | 1 | --- | 0 |
| 8 | 5 | 1 | 0 | 0 |
| 9 ¹ | 0 | 2 | --- | 2 |
| 10 | 0 | 4 | --- | 0 |
| 11 | 56 | 5 | 4 | 2 |
| 12 | 2 | 46 | 0 | 46 |
| 13 | 14 | 0 | 0 | --- |
| 14 | 4 | 13 | 0 | 0 |
| 15 | 10 | 16 | 0 | 0 |
| 16 | 15 | 4 | 0 | 0 |

¹Two colonies collected at the Cox Rd site. All other colonies were collected at the W McCartney Rd site. Dashed lines mean no alates of that sex were present within the colony.

significance ($P = .0548$). The likelihood ratio test for M1 (overdispersion null model) versus M2 was significant ($P = .008$), indicating that effect of sex is a strong predictor of alate infestation probability. Sex ratio was not a significant variable in the model alone ($P = .271$) or with effect of sex, as in M3 ($P = .309$). The Analysis of Deviance table and predicted and observed prevalence for mites on males and females (using M2) are shown in Table 3. Mites showed significant preference for females independent of the available sex ratio within the colony.

TABLE 3: Host sex preference of phoretic mites. (a) Analysis of Deviance table. Results of the comparison of the null model (M1) and the model with sex included (M2). (b) Observed and predicted (using Model 2) male and female infestation prevalence values.

| (a) Analysis of deviance table | | | | | |
|--------------------------------|----|-------------|----|-----------------|--------------------|
| Model | df | Resid. Dev. | df | Deviance Resid. | $P(> \text{Chi})$ |
| M1 null | 32 | 309.36 | | | |
| M2 sex | 33 | 382.74 | 1 | 73.38 | 0.0076 |

| (b) Prevalence probabilities | | | |
|------------------------------|------------|-----------------|------------|
| Sex | Obs. Prob. | Std. Error Obs. | Pred. Prob |
| M | 0.017 | 0.52 | 0.043 |
| F | 0.35 | 1.91 | 0.43 |

3.3. Phoretic Mite Species and Abundance. The total of 593 mite specimens recovered comprised representatives of 6 genera: *Lemanniella*, *Petalomium*, *Forcellinia*, *Armacarus* (Acaridae), *Histiostoma* (Atigmatina: Histiostomatidae), and *Unguoidisus* (Heterostigmatina: Microdispidae). One mite specimen belonging to the family Nanorchestidae was found in a vial with a female alate, but is likely a contaminant from soil.

Armacarus sp. comprised 83% of the mites collected; however, 488 of 490 specimens were found in a single colony. *Lemanniella* sp. and *Petalomium* sp. comprised 10% and 7% of the collections, respectively. *Forcellinia* sp., *Histiostoma* sp. and *Unguoidisus* sp. were collected as doubletons or singletons. Mite abundances and their host sex preferences are shown in Table 4.

3.4. Attachment Site Specificity. Observation of living ant specimens prior to placement in alcohol is necessary to gain a clear understanding of the mite phoretic attachment sites, as phoretics do not hold on to their host in alcohol. The number of mites found at specific phoretic locations on the host is presented in Table 5. *Armacarus* sp. were found on various sites on the host, but the majority (388 of the 490 mites) were found attached anterior-ventrally to the gaster. *Armacarus* sp. individuals would often arrange themselves in the same direction, with legs I oriented toward the posterior end of the ant. *Lemanniella* sp. were found primarily (48 of 56 mites) under the head, beneath the psammophore (beard-like hairs found in desert ant species, used for movement of sand). *Petalomium* sp. were generally (29 of 42 mites) found in the ventral position, particularly between the second and third coxae. *Forcellinia*, *Histiostoma*, and *Unguoidisus* sp. were found in too low of numbers to make generalizations concerning their phoretic locations.

Precise documentation of mite attachment sites is difficult and depends on the method of collection. Rettenmeyer [26] collected mites from army ants using jars with ether, but noted that the mites often became caught in condensation on the jar walls and subsequently lost. Freezing may be an alternative, but any manipulation of dead ants may result in the release of mites from their sites of phoretic attachment.

Moreover, thawing can cause the same issues through vapor condensation.

3.5. Mites in Chaff Piles. Only 3 of the 6 chaff piles hosted mites, generally in low numbers. The majority of mites recovered from chaff piles were small, soft bodied Prostigmata. With the exception of one, a very abundant species found in two chaff piles, Tydeidae sp., most of them, such as *Procaeculus* sp. (Caeculidae), Anystidae sp., Tetranychidae sp., and a nonphoretic female of *Bakerdania* sp. (Pygmephoridae) were singletons.

4. Discussion

4.1. Yearly Variation and Phoretic Mite Species Richness. Representatives of 6 mite genera *Armacarus*, *Lemanniella*, *Petalomium*, *Forcellinia*, *Histiostoma*, and *Unguoidisus* were found associated phoretically with *M. pergandei* alates. The 1997 and 2007 collections by Rissing and Schaedla included *Cosmoglyphus* sp., a species not collected in this study. In contrast they were lacking *Armacarus* sp., the most abundant mite species encountered in this study (primarily in a single colony). It is likely that mite populations exhibit fluctuations in abundance and ubiquity in different years. The mite community may also change in composition throughout the year depending on resource availability. This could not be tested, however, because all of the mites collected in 1997, 2007, and 2008 were collected in February and March, months in which opportunity of dispersal to new colonies by alates is the greatest. To obtain a complete list of ant-associated mites and their yearly or seasonal cycles, a continual sampling regime is required.

4.2. Attachment Site and Host Sex Specificity of Phoretic Mites. Attachment site specificity is apparent in the frequently sampled mite species, *Armacarus* sp., *Lemanniella* sp., and *Petalomium* sp. Although most mites were found in several locations on the alates, a preference for one or a couple of key locations is apparent. In highly infested ants, the mites commonly spilled over to locations beyond their primary attachment sites; however, when only a few mite individuals were present, they were found primarily at their preferred locations on males as well as females. For example, *Lemanniella* sp. rode on the underside of the ants' heads, in both males and females, even though *M. pergandei* males have much smaller heads and less developed psammophores than the females. How the mites select and distribute themselves at attachment locations remains unresolved.

Mites showed a marked preference for female alate hosts, and except *Unguoidisus* sp., which was represented by a singleton, the majority of the representative specimens (98.8%) were found on female alates. Male *M. pergandei* die soon after mating, as is the case for most ant species. Apparently to select a female host is an advantage for a mite requiring resources in the ant nest. The desiccating desert environment provides little time for survival on a dead male host, and this also supports selection for a female host. Mites can be transported back to a nest by way of necrophagic

TABLE 4: Number of representative specimens of the six mite genera found on male (M) and female (F) alates on *Messor pergandei*.

| Colony (1) | <i>Armacarus</i> | | <i>Lemanniella</i> | | <i>Petalomium</i> | | <i>Forcellinia</i> | <i>Histiostoma</i> | <i>Unguoidisus</i> | Total |
|---------------|------------------|-----|--------------------|----|-------------------|----|--------------------|--------------------|--------------------|-------|
| | M | F | M | F | M | F | F | F | M | |
| 1 | 0 | 1 | 2 | 15 | 0 | 2 | 0 | 0 | 1 | 20 |
| 2 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 13 |
| 3 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 6 |
| 5 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 9 |
| 6 | 0 | 0 | 0 | 20 | 0 | 2 | 0 | 0 | 0 | 22 |
| 9 | 0 | 0 | 0 | 6 | 0 | 4 | 0 | 0 | 0 | 10 |
| 11 | 0 | 1 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 6 |
| 12 | 0 | 488 | 0 | 4 | 0 | 10 | 2 | 2 | 0 | 507 |
| Total | 0 | 490 | 2 | 54 | 4 | 38 | 2 | 2 | 1 | 593 |
| Abundance (%) | 82.63 | | 9.44 | | 7.08 | | 0.34 | 0.34 | 0.17 | |

(1) Colony number corresponds to those listed in Table 2.

TABLE 5: Attachment site preferences for phoretic mite species on *Messor pergandei*.

| Location | <i>Armacarus</i> | <i>Lemanniella</i> | <i>Petalomium</i> | <i>Forcellinia</i> | <i>Histiostoma</i> | <i>Unguoidisus</i> |
|----------------|------------------|--------------------|-------------------|--------------------|--------------------|--------------------|
| Ventral head | 7 | 48 | 0 | 0 | 1 | 1 |
| Neck | 0 | 0 | 3 | 0 | 0 | 0 |
| Dorsal thorax | 28 | 1 | 1 | 0 | 0 | 0 |
| Lateral thorax | 11 | 0 | 0 | 0 | 0 | 0 |
| Ventral coxae | 6 | 0 | 29 | 0 | 0 | 0 |
| On leg | 11 | 0 | 3 | 2 | 0 | 0 |
| Petiole | 16 | 0 | 0 | 0 | 0 | 0 |
| Gaster | 388 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 23 | 7 | 6 | 0 | 1 | 0 |
| Total | 490 | 56 | 42 | 2 | 2 | 1 |

activity by ants, and the scarcity of resources in the desert may increase the frequency of necrophagy.

The seven mites associated with male ants occurred in two colonies with male-biased sex ratios. In all female-biased colonies only females carried mites. This may indicate that host sex preference is strongly influenced by host availability rather than sex of the host. However, it is more likely that males are infested in situations in which females are rare or more difficult to find. This idea is supported by the lack of significance for the model including sex ratio (M3). In cases of phoretic mites on males, males were more abundant than females in the nest, yet smaller percentages of males were found with mites.

Other studies have shown similar preference for females. Ebermann and Moser [27] collected five species of mites in the family Scutacaridae associated with red imported fire ant alates (*Solenopsis invicta* Buren) in Louisiana. In another study of the red imported fire ant, mites in the genus *Histiostoma* also showed preference for females [28]. Our study provides further support for this type of mite host selection on a previously unexplored ant genus.

4.3. Mites in Chaff Piles. Chaff piles appear to comprise little mite diversity. Chaff was very dry despite recent rain in the area; humidity is probably the main factor influencing

mite abundance and diversity in the chaff pile. The piles are primarily composed of seed husks and small pieces of plants, but seem to be cemented together by fungal mycelia. The *Bakerdania* sp. was likely feeding on fungus, as most species of the family Pygmephoridae do. *Procaeculus* sp. and Anystidae sp. are predators, and tetranychid mites are plant feeders. The latter may have been deposited in the chaff on plant material refuse by ants. Mites of the family Tydeidae are fungivores, predators, and pollen feeders and their role in chaff piles remains unresolved.

4.4. Possible Roles of Phoretic Mites. During phoresy no harm or benefit is brought upon the host, and once the host reaches a suitable habitat, the mite will disembark, develop into a feeding instar, and subsequently reproduce [11]. Mites in the genera *Petalomium* and *Unguoidisus* have stylet-like chelicerae that are typical of fungivores. Many of them are feeding specialists, and during phoresy, they may carry fungal spores in order to inoculate their habitat [29, 30]. Laboratory rearing has documented that the mite *Petalomium fibrisetum* Ebermann & Rack, associated with *Lasius flavus* (Fabricius), fed on hyphae of various fungi available in ant nests. In this mite species a lack of food triggered development of phoretic females [31]. In our study, *Petalomium* sp. was observed feeding on a white fungus growing on a dead

M. pergandei queen in the laboratory, providing further support for fungivorous habits. Fungivory by mites may be beneficial to the ant colonies, particularly if the mites control entomopathogenic fungi, or fungi growing on food stores. Numerous fungal species exist in ant colonies and soil habitats, so commensalism in the ant colonies can be expected.

Observations concerning the role of astigmatid mites in ant nests are rare in the literature. Mites of the genera *Forcellinia*, *Cosmoglyphus*, *Arm acarus* and *Lemanniella* are almost exclusively found in association with ants, but published biological observations are restricted to *Lemanniella*. *Lemanniella minotauri* Wurst was reared in a laboratory, and its feeding instars were observed to be ingesting a black fungus growing in *Lasius brunneus* (Latreille) nests. *Lemanniella minotauri* was also observed riding under the head of the *L. brunneus* host [32].

Chelicerae of mites of the family Histiostomatidae are modified into feathery filter-feeding structures. These mites tend to inhabit wet substrates where they filter and ingest organic material and microorganisms. Some mutualistic mites of the genus *Anoetus* remove pathogenic microorganisms from pollen and nectar in the nests of halictid bees [22]. *Histiostoma polypori* (Oudemans) was observed developing and feeding on a decaying earwig host after it had died [33]. Phoretic deutonymphs of *Histiostoma* sp. associated with *M. pergandei* might ingest bacteria within the ant nest as later instars or await the death of their hosts to feed on them as scavengers.

It is unlikely that any of the mite species collected on *M. pergandei* are ectoparasites of these ants. More likely these mites, after their phoretic stage, become commensals or mutualists, eating fungi and bacteria within the nest.

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