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Observations on Mites (Arachnida: Acari) Associated with Three Ant Species (Hymenoptera: Formicidae) from Saudi Arabia

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Abstract.- Ants form complex colonies, harboring resources that can potentially be exploited by myrmecophiles (organisms living in association with ants). Myrmecophily has been studied in detail for Coleoptera, but for mites, remain largely unstudied. This work examined astigmatid mites associated with three Saudi ant species, *Monomorium niloticum, Messor meridionalis* and *Tapinoma simrothi*. Mites belonging to two families were found associated with the three ant species, *Forcellinia egyptiaca* Eraky (Acari: Acaridae) and *Histiostoma sammari* Eraky (Acari: Histiostomatidae) on *Monomorium niloticum* and *Messor meridionalis*, respectively. *Cosmoglyphus barbisetus* Eraky (Acari: Acaridae) was recorded on *Tapinoma simrothi* and occurred in large numbers. The abundance of mites varied among colonies, ant species and ant body parts. Mite populations varied not only among ant colonies and also over time. These findings are considered the first record of mites associated with these three ant species.

Keywords: Cosmoglyphus, Forcellinia, Histiostoma, Messor, Monomorium,Tapinoma.

INTRODUCTION

Ants (Hymenoptera: Formicidae) have long been an insect group of great interest to the scientific world, whether for their ecological roles, feeding strategies, or social behaviors (Hölldobler and Wilson, 1990). The ants create carefully structured nests consisting of tunnels and galleries usually in soil or wood (Bayoumi and Al-Khalifa, 1985; Hölldobler and Wilson, 1990). The humidity, texture, chemical composition, temperature, and amount of organic materials are drastically altered by the ants (Beattie and Culver, 1983; Cole, 1994; Laakso and Setälä, 1998; Boulton *et al.*, 2003). This localized change in the soil (or other substrate) composition has been demonstrated to increase litter decomposition by nematodes, mites, collembolans, and microorganisms within the nest (Paris, 2008), as well as to increase the overall abundance and biomass of these associated organisms (Beattie and Culver, 1983; Wagner *et al.*, 1997; Boulton *et al.*, 2003). Myrmecophiles are defined as organisms living in close association with ants. Ants are particularly good hosts for other arthropods as their colonies are long lived and rich in organic materials collected from a larger area than that of the nest (Wheeler, 1910; Laakso and Setälä, 1998). Myrmecophiles are able to overcome the intrinsic colony defenses and apparently have cracked the ants' code (Donisthorpe, 1927; Hölldobler, 1971). Myrmecophiles are divided into five categories (Wheeler, 1910; Kistner, 1979; Hölldobler and Wilson, 1990): 1- Synechthrans: These invaders are treated with hostility by the ants and are usually predators that force themselves upon their hosts. 2- Synoeketes: These organisms are usually scavengers and predators within the nest, but are tolerated by their hosts. 3- Symphiles: These are "true" guests, accepted by their hosts into the colony and fed and groomed as if they are true members. 4- Ectoparasites and endoparasites: These organisms are true parasites that live on or in the body of their hosts, respectively, feeding on bodily fluids. 5- Trophobionts: includes arthropods (such as homopterans) that provide the ants with food in the form of honeydew or other nutritive secretions and in return are protected and transported by the ants.

Ectosymbiont mites have been studied mainly in the formicine genera *Lasius* Fabricius and *Formica* Linnaeus (Janet, 1897a,b; Wasmann, 1902;

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Wheeler, 1910; Samsinak, 1960) and in *Eciton* Latreille (Rettenmeyer, 1960). In the myrmicine ants, they have been investigated in the genera *Aphaenogaster* Mayr, *Crematogaster* Lund, *Tetramorium* Mayr (Hunter, 1964; Kistner, 1982) and *Solenopsis* Westwood (Ebermann and Moser, 2008). Spatial distribution of mites on the host is often nonrandom, particular species are found on one specific part of the host. Location may vary by species and sex of the host (Cross and Bohart, 1969; Krantz, 1978). Numerous cases of mite-ant associations have been described. Most of them were considered as phoretic or commensalist and very few were considered as parasitic (Eickwort, 1990; Hölldobler and Wilson, 1990; Ito, 1994; Schmid-Hempel, 1998; Perotti and Braig, 2009; Berghoff *et al.,* 2009).

Monomorium niloticum Emery is the most conspicuous and abundant of the larger *Monomorium* species throughout western and central areas of Saudi Arabia. It is a household pest, abundant in coastal areas, cultivated farm land and in the neighborhood of dwellings. *Messor meridionalis* André is harvester ants found in arid regions, they often have a polymorphic worker caste. *Tapinoma simrothi* Krausse are small pale brown to black dolichoderine ants nesting in soil or rotten wood and are active daytime scavengers (Collingwood, 1985, 1996).

The following study aims to answer the questions: Which mite species are associated with the ant species? Do the mites have specific attachment sites? and Do the mites number fluctuate over time?

MATERIALS AND METHODS

Collection and maintenance of ants

Seven *M. niloticum* colonies were collected from a residential area near Al Ghat Governorate, while 11 colonies *T. simrothi* and four colonies of *Me. meridionalis* were collected from an agricultural area near Majmaah Governorate, North Riyadh, Kingdom of Saudi Arabia (KSA). Colonies were housed for maximum 100 days starting from the date of collection at 28 ± 1 ºC, relative humidity approximately 30% and a photoperiod of 12:12 (L: D) h. ants were collected with some soil from the natural habitats and housed in a plastic nest which consists of a bottle partly filled with some soil granules. The bottle was placed in a large plastic box (45 x 30 x 18 cm) that was used as a foraging area. Colonies were given water, sugar syrup or honey, and segments of fresh mealworms three times per week. To prevent drying, a few drops of water were added to the soil as needed. For the purpose of study, five hundred to 1500 individuals were collected from each ant colony.

Mite identification

Mite species were separated from ant individuals by using a very fine camel hair brush under the stereoscopic microscope, and then, transferred into small pots. Mite individuals were prepared for microscopic study by using the methods was proposed by Grandjean (1949), in which a slide with a medium concaved area and a thin glass cover (20x20) mm. were used. Mites are covered with a few drops of lactophenol (clearing agent) in the medium of the concaved area, and put the glass cover over a slide with its margin along the transverse axis of the slide, leaving a space to transfer the mite individuals to be examined taxonomically under the stereomicroscope or even under microscope. The specimen may be orientated in any direction inside the cavity by moving the cover glass back and forth nicely. Slides are heated mildly on a hot plate until they become transparent. This mounting as a technique is very useful for quick identification of samples. Mites identification was based on illustrated keys (Eraky and Osman, 2008) using the research microscope (Olympus-BX51). Voucher specimens have been deposited in collections of Museum of Zoology, College of Science, King Saud University, Riyadh, KSA.

Distribution and abundance of mites associated with ants

Ants from each reared colony were checked for mites' location and number under a dissecting microscope (70-400X), number of ants varied depending on purpose of the observation. To examine the density of mites, 300 ant workers (20 – 50 ants per colony) were examined from each ant species. General collections of mites were made by putting ants in 70% ethanol and immediately examining the location and number of mites. The mites dislodged slowly from ant body once submerged.

The distribution of mites on the head, thorax and abdomen of *T. simrothi* (total of 173 ants) and *Me. meridionalis*(a total of 135 ants) were separately examined. Because there are three sizes of *Me. meridionalis* workers, we investigated the distribution of mites according to the worker sizes. Three size classes of workers were distinguished in the *Me. meridionalis* colony: small (approx. <7 mm length), medium (7–10 mm length) and large (approx. >10 mm length). The temporal changes in abundance of mites were examined for *T. simrothi* and *Me. meridionalis* laboratory colonies (about 1500 individuals each), 20 to 120 workers were examined every 10 days. Due to the low count of *M. niloticum* colony, distribution and temporal change in abundance of mites could not be described. Voucher specimens have been deposited in collections of Museum of Zoology, College of Science, King Saud University, Riyadh, Kingdom of Saudi Arabia.

Statistical analysis

All statistical analyses were undertaken using MINITAB software (MINITAB, State College, PA, Version 13.1, 2002). Data from all experiments were first tested for normality using Anderson Darling Test. Because data were not normally distributed, Kruskal-Wallis was used to test the overall differences prior to individual comparisons within treatments using the Man-Whitney non-parametric *U* test.

RESULTS

Distribution and abundance of mites associated with ants

Results revealed the presence of the deutonymphs of three mite species: *Cosmoglyphus barbisetus*, *Forcellinia egyptiaca* (Acari: Acaridae) and *Histiostoma sammari* (Acari: Histiostomatidae) that were detected on *T. simrothi, M. niloticom and Me. meridionalis* respectively (Table I).

The preferred sites for host attachment of each mite species differed according to the species. The deutonymphs of *C. barbisetus* were more common on the head region (62.91%, $P < 0.01$) of *T. simrothi* comparing to the abdomen (30.58%) and the thoracic (6.52%) regions.

Table I.- Mites associated with three ant species.

Mite species	Ant host	Location	Relationship with ants
F. egyptiaca (Acaridae)	*M. niloticum*	Al Ghat, Riyadh	Phoretic; on ant body
C. barbisetus (Acaridae)	*T. simrothi*	Majmaah Governorate	Phoretic; mostly on ant Head
H. sammari (Histiostomatidae)	*Me. meridionalis*	Majmaah Governorate	Phoretic; mostly on ant head and abdomen

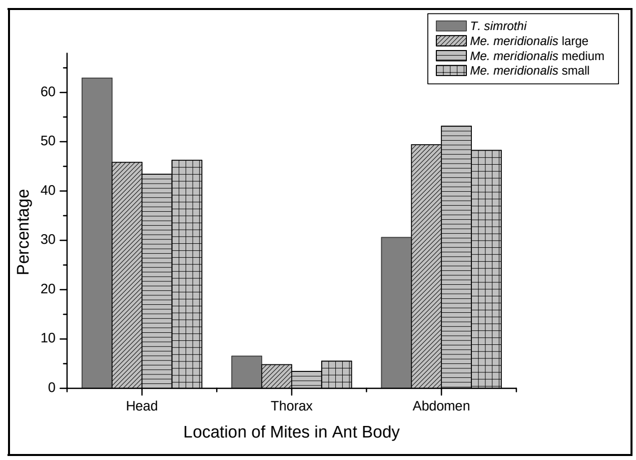

Fig. 1. Distribution of mites on body parts of *T. simrothi and Me. meridionalis*

In *Me. meridionalis,* no difference was recorded in the percentage of mite distribution according to the size of workers. Most of the *H. sammari* mites were found on ant abdomens and heads. On the abdomen, the percentages were 48.24% in small, 53.14% in medium and 49.4% in large workers. Similar results were obtained for the percentages on the head since, 46.23%, 43.43% and 45.82% were obtained on small, medium and large workers, respectively. Only 5.53%, 3.43% and 4.78% of the mites were found in the thorax of small, medium and large worker, respectively (Fig.1). Unlike the *T. simrothi* that recorded a highly percentage of ants with mites (63.11±12.01 ants), *Me. meridionalis* (small: 13.47±3.75, medium: 15.74±6.09 and large: 20±6.19) and *M. niloticum* (9.37±1.03) showed relatively lower percentages (Table II). The mite density on *T. simrothi* ranged from 1.7 to 21.4 per ant (mean =9.95±1.28). They were mostly found on the dorsal or lateral sides of the ant head, and they moved rapidly when disturbed. Mite density on *Me. meridionalis* ranged from 0.8 to 5.7 per ant (Small: 6.29±1.18, Medium: 0.64±0.18, Large: 6.95±1.15). The density of *F. egyptiaca*, a rarely observed species that lives on *M. niloticum*, was 0.8±0.01 with a range from 0.3 to 4.4 per ants.

Temporal changes in mite populations

Mite populations varied not only among ant colonies, but also changed over time. *T. simrothi* colony was observed in the laboratory for two months (Fig. 2). The density of mites was 9.95 (n = 50) per ant when ants were collected from the field. The mite densities dropped and fluctuated to 2.11-1.32 mites per ant when held in the laboratory.

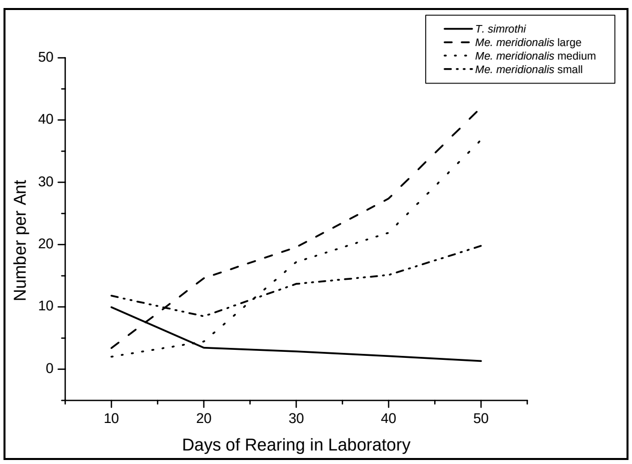

Fig. 2. Temporal changes in mite populations in a *T. simrothi and Me. meridionalis* colonies reared in laboratory.

In *Me. meridionalis* colony the percentages of ants with mites varied between 55-95% (n = 20) in five examination dates and the colony showed an increase in mite population and decrease in ant numbers (Fig. 2). The average mite density was 3.4, 2 and 11.8 mite/ant 10 days after being kept in laboratory in the large, medium and small worker, respectively. After 50 days of rearing in laboratory, the mite density increased to 42, 36.8 and 19.8 mites/ant in the large, medium and small worker, respectively.

DISCUSSION

The Astigmata is a diverse and widely distributed monophyletic group of mites within the suborder Sarcoptiformes. It is the most successful group of mites in establishing symbiotic relationships with both vertebrates and invertebrates (Houck and O'Connor, 1991). The vast majority of acarine species in most social insect nests are scavengers or predators on other arthropods and do not adversely affect the ecology of the host (Eickwort, 1990).

This study provided information on three astigmatid mite species found in association with three ant species in soil habitats. Four species of *Scutacarus* and one of *Imparipes* (Acari: Scutacaridae) are documented from workers of the red imported fire ant *Solenopsis invicta* Buren in Louisiana and Tennessee, U.S.A. In addition, one *Imparipes (Imparipes) louisianae,* and two *Scutacarus nanus* and *Scutacarus tertius* were described by Ebermann and Moser (2008).

In this study, the preferable site for attachment of mite species was the head in *T. simrothi* and the head and abdomen in *Me. meridionalis*. Silvestri (1912) and Jacot (1939) found that *Aenicteques chapmani* and *Messoracarus mirandus* attaches on or below the heads of worker ants, where they are palpated by the ant`s antennae and may steal provisions from their hosts. *Laelaspis equitans* in *Tetramorium* nests rides on the head of ants (Donisthorpe, 1927; Michael, 1891). *Antennophorus grandis* attaches to the head of ants and coaxes trophallaxis (Eickwort, 1990). *Urodiscella philoctena* clings to the legs of its ant host and feeds on a substance which the ant scrapes from its body (Houck, 1994). *Antennophorus* mites, found in nests of *Lasius* and occasionally in nests of other ants (Donisthorpe, 1927; Janet, 1897a). Species of *Oplitis* and *Urodiscella* often attach to the foretibial comb of workers, from which they apparently obtain food from particles groomed by the ants (Donisthorpe, 1927; Pecina, 1980).

Table II.- Abundance of mites associated with three ant species.

Ant species	No. of colonies examined	Total number of ant workers examined	Percentage of ants with mites (Mean ± SE)	No. of mites per ant (Mean ± SE)
M. niloticum	7	300	9.37±1.03	0.8±0.01
Me. meridionalis	4	Small: 100 Medium: 100 Large: 100 Total: 300	Small: 13.47±3.75 Medium: 15.74±6.09 Large: 20±6.19	Small: 6.29±1.18 Medium: 0.64±0.18 Large: 6.95±1.15
T. simrothi	11	300	63.11±12.01	9.95±1.28

Trichocylliba comate frequently attach symmetrically to the abdomen of ant larvae and workers (Donisthorpe, 1927; Janet, 1897b). Within the nest, *Acropyga epedana* workers were heavily parasite by mites. The mites infested most body parts, but seemed to prefer the meso- and metathorax, with many workers having mites symmetrically positioned on either side of the thorax. Mites are also common on the underside of the head (Smith *et al.*, 2007).

The temporal changes in mite populations by decreasing as in *T. simrothi* or by increasing as in *Me. meridionalis* could be due to rearing conditions. The mite tolerance of African bees (Medina and Martin, 1999), climatic conditions (Moretto *et al.*, 1991), and the different *Varroa* genotypes (De Guzman *et al.,* 1998), seem to be important factors in the population dynamics of the mite.

In conclusion, the mites *Forcellinia egyptiaca* and *Histiostoma sammar* were recorded on the ants *Monomorium niloticum* and *Messor meridionalis*, respectively. The mite *Cosmoglyphus barbisetus* was recorded on the ant *Tapinoma simrothi*. The abundance of mites varied among colonies, ant species, ant body parts and also over time.

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