

Nests Structures of *Messor arenarius* Ants Compared with Nests Structures of Other Harvester Ants

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Abstract

Messor arenarius (Fabricius) are harvester ants, which are distributed mainly in deserts or sandy regions in the Middle East and North Africa. Nests structures of *M. arenarius* ants, are compared here with nests structures of other harvester ants. Nests of harvester ants are combined of corridors, storage rooms, nurseries and also other rooms. In nests of some species of *Pogonomyrmex*, most of the rooms were found in superficial layers of their nests. However, in nests of *M. arenarius* ants, most of the rooms, which also include storage rooms as well as nurseries, were found in deeper layers of their nests. That difference is related to differences in the climates between the regions where those ants are found. While *Pogonomyrmex badius* ants usually inhabit temperate or humid regions, *M. arenarius* ants inhabit mainly desert regions. Another aspect of nest building in harvester ants, is that although those ants build nests, that are often widespread in the area, those nests can be connected inside the ground, thus forming a “territorial continuum”.

Keywords

Ants, Deserts, *Messor*, Micro-Climate, Micro-Habitats, Nest Structure

1. Introduction

Messor arenarius (Fabricius) are desert harvester ants which were first identified by Fabricius in 1787 as *Formica arenaria* ([1], p. 310). Forel [2] was the first researcher who gave those ants their name: *Messor arenarius*, which is also the current name of that ant species. Forel [3] exposed, some nests of *M. arenarius* in the highlands of the Sahara Desert. In spite of the good character of the area where those nests were located, which was combined of humid sand, with also natural

erosion, he had to give up on that task, because that ants' nest was so large, and he concluded, that such a nest could cover a total area of about 50 - 100 square meters, with a depth that could reach 2 meters. Lameere [4] worked on different habitats of *M. arenarius* ants in the Sahara Desert, especially in Algeria and also in Tunisia. He found those ants, in areas where the desert soil was combined of sand, and also where there was enough vegetation that could supply some kinds of seeds for those ants. Those ants were not found by Lameere [4], in areas where the soil was not sand, or in areas that did not contain vegetation. He found around nest entrances of those ants, sand craters that had shapes of crescents with diameters of up to 50 cm each. Those craters were combined of sand which those ants brought from inside the ground. Those ants let the wind spread the sand that they gathered around their nest entrances. They had to dig their nests, to an amazing depth in order to find some soil with humidity which is sufficient to grow their larvae. Also Lameere [4], like Forel [3], did not succeed to reach in his dig, the incubation rooms or the granaries in those nests of those ants. He found, that each of those nests had some entrances with distances of about 10 meters from each other. He assumed that the surface area, of such a nest was larger than what was mentioned by Forel [3], and that it could reach hundreds of square meters, probably because of that reason he called the *M. arenarius* ant species: "the most powerful animal of the desert" ([4], p. 165).

2. Nests Structures of *Messor arenarius* Ants

Delye [5] investigated the biology, as well as the ecology of *M. arenarius* ants in the Sahara Desert. He dug some nests of those ants mainly in the Béni Abbès region, in Algeria. He found that inside nests of those ants close to the surface area, there was a system of corridors with slight inclinations, from which exit holes were opened on each evening. Apart of that, he found on each of the nests he checked, 1 - 5 such holes with distances of 2 - 3 meters from each other. He found that vertical or diagonal corridors in those nests, were rare. Diagonal corridors inside those nests reached the humid layer of the sand. Sometimes those corridors became wide, where in some cases formed or form rooms, which contained or contain remains of plants or seeds. Those diagonal corridors reached depths of 60 - 80 cm, with a slight inclination. In such depths rooms were rare. Delye [5] did not succeed, to expose the internal area of those nests completely, although he tracked those corridors, up to a depth of about 3 meters. As for nest entrances of *M. arenarius* ants, he found that those were characterized by craters or by half crescents of sand balls (Figure 1). He also found that when seeds of plants could not been found, ants collected also other different parts of plants, such as stems or leaves.

Delye [6] continued his work, and found that *M. arenarius* ants, doubled the number of the corridors and the rooms in their nests, as the number of ants increased. Worker ants had to clean their nest entrances on each evening in order to let their nest-mates to go out and collect food. The sand balls that those ants removed from inside their nests were kept in their shape for a while, and the prints

of the mandibles of those ants could be seen on them. Delye [6] exposed in such a nest of *M. arenarius*, a society of about 1500 ants. The entrances of that nest were organized in groups. Each of them, led to a corridor, with a diameter of 0.5 - 0.7 mm. Those corridors were connected to each other, and also had slight inclinations. Along those corridors there were small rooms with widths of 3 - 5 cm and heights of about 1cm. The length of each of those corridors, could reach a distance of more than 10 meters. In those corridors, worker ants were gathered on each evening when they were about to start their re-dig of their nest entrances, or their foraging outside their nest. In a depth of about 2 meters inside those nests, there were food granaries. In those nests that were checked in the Sahara Desert, the granaries were very full in April 1969. Delye [6] found in some of those granaries, ant larvae lying on a “mattress” of grains. Together with those larvae he found small worker ants with lengths of 5 - 6 mm, that their duty was to take care on those larvae by feeding them or by cleaning them. Those worker ants appeared on the ground surface rarely. The biggest granary that was dug in that work, was with a length of about 40 cm, a width of about 10cm, and a height of about 2 cm. The distance between the bottom of the deepest granary in that nest, and the roof of the highest granary in that nest, was not more than 25 cm.



Figure 1. A nest mound of *Messor arenarius* ants, in a sandy area in the Coastal Plain of Israel. Photographed by Ittai Warburg, in a certain time during the 1990's.

3. Nests Structures of Other Harvester Ants

McCook [7] was a pioneer in checking structures of nests of harvester ants. He found that around nest entrances of *Pogonomyrmex barbatus* (Smith) there were nest mounds which he called “nest discs”, that had diameters that ranged from 60 cm to 4 meters. In the nests he checked, a nest entrance was usually found in the middle of a nest mound. Inside those nests he found storage rooms—granaries, as

well as rooms for rising ants' larvae—ants' nurseries. The granaries in those nests were found below the nest entrance, which was underneath the middle of each nest mound [7].

Wheeler [8] found that an ants' nest contained chambers and galleries. Those chambers were more spacious with flattened floor and variable sizes and outline. Those galleries were more tenuous and were used as connections between those chambers or between chambers of the nest and the nest entrance ([8], p. 199). According to Wheeler, every ant species had its own type of nest construction, which was adapted to its environment ([8], p. 192).

Lavigne [9] dug nests of *Pogonomyrmex occidentalis* (Cresson) in Wyoming, U.S.A., between the years of 1966 - 1967. He found then differences in nests structures between colonies of different ages, and therefore of different numbers of ants in them. In that research, many chambers were found in the upper layers of those nests, which were between the soil surface and depths of 30 - 46 cm. In older colonies there were found additional larger chambers in greater depths of those nests. Such older colonies with more ants contained also more tunnels (corridors). The nurseries of those ants were found in upper (superficial) layers of those nests directly below the nest mounds. Those nurseries were relatively large chambers. Additional large chambers were found in the deeper layers of those nests, and those chambers were used by those ants to spend winter times. The maximal depth of a nest of *P. occidentalis* was found to be 2.7 - 2.8 meters.

MacKay [10] reconstructed a nest of *Pogonomyrmex montanus* MacKay, and found that also that nest had numerous burrows, which were rooms, in its upper level. Below that level, he found a main vertical tunnel that led to the bottom of that nest, which was in that case, in a depth of 60 - 70 cm. Most of the ants in that nest were found in the burrows which branched from that main tunnel. In nests of *Pogonomyrmex subnitidus* Emery, he found 2 major tunnels which were separated from each other, with a distance of a bit more than 1 meter. The nests of *P. subnitidus* and also of *Pogonomyrmex rugosus* Emery were of similar construction but were deeper than of *P. montanus*, and reached depths of 3 - 4 meters [10].

Tschinkel [11] checked the nest structure of *Pogonomyrmex badius* (Latreille) in Florida. He found, that a colony of about 5000 worker ants dug 20 kg of sand during 4 - 5 days while building their nest, and that such an event can happen once or twice a year. Tschinkel [11] also found that nests of *P. badius* ants were composed of shafts (corridors), as well as chambers (rooms). The diameter of those shafts varied between 1 cm in deeper parts of those nests, and 2 cm in superficial parts of those nests. The shafts in those nests were found to be diagonal with different angles. As for chambers in those nests, Tschinkel [11] distinguished between superficial chambers, which could be found in depths of 10 - 15 cm, and also deeper chambers. Those 2 types of chambers were found to be different from each other in their shapes. Tschinkel [12] found that nests of ants, which were built in the ground, were usually composed of vertical corridors together with chambers of variable shapes. He concluded that those chambers were more fre-

quent close to the ground surface, than in deeper parts of the ants' nests. Tschinkel [12] also determined, that nests of most ant species, do not contain loops, and that they have a tree-like structure.

4. Discussion

Nests structures of different species of harvester ants differ from each other [12]. However, most of the nests of harvester ants are combined of different layers. A nest of *M. arenarius* ants, seems to be combined of the following horizontal layers. 1) An upper (superficial) layer, which contains vertical or diagonal corridors; 2) An intermediate layer, which contains corridors together with storage rooms; 3) A deeper layer, which contains corridors together with nurseries, which are rooms for rising ants' larvae. It seems, that the width of each of those layers, as well as the total depth of a *M. arenarius* nest, vary according to the following parameters. 1) The age of the ants' colony; 2) The type of the soil in which that nest of ants was dug. 3) The formation of soil in which that nest of ants was dug. 4. The climate in the habitat of that nest of ants.

From the findings about nests structures of some species of *Pogonomyrmex*, it seems that those ants, do not have the same nests structures, as those of *M. arenarius*. For instance, in some species of *Pogonomyrmex*, chambers (rooms) were found in upper (superficial) layers of those nests, whereas in *M. arenarius*, such rooms are in deeper layers of their nests. The nurseries in *P. occidentalis* were found in superficial layers of their nests [9], whereas in *M. arenarius* those were found in deeper layers of their nests [6]. Those differences seem to be due to climatic differences. The habitats of *P. occidentalis* are usually temperate or humid, like those in Wyoming that were checked by Lavigne during the 1960's [9]. However, the habitats of *M. arenarius*, are mainly deserts.

The habitats of *M. arenarius* ants, are deserts or sand dunes areas even in Mediterranean regions. In those sand dunes areas, because of some features of the soil, the conditions in the soil are similar to those of deserts. *M. arenarius* ants cannot build many rooms close to the ground surface because of the following reasons. 1) High temperatures of the desert soil surface or of the sand during hot days in most of the year; 2) The fact that in many areas of sand dunes, the upper levels of the sand are not stable enough in order to maintain stable rooms inside their nests. That is not the case in deeper layers of *M. arenarius* nests, where the temperatures are cooler than those close to the ground surface, the humidity is higher than that close to the ground surface, and also the soil is more stable than that close to the ground surface.

The fact, that in deeper levels in habitats of *M. arenarius*, the soil is more stable than close to the ground surface, is a result of the following parameters. The formations of the soils in those areas. In deeper layers of sandy areas, the soil is more packed or dense, than in superficial layers in those areas. Roots of perennial plants stabilize the ground especially in its deeper levels. In some nests of *M. arenarius*, I found in the 1990's, that some entrance corridors of each of those nests, were

dug along major roots of *Retama raetam* (Forsskal) Webb. *R. raetam* is a bush, that also serves as a main natural source of food for those ants, and is actually an ecological niche also for those ants in habitats in the Coastal Plain of Israel [13], or in the Negev desert in Israel [14] (Figure 2). It seems also, that some entrance corridors of *M. arenarius* nests, lean on major roots of *R. raetam* in those areas. Those roots seem to stabilize the sandy soil, and maybe they serve also as “constructional foundations” in the building of *M. arenarius* nests in those areas. That can enable, *M. arenarius* ants, to build major tunnels in their nests, in which the movement of those ants, can be easier or faster. Additionally, the roots of *R. raetam* which contain also water, form microhabitats in those entrance corridors of *M. arenarius* nests, which are more humid and temperate than the sandy soil itself. This also gives those ants an advantage or some advantages in those habitats. The relations between *M. arenarius* ants and *R. raetam* plants seem to be mutual, because the spaces that *M. arenarius* ants form near roots of those bushes let more fresh air also to penetrate into the ground that surrounds those roots. So, we can see also a kind of symbiosis between *M. arenarius* ants and bushes of *R. raetam*.



Figure 2. A bush of *Retama raetam*, in a sand dunes area near Or-Akiva in the central Coastal Plain of Israel. The sand beneath that bush looks like, a nest mound of *Messor arenarius* ants. Photographed in August 2020 by Ittai Warburg.

It seems, that no researches were done about the structures of nests of *M. arenarius* ants in loess soil of desert habitats. Therefore, we cannot compare hereby nests structures of *M. arenarius* ants between habitats of sandy soil, and also habitats of desert loess soil.

Warburg & Steinberger [15] found that *M. arenarius* nests in the Negev Highlands have an ordered spatial distribution, with an average distance of about 20 meters between each two neighboring nest entrances. That kind of spatial distribution was related, to an intraspecific competition between *M. arenarius* ants of different nests in that area, which means also, that such each two neighboring nests entrances were of two different colonies. How can this conclusion, settle with the determination of Forel [3], that the total area of a *M. arenarius* nest can reach dozens of square meters, or with the determination of Lameere [4], that such a nest's area can reach hundreds of square meters. An answer to that can come, from a theory of Zakharov [16]. According to Zakharov [16], some ants' adjacent nests are connected between them possibly inside the ground, though forming a "territorial continuum". That structure of ants' populations, gives those ants some advantages: exchange of genetic material, optimization of population density, and also restoration or reconstruction of ants' colonies under harsh conditions. Forel already, raised a similar idea. He wrote, that a monodomous ant colony, is also a circumscribed unit, whereas a polydomous ant colony, can also spread over several nests, which communicate with each other ([8], p. 198). It is possible therefore, that a population of *M. arenarius* ants, can also include different colonies in different nests, that are distributed orderly, but may be also connected inside the ground, to form an ants' "territorial continuum", like probably was observed also by Forel [3] or by Lameere [4].

It is still unknown where in their nests, some harvester ants including *M. arenarius*, produce the so-called "ants bread", with which they feed their larvae. The ants bread in harvester ants is formed of plant seeds which those ants collect. Future research on ants, can give us an answer to that question, and also advance our knowledge about ants' ecology.

5. Conclusion

The main findings presented here, are that in nests of *M. arenarius* ants, the nurseries and also the granaries, are located in their deeper layers, where there is also a microclimate of cooler or more humid conditions in most of the year. That phenomenon also seems to be an adaptation to desert conditions, as the main habitats of *M. arenarius* ants, are in deserts.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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