WETLAND ANTS: INTERNAL MOUND TEMPERATURE AND HUMIDITY PREFERENCES; LOCATION AND SHAPE OF MOUNDS AS ADAPTATIONS TO A WETLAND ENVIRONMENT

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Abstract

Formica montana, a mound building wetland ant, was studied during the autumn of 1979 in a sedge meadow at Waubesa Wetlands, town of Dunn, southern Dane County, Wisconsin. The report is divided into two parts.

Part I deals with the effects of temperature and humidity on ant activity within the mound nest. By disecting an ant mound with a clear sheet of plexiglass, the activities of the ants could be observed within the mound. Ants were observed stratified in the warmest and most humid parts of the mound nest, even when the temperature levels within the mound were artificially manipulated.

Part II describes the location and shape of the mound. An association between the location of red-osier dogwood (*Cornus stolonifera*) and *Formica montana* mounds was observed. A number of hypotheses are suggested to explain the association. The shapes of different-aged ant mounds suggest that ants first build their mounds up, above the surface of the wetland, and then out, at which time they crop the vegetation that otherwise shades the mound's surface. By constructing mounds in this manner, wetland ants maximize the range of temperatures and humidities available.

INTRODUCTION

Formica is a genus of ants noted for distinct methods of nest construction (Creighton, 1950). According to Wheeler (1910), there is much variability in nest architecture, not only within a genus of ants but also within a species. The architectural variability within a species depends on the habitat and the time of year. *Formica montana,* an ant that builds a mound nest, occupies a variety of habitats with peat soils, including prairie remnants, sedge meadows, and forests (Ohio to Colorado) (Francoeur, 1973). These animals and their mounds were studied in a sedge meadow in southern Wisconsin during the cool autumn months, when the ants stayed inactive within their mounds.

Mound building wetland ants find themselves in a curious situation. I know of no other strictly terrestrial burrowing animal that spends its lifetime in peat soil periodically flooded by a fluctuating water table. Mound flooding is not the only hazard: wetland ants are ectothermic and must also contend with unfavorable temperature fluctuations. This study views these problems by considering certain characteristics of the ants' mound. Denning *et al* (1977) studied *Formica cinerea montana* mounds and found that the mounds' properties were similar to those of gravel; thus the mounds' clayey wetland soil drains quickly. More attention has been given to the thermal properties of mounds. According to Raignier (1948) and von Frisch (1974), an earthen mound offers a selection of temperatures and humidities that can change by the hour. In the early and late hours of daylight, the dome shape allows the mound to receive about three times the solar radiation that could be obtained on a flat area of the same radius.

This study is divided into two parts. Part I reports the investigation of ant behavior within the mound, including adjustments to the fluctuating water-table, natural and controlled autumn temperatures, and humidity. Part II is concerned with the relationship between ant mounds and the surrounding vegetation, and proposes a strategy for mound construction by ectothermic terrestrial animals in a wetland environment.

Methodology

Formica montana, identified by A. Francoeur, Université du Quebec a Chicoutimi, was studied during September, October, and November 1979 at a sedge meadow in Waubesa Wetlands, Dane County, southern Wisconsin.

Part I

Eight ant mounds were excavated to examine their basic structure and stratification of ant activity. One mound, hereafter referred to as the test mound, was bisected by a clear plexiglass sheet that extended well below the water table. One half of the bisected mound was packaged in plastic so that it could be removed during periods of observation and then replaced. Seven copper-constantan thermocouples were secured to the vertical midline of the plexiglass, spaced at 10 cm intervals at and below the surface of the mound (see figure 1). Mound temperatures were taken on seven days in October. Millivolts, later converted to degrees Celsius, were recorded with a potentiometer. An electric heating rod, in circuit with a variable transformer, was placed 35 cm below the mound surface and next to the plexiglass in the permanent half of the mound. The percent moisture available to the soil, recorded with a Bouyocous moisture meter (model BN-2N) on four days in October, was measured at five depths on and below the surface of the test mound (see figure 2).

Part II

Height and width of each mound to the nearest dm, fraction (to the nearest third) of the mound top covered by vegetation, and the distance between a mound and the nearest red-osier dogwood (*Cornus stolonifera*) were recorded for each of 122 mounds. A chi-square test was performed to determine

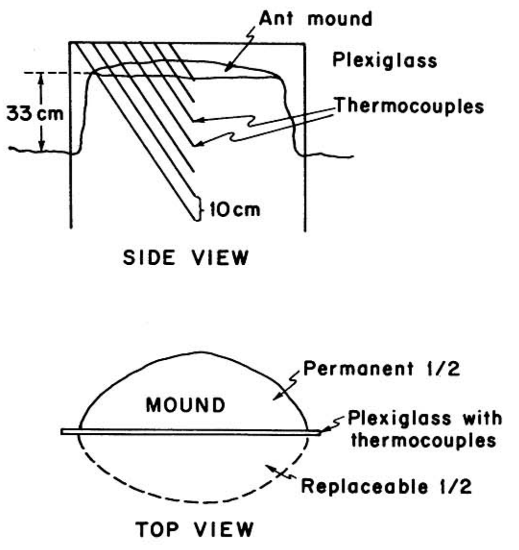

Fig.1. Test mound showing placement of plexiglass and thermocouples.

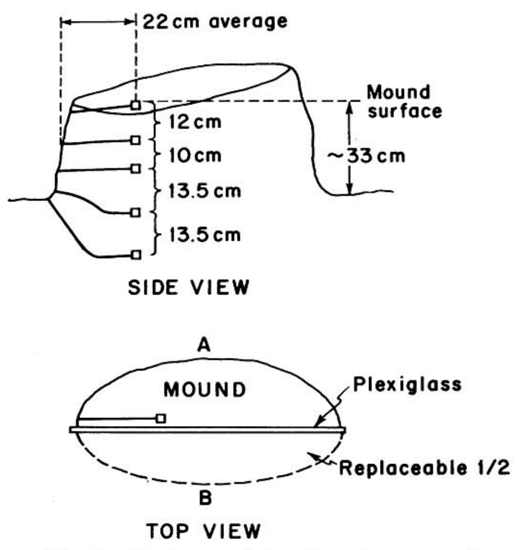

Fig. 2. Test mound showing placement of soil moisture detectors.

whether or not the amount of vegetation covering an ant mound was correlated with the shape of the mound.

Results and Discussion

Part I

Ant Activity Within Their Mounds

Eight excavated ant mounds revealed a network of burrows that extended over 1 m below the wetland surface, more than 65 cm below the lowest recorded water table level. Ants must have been present and active 1 m below the wetland surface when water table levels were lower. Water table levels did drop below 50 cm beneath the wetland surface between 1 April and 30 July 1979 (DeWitt, pers. comm.). Ants were consistently found immediately above the water table in a 2-4 cm horizontal stratum of burrows. These burrows were completely filled with apparently inactive ants. The water table level, measured daily throughout the study period, rose 20 cm. Although appearing completely inactive, the ants were actually active enough to stay just ahead of the rising water. While excavating one of the eight mounds, I discovered a chamber filled with ant pupae. This chamber was unattended and well above the stratified adults. According to Wilson (1970), however, the larvae and pupae are closely attended by adults who move them to areas of preferred temperature and humidity. There are two possible reasons why the pupae were left unattended. First, little development occurs during the cold fall months; chambers at optimal temperatures for pupal development are not available to the ants at this time. Second, *Formica montana* adults are likely to deposit the pupae high in the mound where they will not be flooded by the rising autumn water table.

Temperature Preferences of Ants

Temperatures at the mound-plexiglass interface, level of water to the nearest thermocouple, and location of horizontal strata containing ant activity were recorded on seven days in October (table 1). Because the heating rod was not in place on 13 or 16 October, the highest mound temperatures were at the water table. As expected, the ants clustered in the burrows 5-7 cm above the water table on both these dates. Although the ranges, throughout the entire test mound, of temperatures on 13 and 16 October were only 1.7°C and 2.6°C respectively, the ants were found at the highest constant temperature, that of the water table and peat directly above it. The mound surface temperature fluctuated widely owing to highly variable external weather.

The ants moved from the burrows adjacent to the water table to the preferable

TABLE 1. Temperatures recorded in 7 different strata within test mound.

Date on which thermocouple temperatures (°C) were recorded	*Thermocouples distances (cm) below test mound surface*							*heating rod*	*air temp.*
	0	*10*	*20*	*30*	*40*	*50*	*60*		
13 Oct.	9.1	10.6	9.8	10.4	10.75	10.75	10.75$_{w}$[a]	—	9.25
16 Oct.	13.3	9.5	9.8	10.0	9.3	10.5	10.75$_{w}$[a]	—	13.0
18 Oct.[b]	15.1	10.3	10.8	10.8[a]	12.6[a]	10.4[a]	10.25$_{w}$	37.5	—
20 Oct.	22.0[a]	18.75[a]	16.5[a]	16.75[a]	14.5	10.75$_{w}$	10.5	44.25	—
23 Oct.	5.25	9.5	13.0[a]	12.75	13.74	13.25$_{w}$	11.0	—	—
25 Oct.	2.75	5.25	8.5[a]	11.75[a]	12.5	10.5$_{w}$	11.75	39.25	—
30 Oct.	18.0	12.0	16.75[a]	19.25[a]	20.5	11.5$_{w}$	10.6	74.75	—

[a] Ants active at this depth
[b] Permanent placement of heater
$_{w}$ water table level to nearest decimeter

higher burrows after the placement of the electrical heating rod. The heating rod increased the temperature of that part of the mound by as much as 9.75°C. Before the heating rod was in place, the only special quality of the peat just above the water table was that it had the highest temperature available to the ants. The ants definitely preferred levels in the mound with higher temperatures. No doubt the higher mound temperatures in the summer months would be found at the surface, and one would expect the ants to be active nearer the surface at that time of year.

Soil Moisture Preference

Moisture available to the soil in the part of the mound occupied by ants was always 100%. Drier strata were available to the ants on 13, 16, and 18 October. Although the percent moisture available to the soil is not a measure of relative humidity, the soil surrounding the ant-occupied burrows was saturated. Therefore, I assume that the air in the burrows was close to, if not at, 100% relative humidity. These wetland ants did not differ markedly from those studied by von Frisch (1974) which preferred 100% relative humidity.

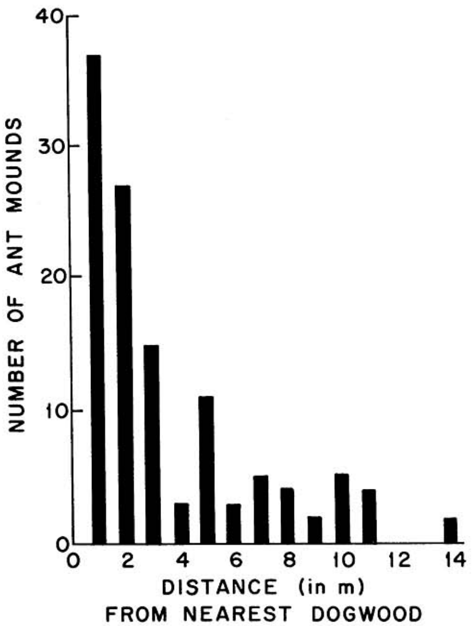

Fig. 3. Number of ant mounds vs. distance from dogwood shrubs.

Part II

Association of Ant Mounds with Vegetation

Mounds were most likely to be near a red-osier dogwood (see figure 3). Red-osier dogwood is a species that tolerates a great deal of water in the soil, but, like the wetland ants, it cannot tolerate permanent submergence of the entire root system. Wetland ants can only survive between the wetland surface, somewhat elevated by their mound, and the water table. With the water table fluctuating as a result of precipitation, artesian water sources, and evapotranspiration during the growing season, the thickness of habitable peat available to these ants changes constantly. A habitat that consistently offers a greater vertical space between the wetland surface and the water table will also offer a greater range of temperatures and humidities. Maximizing this vertical space would be advantageous to an ectothermic animal such as *Formica montana*.

There are many plausible explanations for the observed association between wetland ants and red-osier dogwood:

1) The ants and dogwood are both adapted to a habitat that is not frequently inundated with water.
2) The dogwoods supply the ants with a preferred food source.
3) The dogwoods locally create a suitable ant habitat by evapotranspirative depression of the water table.
4) The ants aerate the soil for the root systems of the dogwood.

Ant Mound Structure

Formica montana mounds are cylindrical. The dimensions of the mounds vary; some mounds are taller than wide while others are

TABLE 2. Number of ant mounds with a specified shape and amount of vegetation covering the top surface.

	Less than ⅓ covered by vegetation	*⅓-⅔ covered by vegetation*	*⅔ to fully covered by vegetation*	*T*
Mound as tall as wide	9	9	12	30
Mound taller than wide	1	16	10	27
Mound wider than tall	21	22	3	46
T	31	47	25	103

Null Hypothesis: The amount of vegetation covering an ant mound is independent of the shape of the mound.
d.f = 4; $\chi^2 = 23.57$; p∠,01

wider than tall. Vegetation is cropped by the ants from the top of some of the mounds exposing bare soil. A chi-square statistic was used to test the null hypothesis that the amount of vegetation covering an ant mound is independent of the shape of the mound. The test revealed that a mound whose width is greater than its height is likely to be void of vegetation on its top, whereas a mound whose height exceeds its width is likely to have an abundance of vegetation on its top ($\chi^2 = 23.57$, p∠0.01; see Table 2).

Assume, as did von Frisch (1974), that a primary function of ant mounds is to increase the surface area exposed to solar radiation, thereby facilitating heating. The data suggest the hypothesis that wetland ants first build their mounds up, and then out, in order to maximize the amount of mound space with preferred temperatures and humidities. The larger the mound, the more ants reside therein. All the ants of a mound are closely related, being the offspring usually of one queen (Wilson 1970). Time is needed to build a population and a mound large enough to house it. The largest mounds are the widest mounds. Since the largest mounds are most likely the oldest, and the narrowest mounds most likely the youngest, ants first build their mounds up and then out. By building their mounds up the ants create a larger vertical habitat subject to a larger range of temperatures and humidities. By building the mounds out, the ants keep the surrounding grasses and sedges from shading the top of the mound. By cropping the top vegetation, the ants allow direct heating from solar radiation incident on the mount top. Once again, the range of temperatures and humidities available to the ants increases. Ants are ectothermic; therefore any architectural adaptations providing them with a greater range of temperatures and humidities would certainly be selected for.

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