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THE BIOLOGY OF THE THATCHING ANT, *FORMICA RUFa*
OBSCURIPES FOREL, IN NORTH DAKOTA

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THE BIOLOGY OF THE THATCHING ANT, *FORMICA RUFa*
OBSCURIPES FOREL, IN NORTH DAKOTA

I. INTRODUCTION

The thatching ant, *Formica rufa obscuripes* Forel, is widespread in North Dakota and lives in conspicuous thatched mounds. I have been able to find in the literature only one reference to it in North Dakota (McCook, 1884). Specimens of ants from nests at Jamestown were sent to Rev. McCook by R. G. DePuy, M.D. McCook called these *Formica rufa* and the description of the mounds leaves no doubt that they were *obscuripes*. DePuy's measurements show heights of mounds varying from eight inches to one and one-half feet and what was probably the brood chamber was occupied by "a ball of twigs, about eight inches in diameter." DePuy reports that there were never more than three openings, usually near the summit. He found chambers extending down as far as he dug, four and a half feet. Apparently his observations were made in the fall or early spring as the ground was already frozen.

McCook reports conversations with another resident, Mr. B. S. Russell, to the effect that numerous swarms of "flying ants" appear from late July into September and erroneously assumes that they were *obscuripes*. I have seen many swarms of winged ants which were much smaller than *obscuripes* and were of species of *Myrmica* and *Lasius*. Frequent inquiries of residents of the state have invariably brought the statement that the swarms of winged ants are the smaller ants which I have seen. A swarm of winged ants as large as the male and female *obscuripes* would be very conspicuous.

Mr. Russell also mentions the damage to the thatch mounds by prairie fires which "burn them quite up, and penetrate far enough beneath the surface to leave a hole that would contain a bushel-basket!" McCook states that the nests frequently are protected from prairie fires by "a narrow belt of smooth soil [which] generally surrounds the base of a hill, on the outer margin of which springs up a circle of tall, stiff, thick-stalked grass. . . ." "This grass remains green until late in the fall, and when the dry prairie is swept by the flames, it stands as a breastwork around about the mounds, often deflecting the fire or greatly modifying its destructive effects. In this way the formicaries are kept safe within the girdling ranks of the friendly plant." My studies do not bear out this statement. I have found several nests surrounded by dense grass which was encroaching upon the mounds. One of these nests had been burned by a prairie fire as shown by the charred twigs within the mound. It is more probable that these margins of grasses or herbs increase the danger from prairie fires.

McCook also states that the mounds are made of "an alternation of

layers of earth and vegetable substance, the latter falling into decay in due season." Such a structure is accidental and is not found in the average vigorous nest during normal years. Soil is brought up in excavating the chambers below but is carried either to the margin of the mound or dropped in such small amounts upon the nest as to be a negligible factor in nest structure. In very dry springs, however, such as that of 1934, an enormous amount of soil is transported by the frequent winds. Much of this wind-blown soil lodges in the thatch.

This brief and none too accurate account by McCook constitutes practically all which has been published on the ant fauna of the state.

The following observations were made chiefly in McHenry County which is situated in the north central part of North Dakota, about equidistant from the Montana and Minnesota state lines and twenty-five miles from the Canadian boundary. The physiographic and biological characteristics of this county are fairly representative of the state.

This paper is a condensed and revised form of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at the University of North Dakota. To Professor G. C. Wheeler, under whom this study was undertaken, I wish to express my sincere appreciation of his generous assistance. I am also indebted to Dr. E. A. Baird, Professor of Botany at the University of North Dakota, for aid in the determination of plants and to Professor W. M. Wheeler of Harvard University and Dr. Esther W. Wheeler for helpful suggestions.

II. DISTRIBUTION

Formica obscuripes is an ant of western North America. Since *aggerans* is a synonym of *obscuripes* and since the status of the variety *melanotica* is doubtful, their distribution will be given together. Wheeler (1913 and 1917) records this ant from the following states and provinces:

Wisconsin	Montana	Idaho	Manitoba
Illinois	Wyoming	Utah	Alberta
North Dakota	Colorado	Arizona	British Columbia
South Dakota	New Mexico	Oregon	Washington
Nebraska	Texas	California	

Recently it has been collected in Minnesota at Delorme, Erskine and Little Falls by G. C. Wheeler and at Mallory, Walker and Bemidji by myself. I have seen specimens in the United States National Museum from Iowa and have collected *obscuripes* at Gainsborough, Saskatchewan.

F. obscuripes is found in North Dakota from the Red River "Valley", forming the eastern boundary, to the Badlands near the western boundary. It ranges in altitude from the lowest part, the Red River "Valley", at an

elevation of about 800 feet (244 m.) to the very highest point in the state, Black Butte, at an elevation of 3468 feet (1077.7 m.).

It has been collected from the following localities in North Dakota, the collectors' initials G. C. W. and N. A. W. representing G. C. Wheeler and myself:

Walhalla (G. C. W.)	Pembina County
Niagara, Larimore (C. V. Johnson), Grand Forks and Arvilla (N. A. W., G. C. W.)	Grand Forks County
Binford (M. A. Hetland)	Griggs County
McHenry (M. A. Hetland)	Foster County
Jamestown (H. C. McCook)	Stutsman County
Leeds (N. A. W.)	Benson County
Bottineau, Lake Metigoshe (N. A. W.)	Bottineau County
Balta, Barton, Rugby (N. A. W.)	Pierce County
Towner, Upham, Norwich, Granville, Denbigh, Guthrie, Bantry, Smoky Lake, Anamoose, Velva, Drake, Round Lake (N. A. W.)	McHenry County
Minot (N. A. W.)	Ward County
Sherwood (N. A. W.)	Renville County
Dunseith (N. A. W.)	Rolette County
Butte, Washburn (N. A. W.)	McLean County
Parshall, Plaza (N. A. W.)	Mountrail County
Bismark, Sterling (N. A. W.)	Burleigh County
Denhoff (N. A. W.)	Sheridan County
Hebron, Glen Ullin (Emil Krauth), Breien, Mandan (N. A. W.)	Morton County
Yucca (N. A. W.)	Oliver County
Sentinel Butte (G. C. W.), Trotters (J. E. Goldsberry)	Golden Valley County
Bicycle (G. C. W.)	McKenzie County
Medora (N. A. W., G. C. W.), Mikkelson (J. E. Goldsberry)	Billings County
Black Butte, Amidon (G. C. W.)	Slope County

Obscuripes is found throughout McHenry County, the ants avoiding only small unsuitable areas such as the damp borders of sloughs and the wooded Mouse River Valley.

III. TAXONOMY

The ant, *Formica rufa obscuripes* Forel, belongs to the family Formicidae in the order Hymenoptera.

Formica rufa was first described by Linné in the 10th edition of his *Systema Naturae*, Volume 1, p. 580, in 1758.

The subspecies *obscuripes* was first described by Forel in 1886 (Ann. Soc. Ent. Belg. 30, C. R. p. 39) from specimens collected at Green River, Wyoming. Only the workers were described and these so inadequately that Wheeler (1912, p. 90) named the same ant *Formica rufa aggerans*. Later

(1913, p. 430) he fully described the castes of *aggerans* and (pp. 433-434) redescribed *obscuripes* suggesting that further study may show them to be the same subspecies. In 1917 (1917, pp. 535-537) Dr. Wheeler definitely cleared up this question of nomenclature by synonymizing *aggerans*. Previous to this many observers had reported *obscuripes* under the name of *aggerans* from a wide area in the western part of the United States.

Forel's original description of *obscuripes* is as follows:

Ouvrière. Long., 3, 8 à 8 mill. Très semblable à la *F. rufa i. spec.* d'Europe. Mais elle est plus petite; les grandes ouvrières sont d'un rouge plus clair et presque ou entièrement sans tache sur la tête et le thorax, tandis que les pattes et l'écaïlle sont d'un brun noirâtre. Les petites ouvrières sont beaucoup plus foncées et tachées de brun sur la tête et le thorax. L'abdomen est mat, noir, et a une pubescence grise un peu plus forte que chez la *F. rufa i. sp.*, tandis que la pilosité est plutôt un peu plus faible.—Green River, Wyoming (Scudder).

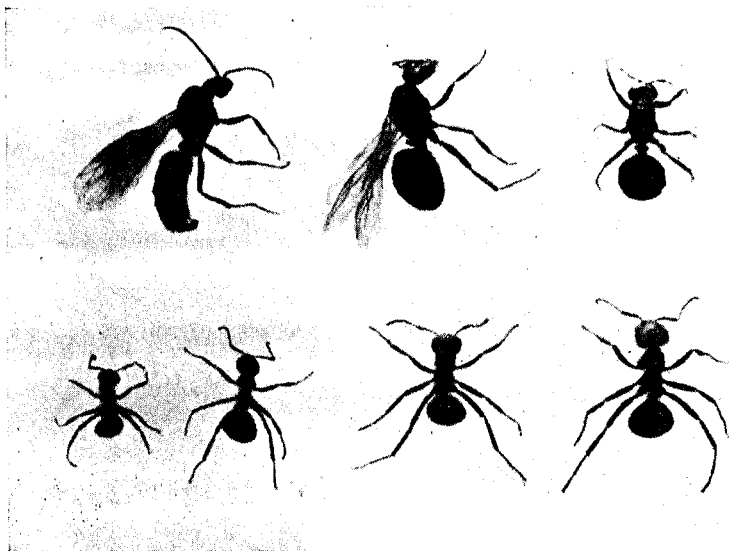


FIG. 1. *Formica rufa obscuripes* Forel. Above: winged male, winged female, queen. Below: minima, media, and maxima workers.

Emery in 1893 (Zool. Jahrb. Syst. Vol. 7, p. 650) established the variety *melanotica* as a form of *obscuriventris*:

Einige ♀ aus Wisconsin sind noch dunkler rostbraun mit mehr blutrothem Kopf.

In 1910 Wheeler (p. 570) regarded it as a variety of *obscuripes*, but in his monograph of the genus *Formica* (1913, p. 432) he transferred it to the subspecies *aggerans* and described the castes.

Representative ants from typical nests from widely separated localities in the state were sent to Dr. W. M. Wheeler in March 1932. These were all thought to be the variety *melanotica* because *obscuripes* was considered a form restricted to the Rocky Mountains and westward. Of these representative specimens Dr. Wheeler wrote, "I . . . should pronounce them all to be specimens of *Formica obscuripes* Forel. There are some color differences and perhaps the very darkest ought to be designated as Emery's variety *melanotica*, which in the large worker has the thorax black and only the head red. I am wondering, however, whether this variety has any validity, since there is such a variation in the same colony from dark minima worker up to maxima forms with rather light red head and thorax."

From my observations in North Dakota I would concur in this opinion that *melanotica* as a variety of *obscuripes* is of doubtful validity, for the following reasons:

1. Some workers from a colony may answer the description of *obscuripes* perfectly, while others of the same size from the same colony may equally well fit the description of *melanotica*.
2. Workers from one colony may answer the description of *obscuripes* while workers of the same size from a similar nest nearby may answer the description of *melanotica*.
3. All gradations of color from completely dark brown or black minima workers up to maxima workers with orange red heads and thoraces may be present in the same colony.
4. Such color differences as occur are not correlated with nest structure or habitat.

IV. ENVIRONMENT

A. PHYSIOGRAPHIC CONDITIONS

1. NORTH DAKOTA:

North Dakota includes parts of two great physiographic regions of North America, the Central Lowland and the Great Plains. The Missouri River forms the boundary between the two. For a complete account of the physiography of the state see Leonard (1919).

2. McHENRY COUNTY:

McHenry County lies almost entirely in the Drift Plain of the Central Lowland, but with the Missouri Plateau crossing the southwestern corner. In general the surface of the county is gently rolling. The most striking features are the small hummocky sandhills or sand dunes which cover considerable areas, especially north, west, and south of Towner. These hills are 10 to 30 feet (3-9 m.) high and sometimes occur in irregular ranges. They are of pure sand and the tendency of the prevailing northwesterly winds is to give them a long windward slope and a sharper leeward slope.

Naturally, the binding effect of vegetation is to modify and resist the migration of these hills; but, where the cover of vegetation is scanty, the hills are true migrating sand dunes. There are a few scattered hills, as Buffalo Lodge near Granville and White Rock near Denbigh which are higher morainic hills. The rough belt of the hills of the Altamont Moraine crosses the southwestern corner.

There are no elevations in the county higher than 1800 feet (548.6 m.) above sea level, most of the county lying between 1400 and 1500 feet (426.7 m. and 457.2 m.).

The county is incompletely drained by the Mouse (or Souris) River and its tributaries, Wintering, Deep, and Little Deep "Rivers" and a number of small intermittent creeks. There are a number of small lakes, especially in the southern part, and many sloughs. Most of the lakes are "alkaline", which dry up during drouth years, leaving barren, salt incrustated, white "alkali" flats.

B. METEOROLOGIC CONDITION

1. NORTH DAKOTA:

North Dakota, situated as it is in the center of North America, has a truly continental climate. Temperatures in the summer of 100°F. (38°C.) to 105°F. (40.6°C.) are common and in the winter temperatures of -20°F. to -30°F. (-23°C. to -34°C.) are frequent.

The average annual rainfall for the state is slightly over 17 inches (43 cm.) and varies from 12 to 22 inches (30 cm. to 56 cm.) per year. The eastern half of the state has the highest rainfall, the Red River "Valley" being generally the wettest area. The western part of the state is the driest, averaging 10 to 15 inches (25 cm. to 38 cm.) per year. Rain falls mostly in the spring and summer months. Snowfall is light, being heaviest in the Red River "Valley" and decreasing westward. In the western part of the state the ground is frequently bare of snow in the winter for weeks at a time.

The winds are prevailingly northwestern. Winds from some direction occur most days of the year and in the spring are apt to be in the nature of violent sand or dust storms.

B. McHENRY COUNTY:

McHenry County has a climate perhaps more rigorous than most counties of the state. Climatological data from the United States Weather Bureau records for Towner are typical for the county as a whole, since there are no complications due to appreciable differences in altitude, exposure, or other factors.

Maxima of 105°F. (41°C.) are not unusual and 108°F. (42.2°C.) has been recorded. Minima of -30°F. (-34°C.) in the winter are not infrequent, -49°F. (-45°C.) being the lowest recorded. Temperatures of

32°F. (0°C.) have been recorded every month of the year but infrequently in July. The ground generally freezes to a depth of 6 to 7 feet (180-215 cm.)

The average annual rainfall over a period of 30 years is 15.7 inches (40 cm.), the maximum being 28.7 inches (72.9 cm.) and the minimum 8 inches (20.3 cm.) per year. Seventy-eight per cent of the rainfall falls in the months from April to September inclusive. Snowfall is very light, the prairie generally having a very scanty covering or none at all. Snow generally forms drifts in sheltered places.

Winds are prevailing northwestern, winds from some direction occurring most days of the year.

C. PLANTS AS A FACTOR OF THE ENVIRONMENT

1. NORTH DAKOTA:

The vegetation of North Dakota is relatively homogeneous over the state and a clear, distinct geographical classification cannot be made. There is considerable overlapping of the different plant regions and in most places they are not sharply defined. The woodlands bordering rivers may straggle out on the prairie, particularly following up valleys. The prairie may border rivers as in the northern part of McHenry County along the Mouse River. Since altitude in itself does not exert a conspicuous effect upon the flora there are not the better defined plant zones of many regions.

For the plants of the state and their distribution reference may be made to Bergman (1912).

2. MCHENRY COUNTY:

The flora of McHenry County may be more readily classified since only a small area is considered. The flora may be divided into:

(1). MOUSE RIVER VALLEY. The valley is forested by the same deciduous trees characterizing the rest of the state, the ash (*Fraxinus pennsylvanica* Marsh.), oak (*Quercus macrocarpa* L.), box elder (*Acer negundo* L.), elm (*Ulmus americana* L.), willow (*Salix* spp.), and, in addition, dense pure stands of the quaking aspen (*Populus tremuloides* Michx.). Characteristic shrubs which I have collected are:

Betula glandulosa Michx.

Prunus americana Marsh.

Prunus virginiana (L.)

Ribes oxycanthoides L.

Amelanchier alnifolia Nutt.

Cornus stolonifera Michx.

Viburnum pubescens (Ait.)

Viburnum opulus L.

Salix discolor Muhl.

Salix longifolia Muhl?

Crataegus chrysocarpa Ashe

Herbaceous plants collected include:

Bidens cernua L.

Epilobium adenocaulum Haussk.

Helianthus maximiliani Schrad.

Helianthus autumnale L.

Helenium autumnale L.

Oxalis cymosa Small.

<i>Mentha arvensis canadensis</i> L.	<i>Carex siccata</i> Dewey?
<i>Asclepias incarnata</i> L.	<i>Thalictrum occidentale</i> A. Gray.
<i>Equisetum laevigatum</i> R. Br.	<i>Vernonia fasciculata</i> Michx.

(2). PRAIRIE. McHenry County lies in the transition between the short grass and long grass prairie and the plants would thus be somewhat representative of the state. In addition to the plants listed by Bergman for the state as a whole and characteristic of the prairie, other plants, which I have collected from the upland prairie, include:

Grasses:

<i>Stipa comata</i> Trin. and Rupr.	<i>Poa nemoralis</i> L.
<i>Bouteloua gracilis</i> Lag.	<i>Poa compressa</i> L.
<i>Calamagrostis hyperborea</i> Lang.	<i>Poa buckleyana</i> Nash.?
<i>Agrostis hyemalis</i> (Walt.) BSP.	<i>Koeleria cristata</i> (L.) Pers.
<i>Hordeum jubatum</i> L.	<i>Calmovilfa longifolia</i> (Hook) Scribn.
<i>Panicum capillare</i> L.	<i>Andropogon furcatus</i> Muhl.
<i>Poa pratensis</i> L.	

Cacti:

<i>Mammillaria vivipara</i> (Nutt.) Haw.
<i>Opuntia fragilis</i> (Nutt.) Haw.

Herbs:

<i>Lepachys columnaris</i> (Sin.)	<i>Liatris punctata</i> Hook.
<i>Chrysopsis villosa</i> (Nutt.)	<i>Potentilla arguta</i> Pursh.
<i>Solidago missouriensis</i> Nutt.	<i>Rosa pratincola</i> L.
<i>Solidago rigida</i> L.	<i>Anemone patens</i> var. <i>Wolfgangiana</i> (Bess.) Koch.
<i>Aster multiflorus</i> Ait.	<i>Amorpha canescens</i> Pursh.
<i>Artemisia canadensis</i> Michx.	<i>Glycyrrhiza lepidota</i> (Nutt.) Pursh.
<i>Artemisia caudata</i> Michx.	<i>Peralostemum purpureum</i> (Vent.) Rydb.
<i>Artemisia frigida</i> Willd.	
<i>Artemisia glauca</i> Pall.	
<i>Brauneria augustifolia</i> (D. C.) Heller	<i>Symphoricarpos occidentalis</i> Hook.

The cactus, (*Mammillaria vivipara* (Nutt.) Haw.), is common over much of the dry sandy soil and prickly pear, (*Opuntia fragilis* (Nutt.) Haw.), has been found in several areas. *Bouteloua gracilis* is perhaps the most common grass and one of the more important for grazing. Wolfberry, (*Symphoricarpos occidentalis* Hook.), is a widespread shrub forming patches up to several acres in extent.

(3). ALKALI LAKES. About the "alkali" lakes and the more or less

dried flats of previous lake beds are found plants of species of the genera *Juncus*, *Scirpus*, *Carex*, *Chenopodium*, *Triglochin*, *Atriplex* and *Salicornia*. Away from the margins of the lakes or flats these plants intermingle with the prairie plants without forming any distinct boundaries.

(4). SANDHILLS. The flora of the sandhills is not strikingly different from the prairie surrounding them. The grasses and herbaceous plants are identical. The flora differs, however, in that many of the slopes of the hills, generally the north or east, are clothed with dense stands of the chokecherry, (*Prunus virginianum* L.) the wild plum (*Prunus americana* Marsh.), the Juneberry (*Amelanchier alnifolia* Nutt.), and the quaking aspen (*Populus tremuloides* Michx.). The bur oak (*Quercus macrocarpa* L.) and the box elder (*Acer negundo* L.) are commonly interspersed with other trees or shrubs. *Salix* spp. occur in clumps in the damper depressions.

V. INFLUENCE OF THE CLIMATE

A. TEMPERATURES

Temperatures, of course, exert a conspicuous and primary influence upon the activities of these ants. Their influence may be divided into: seasonal and daily.

1. SEASONAL INFLUENCE

The cold of winter necessitates hibernation and the complete cessation of all activities. Early spring is likewise too cold for activity but in normal years, early in April, the warmth of the heightening sun causes the ants to emerge. Freezing temperatures at night do no harm; the ants may be out on the nest moving sluggishly about during the day at a temperature close to freezing.

Later in the spring they are really active and commence to build up their nest and gather food industriously. Summer is the time of greatest activity, although hot weather curtails activity during the middle of the day. They maintain considerable activity in gathering food all during the fall and normally are active until well on in November. The second week in November 1931 they were slightly active during the day at temperatures from 44°F. to 57°F. (7°C. to 14°C.), though the temperatures at night ranged from 22°F. to 29°F. (-6°C. to -2°C.).

2. DAILY INFLUENCE

Temperatures at night, except in the summer, are too low for activity. During the summer numbers of workers are found on the nest and even wandering about the surrounding vegetation until well into the night. The coolness of the period before dawn causes them to retire and they do not again come out until the sun's rays strike the nest.

Except during early spring and late fall the morning is the time of greatest

activity. In the early morning the ants use the sunlit nest-openings; later as the temperature rises and the sun strikes directly, they avoid the openings in the sunlight and use only those which are partially or wholly shaded by the surrounding vegetation.

In the spring and fall the middle of the day is a time of considerable activity, but during the summer little is then accomplished above the nest. When the temperature is in the eighties Fahrenheit (= around 30°C.) or higher and the sun beats directly down upon the nest without the alleviating effect of a cooling breeze there is practically no activity. A few openings of the nest may be partially shaded during these hours and only from these do ants emerge. Partly because of the desiccating effect of the sun's rays paths are constructed under and through the vegetation to the plants upon which the aphids are pastured and to hunting territory. These semi-covered runways may extend up the sides of the nest to one or two major openings. A few workers occasionally emerge to run quickly about on the mound and then go back down, as if scouting hurriedly. When a passing cloud temporarily obscures the sun, numbers of workers quickly come out and scatter about the periphery, only to return when the sun shines again. Single workers, however, have been observed on the nest even at a temperature of 103°F. (39.4°C.).

Although in the evenings during the spring and fall there is little or no activity, during the summer their evening activity is second only to that of the morning. Even after dusk they continue building and repairing the nest and foraging about for food, the temperatures remaining in the sixties or seventies Fahrenheit (15°C. to 25°C.) until several hours later.

In summary, then, the ants are most active at temperatures in the sun between 50°F. (10°C.) and 80°F. (27°C.) or in the shade between 60°F. (15°C.) and 90°F. (32°C.), provided the relative humidity is above 25%.

B. LIGHT

In North Dakota *F. obscuripes* has a decided preference for nesting in open situations. Nests are rarely found in woods, never in dense woods, and all nests are exposed to sunlight for a large share of the time.

Full sunlight during the entire day does not curb their activities unless accompanied by high temperatures and low relative humidities. On the contrary it is conducive to their maximum activity. When the winged ants are emerging they wait for sunny periods to take flight, other meteorological conditions being favorable.

On evenings of hot days during the summer the workers are very active in food-gathering and nest-building until dusk. At these times the period from shortly before sundown to dusk is the time of activities second only to the early morning hours.

Long after dark in the summer workers are found slowly crawling about

the nest as if on patrol. Probably little is accomplished after dusk, however, as much of their prey is not moving about.

C. WINDS

North Dakota lies in a region having considerable windy weather, which at times exerts an appreciable effect upon the activities of the ants.

The harmful effects of the wind are evidenced by the loosening of the thatch and even the blowing away of some of the twigs where the nest is exposed. Ants are forced to suspend their activities above ground if a strong wind, particularly when laden with dust or sand, sweeps across the nest. As noted later, winds prevent emerging of the sexual forms for the marriage flight.

D. HUMIDITY

During the summer of 1930 I made a number of relative humidity measurements in connection with the activities of *F. obscuripes* with the following results:

The sexual forms emerged only at temperatures above ca. 60°F. (15°C.) when associated with a relative humidity above ca. 50%.

A few workers were active in shaded spots even when the relative humidity was as low as 17% at temperatures in the nineties Fahrenheit (thirties Centigrade) but were not active in the sun at relative humidities of 40% to 50% even when the temperature was 10°F. to 20°F. (5°C. to 10°C.) lower. There were no ants above the nest surface at a relative humidity of 14% when coupled with temperatures above 90°F. (32°C.).

During light rains the ants continued their activity.

In general, one might say the ants are active at relative humidities above 25% and may continue their activity at relative humidities even lower, provided they can avoid direct sunlight. The combination of the sun's rays and low humidities probably has a desiccating effect upon them.

E. RAINFALL

Formica obscuripes adapts itself to considerable variations in rainfall as shown by the thriving colonies in the semi-arid western part of the state and those in the more humid Red River "Valley". That it endures the wide range in annual rainfall from 5 to 35 inches (13 to 89 cm.) shows a considerable degree of adaptability.

Drouths of a month or more during the summer do not retard activities, except when low humidity prevents the ants from being active above ground and in the sunlight during the middle of the day.

During a moderate rain the ants continue their normal activities and seem not at all hindered. Since the aphids from which they receive considerable nourishment are frequently stationed on the under surface of curled leaves, "milking" may be continued even during a rain.

F. PRAIRIE FIRES

Prairie fires are a factor of some importance in areas of the state where there is considerable grassland.

In McHenry County prairie fires are not infrequent and are detrimental in two ways: first, they set fire to the twig mound and may burn it out, resulting in a serious set-back to the colony, particularly when the brood is in that part of the nest; second, by burning the vegetation, prairie fires destroy the food of the insects forming a large part of the prey of the ants; these insects are driven out when not actually killed. The fires kill not only the vegetation upon which the aphids feed but also the aphids themselves, thus destroying the other main source of food.

VI. RELATIONS OF PLANTS AND *F. OBSCURIPES*

A. INIMICAL RELATIONS

The encroachment of grasses, herbs, and shrubs constitute an ever present menace to the mound. Particularly is this true in wet seasons when vegetation is growing luxuriantly. At such times plants grow up through the nest, and the efforts of the ants are not very effective. I have seen them actually gnaw grass blades down or cut them in sections, but it is doubtful whether they could cut down large vigorous weeds, herbs, or shrubs. Later in the summer, when the nest interior is dry, the plants probably die out from lack of moisture rather than from the activities of the ants.

In the nests are sometimes found roots of shrubs which may have been killed by the ants in building up their mound. Such roots are frequently removed to form tunnels which are used by the ants to connect chambers. In one case, stout plants of the grass, *Calamovilfa longifolia* (Hook) Scribn., had kept pace with the growth of the mound for some time, as shown by their bases being from 6 to 12 inches (15-30 cm.) below the crown of the nest; while they eventually were killed off from the summit of the mound, they maintained a very heavy growth on the periphery. The overshadowing of plants, even when not a result of actual encroachment constitutes a second menace. Colonies are driven out of nests when such plants as wolfberry become too dense about them and shade completely.

B. FAVORABLE RELATIONS

Plants are of benefit to *obscuripes* colonies in three chief ways:

(1). By affording food for aphids plants are of considerable importance. The proximity of wolfberry (*Symphoricarpos occidentalis* Hook.) growths and *obscuripes* nests is not fortuitous—wolfberry is attacked by aphids which in turn afford an important source of food to the ants. Wild liquorice, *Glycyrrhiza lepidota* (Nutt.) Pursh., is similarly the host plant of the same aphid which in turn is tended by *obscuripes*. Other plants include *Populus*

tremuloides Michx., *P. deltoides* Marsh, *Salix* spp., *Artemisia cana* Pursh., *A. glauca* Pall., *A. longifolia* Nutt. and *A. tridentata* Nutt. and *Rosa pratincola* L.

(2). Plants furnish the material out of which the thatch nest is constructed. Small twigs from shrubs, grass blades, and herb stems are universally used, though in varying proportions.

(3). Plants, of course, are the ultimate source of food of *obscuripes*. The chief source of food of this ant is insects, which either feed directly (membracids, grasshoppers, and aphids) or indirectly on plants.

VII. OTHER INFLUENCES

Besides the more important influences of the climate and vegetation there are other influences at work upon the distribution or activities of *obscuripes* colonies:

(1). Physiographic Influences. As a whole, the physiography of the state is favorable to the establishment of *obscuripes* colonies. There are, however, limited areas unfavorable to them. Such areas are the steep, bare slopes of hills and buttes, chiefly in the Missouri Plateau; the damp margins of sloughs, marshes, and lakes of the rest of the state; and areas along streams subject to seasonal overflow, or at the base of buttes subject to the run-off from their bare sides.

(2). Man exercises an appreciable effect upon *obscuripes*. By cultivation of large areas of the state, he prevents the establishment of mounds in the fields and drives them to the margins. At the same time, the cultivation of crops attracts hordes of insects, particularly grasshoppers, the chief prey of the ants. The destruction of woodlands increases the nesting area, while the establishment of groves lessens the area. By bringing in herds of domestic animals he adds a new danger to the nest, i.e., trampling; but probably not of more consequence than in the days of the vast herds of bison.

(3). The influence of other animals is sometimes appreciable. The kingbird, *Tyrannus tyrannus* (L.), has frequently been observed capturing the winged *obscuripes* as they fly away from the nest. In fact one kingbird stationed itself upon a tree a short distance from an *obscuripes* nest and with great regularity captured the winged ants as they flew by, one after another. The Arkansas kingbird, *Tyrannus verticalis* Say., has also been observed near nests, feeding upon insects, presumably including the winged *obscuripes*. The flicker, *Colaptes auratus borealis* Ridgw., is a well-known ant eater. It has frequently been seen on the ground near *obscuripes* nests and is very likely responsible for holes sometimes made in the mound. Bird feces composed entirely of *obscuripes* remains were found by a nest. The common crow (*Corvus brachyrhynchos* Brehm) has been observed eating the workers.

Newly captured toads, *Bufo hemiophrys* Cope and *B. woodhousei* Girard, readily ate many workers.

Lastly, domestic animals, particularly cattle, sometimes damage mounds by tramping upon them.

VIII. THE NEST

A. FORM

The form of *obscuripes* nests varies considerably from a low, almost flat, crown to a paraboloidal structure. The occasional hollowed out surface of the nest, forming a "massive rampart", described by Muckermann (1902) for *obscuripes* nests in Wisconsin has not been seen by me.

The nest is invariably a superstructure of twigs, herb stems, or grass stems constructed above the chambers in the soil. These nest materials will hereafter be referred to as thatch.

On the open sandy prairie this superstructure of thatch is frequently built upon a slight eminence of soil, which is doubtless the result of excavating the soil chambers. Among shrubs or in less sandy soil, however, the thatch superstructure rests directly on the ground.

The form of what may be termed secondary nests is similar to that of the main or primary nest except that the roots of plants furnish the nucleus about which thatch is placed and tunnels excavated. Such secondary nests are generally connected by a well-defined runway to the main nest. These roots of plants were originally preyed upon by aphids which were tended by the *obscuripes* workers. As the ants excavated the soil about the roots an arborescent chamber developed which upon the death of the plant or even while still alive, was easily made into a small secondary nest. A secondary nest may eventually develop into the chief nest of the colony.

The form of the thatched crown is always in a state of change due to the activities of the ants and to the action of the environment. The changes are brought about by:

(a). Work of the ants themselves. If there is one thing that impresses the observer of a colony it is the continuous building and repairing of the nest. Whenever any workers are above the nest surface, most of them will be engaged in altering, repairing, or adding to the thatch. They are continually changing the openings of the nest, both in number and position.

(b). Depressing action of rains and snow. The effect of rains and melting snows naturally is to level the thatch and make it more compact. While such actions are partly beneficial in that they render the nest more resistant to the elements, they are as a whole, harmful because the nest is made more susceptible to plant invasions and also is lowered with consequent shading by the surrounding plants.

(c). Destructive effect of severe winds. As mentioned before, wind-

storms are apt to loosen and even blow away portions of the thatch. Many nests, however, are protected by nearby vegetation.

(d). Destructive effects of other animals. Domestic animals, particularly cattle, sometimes trample upon the nests when grazing and damage them. Such damage, however, generally is repaired in a few days in favorable weather. Nests have frequently been observed with their openings excavated to a depth of several inches. From the circumstance that flickers (*Colaptes auratus borealis* Ridgw.) are frequently found in their vicinity and have been seen on the ground nearby and are known ant eaters it seems highly probable the openings were made by them in searching for ants.

The peculiar behavior of two pet crows indicated an unexpected factor which may, perhaps, be of some importance. These crows, entirely normal in every respect and able to fly as well as any wild ones, several times flew to the nest while I was observing the general activity. They stood upon it, fluffed out their feathers, squatted in the manner of birds taking a dust bath, and deliberately allowed the ants to crawl over them. The workers swarmed in large numbers over and through their fluffed out feathers, spraying formic acid liberally. After a few moments, when covered with ants, they hopped off the mound and shook themselves vigorously. Those ants that were still clinging to the feathers were picked off and thrown aside; none was eaten. It seemed to me the crows might have acted in this manner to disinfect themselves: the formic acid sprayed by the ants might repel the ectoparasites of the crows. The effect of this behavior to the nest was to scatter the thatch and flatten the nest appreciably.

B. SIZE

1. MOUND PROPER

The size of the mounds of *obscuripes* is highly variable. The height of the mound varies from an inch (2.5 cm.) or less in young nests to a maximum of 18 inches (45.7 cm.) in populous, flourishing colonies. The average height is about 8 inches (20 cm.) for typical nests. The diameter of the entire mound, including the soil base (when present) varies from a maximum of 11 feet 3 inches (343 cm.) to about one foot (30.5 cm.). The average typical nest is from two to three and one-half feet (60-110 cm.) in diameter. The diameter of the thatch part of the nest, alone, varies from a maximum of eleven feet (335 cm.) to a minimum of 5 inches (13 cm.), averaging about 17 inches (43 cm.). The disc area of the entire nest varies from about 98 square feet (9 sq. m.) to 0.8 square feet (0.07 sq. m.).

The thatching material extends down below the surrounding soil level to a depth of about 10 inches (25 cm.) or about 18 inches (45.7 cm.) below the top of the mound. The topmost soil chambers are made very large and close together and are filled in with thatch. The quantity of thatching material, mostly twigs, from an average nest was 0.75 bushel or 25.6 liters.

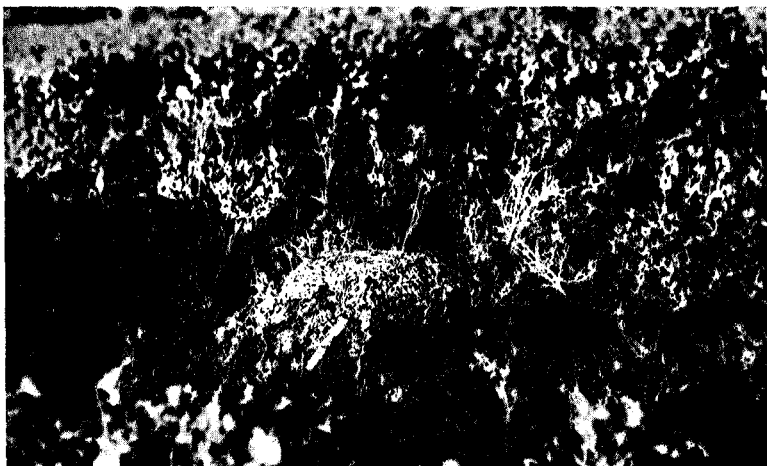


FIG. 2. Typical twig nest in *Symphoricarpos occidentalis* patch. Six inch (15 cm.) ruler at base.

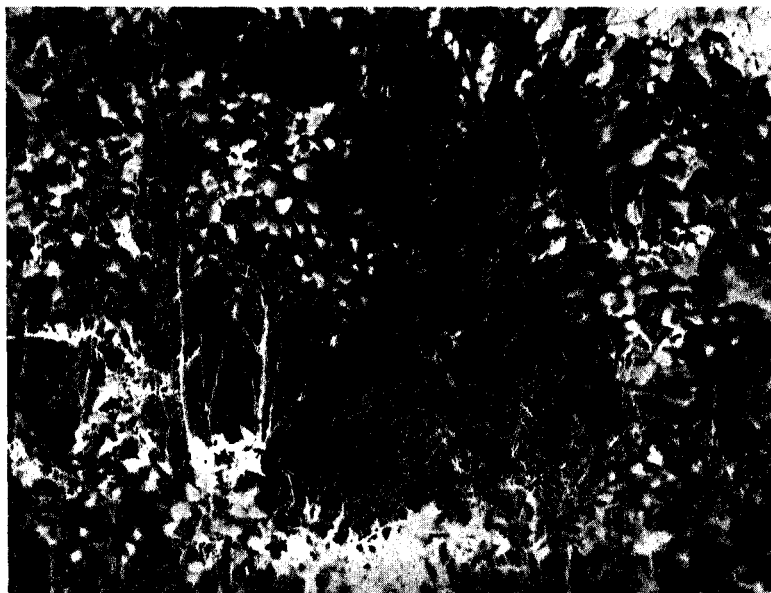


FIG. 3. Nest in margin of bushes.

The thatching material has a composition varying according to the immediate plant environment. Nests in or near wolfberry (*Symphoricarpos occidentalis* Hook.) patches are of coarse wolfberry twigs mixed some finer material of grass and herb stems. Nests on the prairie at some distance from shrubs consist of somewhat finer material from grasses and herbs. Occasionally a nest is found thatched with fine grass stems which form a more compact

mound. Such nests are low and quite flat and seem to be inhabited by young colonies of small populations.

The typical *obscuripes* mounds are of coarse twigs from a fraction of an inch (1 cm.) to as much as eight inches (12 cm.) in length and usually about 1/16 inch (1-2 mm.) in diameter.

2. CHAMBERS IN SOIL

The lower part of an *obscuripes* nest, i.e., the chambers in the soil beneath the mound proper, furnishes a suitable place for the young brood and a safe place for hibernation.



FIG. 4. Young nest, showing soil periphery, at base of bushes. 6 inch (15 cm.) ruler on nest.

Chambers in the soil extend laterally less than the diameter of the entire nest but may be of greater or lesser expanse than the diameter of the thatch. Tunnels and chambers are excavated in the soil to a maximum depth of 62 inches (157.5 cm.). The minimum depth for the lowest chambers was 53 inches (135 cm.). The average depth was 57 inches (145 cm.), indicating a remarkable uniformity.

Hardness of the soil does not seem to be a serious limiting factor. In McHenry County the soil is not rocky and bed-rock is hundreds of feet below the surface. Generally the soil is sandy to a depth of several feet at least and below this it is a mixture of clay and sand. This clay-sand mixture is frequently very hard packed but penetrable by the ants.

The important limiting factor is the water table. In McHenry County it lies at a depth of 6 to 8 feet (180-245 cm.). Below about 5 feet (152 cm.), the soil is so damp that when squeezed the expressed water wets the hand.

This is apparently too wet for the ants and their chambers are never found at this depth.

C. AREA PATROLLED BY COLONY

The territory patrolled by the workers of a single colony is difficult to determine. The area can be indicated, however, by the paths which these ants make radiating out from the nest. These paths are clearly made near the nest and follow the ground closely, going beneath leaves, fallen stems, and other material so that in reality they are partially covered runways. The workers traverse these regularly in going to and from the aphids, and in bringing in prey.

On September 8, 1931, such a path was watched for two minutes from 7:36 to 7:38 A.M. at a point three to four feet (0.9-1.2 m.) from a nest. The path led to a wolfberry patch on the partially dried leaves of which still remained a few aphids. In those two minutes 11 workers passed towards the nest and 6 in the opposite direction. They were mostly minima workers and all traveled quite leisurely, keeping close to the path. A few minutes later, on the same morning, a path about 3 feet (0.9 m.) from another nest which was 90 feet (27 m.) away from the first nest was watched. In one minute 22 workers passed going towards the nest and 12 away, towards the wolfberry patch.

The maximum length to which an ant path was traced was 70 feet (21.5 m.). I have, however, found a worker 156 feet (47.6 m.) from the nearest nest. A worker was once noticed dragging a noctuid larva towards its nest, 13 feet (4 m.) away over a path which extended farther into the wolfberry patch. Paths were frequently traced three to ten feet (0.9-3 m.) from nests before being lost.

Ant paths generally lead toward areas where there is an abundance of plants upon which aphids are pastured. These paths are best developed toward wolfberry and *Artemisia glauca* patches or to the bases of *Rosa pratincola* bushes.

The extent of territory of a colony can only be very roughly estimated from such data, but it seems probable that the workers from an average colony have a territory at least of 1,000 square feet (35 sq. m.) and probably much more.

D. THE BROOD CHAMBER

In April the first brood consisting of eggs is found in soil chambers at a depth of one to two feet (30-60 cm.). Later in the spring, eggs, larvae, and pupae are found at about the same depth. It is only during the summer that the large conspicuous brood chamber is developed. This chamber, which is very incompletely divided by twigs running through it at all angles, is

generally at the base of the thatch part, resting upon the highest soil chambers. It is about 6 inches (15 cm.) high and is enclosed by thatch from 3 to 10 inches (7.6-25.4 cm.) thick. In some cases the floor is also of thatch but in others of soil. The chamber is roughly ellipsoidal in shape; one chamber measured 4 x 3 x 3 inches (10 x 7.6 x 7.6 cm.) and another 10 x 8 x 6 inches (25 x 20 x 15 cm.).

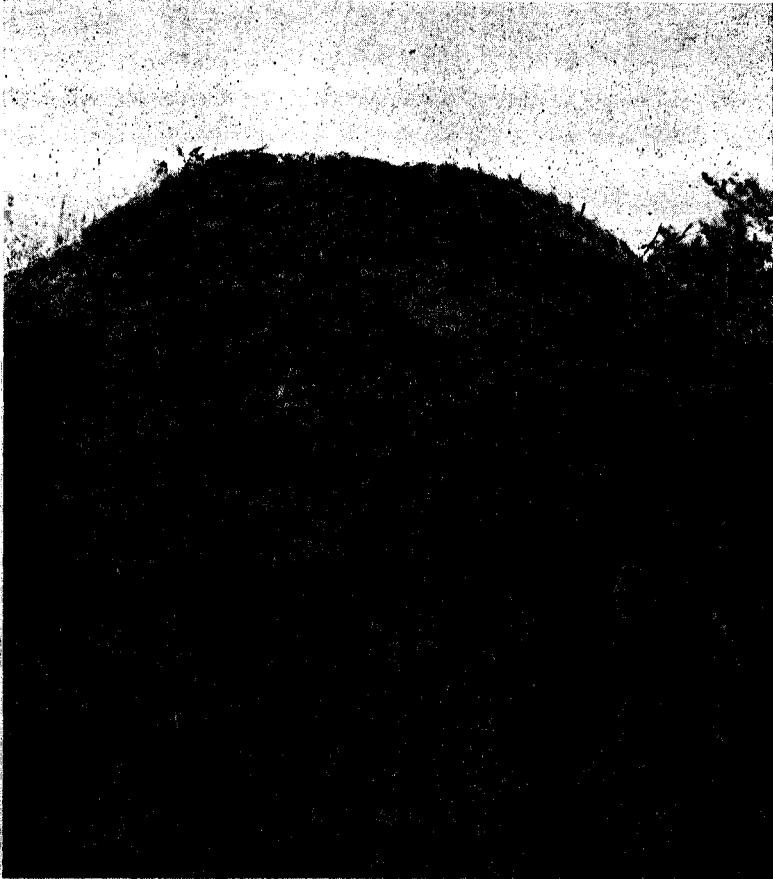


FIG. 5. Section of nest on the prairie showing central brood chamber (filled with thatch) and soil chambers beneath. Thatch superstructure is unusually compact and soil filled as a result of the severe duststorms of the spring of 1934.

Pupae and callows are kept in the upper part of the chamber while eggs and larvae are to be found in the basal part and in the uppermost soil chambers.

In the fall, after the brood has all emerged, the brood chamber is filled with thatch; hence no brood chamber is present from fall to spring.



FIG. 6. Section of nest on the prairie showing location of the brood chamber by the 6 inch (15 cm.) ruler. Thatch superstructure has an unusual amount of soil as a result of the severe duststorms of the spring of 1934.

No clear evidence was found showing that the presence of the workers or the brood raised the nest temperature. The brood chamber is so situated as to be effectively insulated and doubtless retains for some time heat absorbed during the day. During rainy periods the chamber is well drained and can dry out quickly. These are probably optimum conditions for rearing the brood.

E. TEMPERATURES

Andrews (1927) found in the case of *Formica exsectoides* F. that inside temperatures of the nest were higher than the surrounding earth and were due to heat received from the sun.

In the case of *F. obscuripes* inside temperatures of the thatch were also found to be higher than the surrounding earth and were likely due to the heat-absorbing and heat-retaining qualities of the thatch. The presence of the brood or workers probably had no effect upon the temperatures.

Below the thatch part there is a regular drop in temperature from the highest to the deepest chambers. The temperatures of the lower soil chambers are nearly constant all summer but show a gradual increase as the summer progresses.

F. NUMBERS OF NESTS

Formica obscuripes colonies may be absent over large areas of the state which are seemingly well suited to them and abundant in other limited areas. They do not, however, appear to be associated in such large numbers as are those of *Formica exsectoides*. It is not uncommon to find several nests a few rods (10-20 m.) apart, but additional nests are likely to be much farther away. The greatest numbers of *obscuripes* colonies found were in the sandy park-like country containing numerous, more or less continuous *Populus tremuloides* groves north of Towner. In a distance of 150 feet (45.8 m.) along the west side of such a grove were found twelve small nests. Numerous *Formica fusca* colonies were significantly present. An abundant source of food was the secretions of aphids found in great numbers on the *Populus* trees.

IX. NESTING SITES

Formica obscuripes in North Dakota is conspicuously an ant of the open and not of woodlands. The nests have always a long exposure to sunlight, many being exposed to the very maximum amount of light possible. The nesting sites chosen by *obscuripes* may be classified on the basis of the exposure, viz., those having full exposure and those having partial exposure.

A. FULL EXPOSURE

Nests having full exposure, *i.e.*, those not shaded to any appreciable extent during the entire day, are common throughout the state. Such nests are built among grasses and herbs at some distance from trees. They may be located in a great variety of places—on level or rolling prairie, in valleys, on sides and crests of hills, along roadsides, and in pastures. Dr. G. C. Wheeler has found nests upon the summits of Sentinel Butte and Black Butte (the two highest points in the state) and only a few feet from the precipitous sides.

B. PARTIAL EXPOSURE

While most *obscuripes* nests are built in places affording a full exposure, there are limited areas throughout the state where mounds are established in places shaded to a greater or less degree.

As mentioned before, the wolfberry, *Symphoricarpos occidentalis*, is a widespread shrub of the state, occurring in patches up to several acres in area. It is attacked by the aphid, *Aphis symphoricarpi*, and perhaps others. This aphid is frequently found tended by *Formica obscuripes* and this association of wolfberry, aphids, and *obscuripes* nests is common. Such nests are usually built in the margins of the patch and may be somewhat shaded by the shrub on one or more sides but never completely shaded.

Dense growths of grasses about the nest sometimes results in partial shading, usually of only one side. However, several nests of *obscuripes* were found completely hidden by the grass, *Calamovilfa longifolia*. The grass grew to a height of four feet (122 cm.) and completely hid the nest. In these cases the grass was probably choking out the colony.

A third condition of partial exposure is afforded by those mounds in grassy glades in groves of the quaking aspen, *Populus tremuloides*, near Towner. This association approaches the association of *Formica rufa* in the forests of Europe. Occasionally nests are shaded to some extent for a large part of the day. They are not built in locations too shady to permit a growth of grasses.

A case of partial exposure, hardly typical, was a mound found by Dr. G. C. Wheeler on the summit of Black Butte partly overgrown with the creeping juniper, *Juniperus horizontalis* Moench. Only a few ants were found in the mound and the colony was probably being crowded out by the juniper.

The sagebrush flats of the Little Missouri River and its tributaries afford a condition of partial exposure similar to that of the wolfberry. Nests are sometimes established close to the sagebrush and are protected and shaded by it on one or more sides. It is unlikely that they are ever completely shaded by the shrubs.

In the Turtle River Valley are found nests in comparatively shady situations. Here on the grassy valley floor *obscuripes* nests on the very margins of open deciduous woodlands. The shading is never dense but the trees afford some shade and considerable protection. A striking exception, however, was an enormous nest found north of Arvilla which was completely surrounded by trees. The nest received very little direct sunlight. It was distinctly not typical in shape and size as well as in location.

X. LIFE HISTORY

A. COLONY FORMATION

It has not been my good fortune to actually observe the founding of a colony of *Formica obscuripes*. However, that harbinger of colony formation, the marriage flight, has been observed in two successive summers.

Mating among ants is generally accomplished on the marriage flight or swarming of the winged sexual forms. But judging from my own observations *obscuripes* seems to have no true marriage flight. The winged sexual forms merely emerge from the nest singly or a few at a time and take flight. Fertilization by this method seems very hazardous. Local popular accounts of the swarms of winged ants always refer to much smaller ants. I have never found an observer of swarming winged ants as large as *obscuripes*.

Dr. W. M. Wheeler suggests that this situation may parallel that in middle Asia described by Kuznetsov-Ugamsky (1927). The latter states that only those ants which can modify their marriage flight to meet the harsh conditions prevailing in this steppe and desert regions are able to flourish and extend their range. The genus *Cataglyphis*, for example, has a modification of the marriage flight in which the winged sexes run about the surface of the ground and take long leaps (*Sprünge*). There is no true nuptial flight.

It may be that *F. obscuripes* in North Dakota has modified the typical marriage flight, even more than the parent stock *F. rufa*, to fertilization in the nest, or, at the most, on the ground, because of the windiness of the region at this time of year. The genus *Myrmica* forms a typical marriage flight in the same region but it takes place in late August and early September. United States government weather records show that wind movement is less in September than in June and least in August of any month of the year.

The winged males and females wait for favorable weather conditions before taking flight. When the air is calm, the sky quite clear, the temperature above 60°F. (15°C.), and the humidity above 50%, the ants take flight. In so doing they climb up a grass blade or herb stem, vibrate their wings for a moment as if to try them out, then fly upwards and are generally carried by a slight breeze until out of sight, which is a matter of 40 feet (12 m.) or more. Commonly but one or a few take flight at the same time but, whether of the same or the opposite sex, they do not fly in a group. Thus there is not the least indication of a nuptial flight. As a rule but one sex is present upon the nest at any one time, though when both sexes are present there is no interest displayed between one another. Winged ants may emerge from several nests in the same vicinity at the same time but have never been seen to fly off together. They begin to emerge early in June and may leave the nest irregularly for a month. Many of these winged ants were collected with one or

more wings crumpled or even dwarfed so that they could not fly, although they attempted to take flight in the same manner as the normal winged.

In all probability *obscuripes* follows the other Formicas of the *rufa* group in founding colonies outlined by Wheeler (1933, p. 156) by "temporary, or protelian, social parasitism". By the conciliatory type of this method the "female invades nest of the host species and is adopted by the workers after acquiring the brood and nest-odor. Host queen probably killed by her own workers". The workers "rear the successive broods of the parasite. Eventually the host species dies out and a pure colony of the parasite survives."

That this is the method likely used is supported by the coincident range of the *Formica fusca* group, the host species. Furthermore, the greatest numbers of *obscuripes* nests found by me were interspersed with numerous *Formica fusca* crateriform nests.

Muckermann (1902, p. 356) states that in Wisconsin a new colony of *F. obscuripes* is formed thus: a "little squadron sallying forth to establish a new foundation no sooner discover a warm, sunny place, than they begin to dig a few holes in the soil, when there arises gradually a little hill." He does not say whether one or more queens are brought along but I assume such must be the case. I have never seen such a "little squadron" so occupied.

B. THE BROOD

The brood of *Formica obscuripes* in North Dakota is probably not carried over the winter but raised to maturity between spring and autumn.

The time required for development, when kept in the laboratory at room temperature of about 63°F. and 72°F. (17°C.-22°C.), varies from 61 to 122 days. These periods agree singularly well with developmental periods found by Miss Fielde for *Aphaenogaster fulva* and by Janet for *Myrmica rubra*, as reported by Wheeler (1910, p. 81), of from 54 to 141 days and 71 to 117 days respectively.

The milky white egg is ellipsoidal, with a length of about 0.60 mm. and diameter of about 0.31 mm. Eggs have been found in nests as early as April 30, and as late as August 14. Those kept in the laboratory at a room temperature from 63°F. to 72°F. (17°C.-22°C.) developed into larvae in a minimum of 23 days and a maximum of 53 days.

Youngest larvae are of about the same length as the egg and develop to a maximum size of about 6 mm. in straight-line length. Larvae have been found in nests from June 6 to August 22. Kept in the laboratory at room temperature of about 72°F. (22°C.) they developed into the pupal stage in a minimum of 7 days. At 63°F. to 68°F. (17°C.-20°C.) they pupated after 7 to 33 days.

Male and female pupae are about 9 mm. in length, while the worker pupae vary from 3.5 mm. to 7 mm. Sexual pupae have not been found in nests later than June 20, but worker pupae have been found from June 11 to

September 9. The length of the worker pupal stage when kept in the laboratory at a room temperature of from 63°F. to 68°F. (17°C.-20°C.) was from 31 to 93 days.

The callow stage lasts only one or two days. The sexual forms and some workers scarcely have a callow stage but emerge directly from the cocoons into adults and are able to move about normally in a few hours.

C. DIVISION OF LABOR

Each worker caste has fairly well-defined duties among the various activities of a colony.

Most of the activities of the minima workers are concerned with foraging and the care of the brood. Both minima and media, but chiefly the minima, workers are occasionally seen bringing up a larva or pupa from a nest opening, carrying it about for a moment, and then taking it back. While this behavior is frequently exhibited after a rain, the young do not seem abnormally moist but appear normal in every respect. The minima workers also are many times observed carrying out empty cocoons from the nest to the periphery. In short, the minima workers act as the chief nursemaids.

Workers found on the ant paths are chiefly the minima and media. They are the ones observed dragging prey to the nest and tending aphids. Very rarely is a large worker observed near an aphid colony.

While all sizes of workers take part in the building and repair of the nest, the maxima are especially active. They are, moreover, the most aggressive and effective in the defense of the colony, although all sizes are pugnacious and rush to its defense.

XI. POPULATION

The census of a representative *obscuripes* nest was taken in late August and early September, 1931. A rather large nest was selected which was 16 inches (40.6 cm.) high and 54 inches (137 cm.) in total diameter. The nest was surrounded and completely hidden by a dense growth of the grass, *Calamovilfa longifolia* (Hook.) Scribn., but seemed flourishing. There was another *obscuripes* nest 300 feet (91.4 m.) away, but there was no evidence of any communication between the two.

The first method used was to allow the workers to crawl upon my hand placed upon the nest, and then to brush them off into a small pail with a layer of carbon bisulphide in the bottom. While with this method many were secured at the beginning of the afternoon's collecting, the numbers of those rushing out to grasp my hand soon dwindled, and another method was then used.

Handfuls of the nest were taken up and placed in the middle of a large piece of canvas. As the ants crawled to the periphery they were picked off. This was the method generally used.

A third method was to pick up the ants individually from the nest or the cavity as I dug down.

Using these tedious methods with the assistance of several helpers, in the course of eight afternoons and a total of sixteen hours of labor most of the inhabitants were collected.

The ants, all workers, were then counted individually and a total of 16,481 was thus secured. Many cocoons and callows were dug up but were not counted since the adult population was desired. These, which would probably become adult workers in a few weeks (before the onset of winter) would probably add at least two thousand to the total inhabitants. The workers which escaped the census may have numbered 500, probably not much more. The total population of this large sized nest may thus be considered to be about 19,000.

Yung (according to Wheeler, 1913) has found for the larger nests of *Formica rufa* in Europe a population of from 20,000 to 94,000. He found, furthermore, that population of the colony did not vary with the size of the nest; the largest nest counted having scarcely half the population of the next to the smallest mound.

Until further counts of *obscuripes* are taken it may be assumed that the population of the nests will not exceed 40,000. Although in the typical *rufa* there appears to be no direct correlation between the population and the size of the nest, in the case of *obscuripes* there may be a direct relationship. Small nests have been watched and the numbers of workers about the nest are considerably smaller than those of large nests. I suspect that the size of nests of *obscuripes* indicates the size of the colony, because only a populous, flourishing colony can maintain a large twig nest. Were a small colony to occupy a large nest the numbers of workers would probably be too small to maintain the mound against the depressing effect of water and the destructive effect of winds.

XII. DAILY AND SEASONAL ACTIVITY

The daily activity of the workers varies directly with the seasons.

In the winter, since they are hibernating in the earthen chambers a few feet below the surface, there is no activity. A thaw during the winter may draw the workers in the higher soil chambers up into the twig part, but colder weather forces them down again; there is nothing they could do if they did come out.

The workers emerge early in April in average years. During the warm part of the day they come forth and slowly mill about, seemingly enjoying the warmth of the sun's rays. At first, their activity is confined to repairing the damage wrought by the snows and thaws of winter. Later, when the hordes of insects emerge, they take up the serious occupation of getting food.

At the same time they repair and build up the nest. The developing brood must be cared for and, when the weather gets warm enough, carried up into the rebuilt brood chamber.

The summer, particularly the early summer, is the time of their greatest activity. The brood requires more care, the emerging workers and sexual forms needing much attention. From early in the morning until late in the evening the workers forage about for food, taking a "siesta" only during the hottest, driest part of the day. Many are occupied in attending aphids.

During the fall they are especially active in gathering food until well on in October or November, or until all their prey is gone and the weather gets too cold. Nest building and repair takes most of the time. Only pupae are left to attend to in the early fall; after they emerge there is no brood to care for. The ants go into hibernation in November after continued cold weather or the arrival of snow.

XIII. FOOD

A. METHODS USED TO OBTAIN DATA

During all hours of the day three nests at Towner were observed continuously for periods of an hour or less. At such times only a portion of the nest was in full view, because vegetation hid some of the openings on the sides. Hence, not all of the food brought to the nest at the time of observation would be seen. The food observed brought to the nest likely constituted a representative amount, however.

B. METHODS USED BY THE ANTS IN OBTAINING FOOD

The food, other than aphid secretions to be considered later, was dragged by one or more workers to the nest. In the great majority of cases the prey was already dead by the time it reached the nest. In many cases parts of insects were taken; sometimes several parts of what seemed to be the same insect were dragged successively to the nest. A specimen of *Coccinella 5-notata* Kby. was collected as it was being dragged down an opening of the nest, still alive and struggling. A *Ludius elegans* (Kby.) was also collected on a nest, still alive and struggling with a number of workers.

A possible method of capturing prey is suggested by an observation made near a nest: a worker, clinging to a grass stem, seemed deliberately to fall two or three inches (5 or 7 cm.) to a moth fluttering beneath. Although it failed to capture the moth, its behavior indicated a method which may be employed.

Upon one occasion near a nest three workers were observed investigating a membracid which was appressed to the stem of an evening primrose, *Oenothera pallida* Lindl. They climbed over and around it, touching it with their antennae; but the Membracid remained motionless, and the workers

shortly went away. If it had moved they probably would have tried to capture it.

The inedible parts of the insects used as food are either brought up and taken away from the nest, or stored in chambers within the nest. In several cases grasshopper, beetle, *Myrmica*, and *obscuripes* remains have been found stored in soil chambers between one and two feet (30-60 cm.) down the nest.

C. NATURAL FOOD

The natural food of *Formica obscuripes* was found to be derived mostly from two sources: insects and aphid secretions. Most of the insects listed below were taken from the workers as they were being brought to the nest. In many cases they were dismembered to a greater or lesser extent and sometimes seemed already partially eaten. A few spiders were also collected.

Not the slightest evidence was found to suggest that this ant might use plants as food.

1. ARTHROPODA

The following table, listing the arthropods used as food by *obscuripes*, includes only those specimens which I have collected directly from the workers or have found dead in the chambers of the nest. With the exceptions of the ants and spiders they were all identified at the United States National Museum.

ORTHOPTERA

Acrididae

<i>Psoloessa delicatula?</i> Scudd.....	adults and nymphs
<i>Psoloessa?</i> sp.	nymph
<i>Melanoplus bivittatus</i> Say.....	adult
<i>Melanoplus</i> sp.....	5 small nymphs
<i>Phoetaliotes nebrascensis</i> Thomas.....	male nymph
Acridinae.....	head and thorax of adult
Oedipodinae.....	small nymphs
Many grasshoppers, both adults and nymphs, which, because of their fragmentary conditions, could not be further determined.	

Tettigoniidae

<i>Orchelimum?</i> sp.....	very small nymph
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COLEOPTERA

Scarabaeidae

<i>Dichelonyx elongata</i> Fabr.....	3 adults
<i>Serica curvata</i> Lec.....	5 adults

Coccinellidae

<i>Coccinella 5-notata</i> Kby.....	adults, including a live specimen
<i>Hippodamia parenthesis</i> Csy.....	adult

Elateridae

<i>Ludius elegans</i> (Kby.).....	adults, including a live specimen
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Chrysomelidae	
<i>Trirhabda</i> sp. (<i>T. canadensis</i> Kirby?)	adult
Carabidae	
<i>Harpalus</i> sp.	adult
Curculionidae	
<i>Anametis granulata</i> Say	adult
? <i>Hypera</i>	headless pupa
Harpalidae	
<i>Harpalus herbivagus</i> Say	adult
Cantharidae	
<i>Podabrus?</i> sp.	adult

HEMIPTERA

Pentatomidae	
<i>Coenus delius</i> Say	adults
<i>Peribalus abbreviatus</i> Uhler	adult
<i>Neottiglossa undata</i> Say	adult
Coreidae	
<i>Alydus conspersus</i> Montandon	adult
Lygaeidae	
<i>Emblethis vicarius</i> Horvath	adult
Nabidae	
<i>Nabis subcoleoptratus</i> Kirby	2 adults
Corixidae	
Sp. of Corixidae	2 adults

HOMOPTERA

Membracidae	
<i>Ceresa bubalus</i> (Fabr.)	4 adults, 3 nymphs
<i>Ceresa</i> sp.	adult
Membracid	adult

LEPIDOPTERA

Gelechiidae	
<i>Gelechia</i> sp.	larva
Olethreutidae	
undet. larva	
Noctuidae	
<i>Euxoa minis</i> Grt.	adult
Seven and possibly eight undeterminable species	10 larvae
<i>Epizeuxis</i> sp?	larva
<i>Feltia</i> sp.	adult
Tortricidae	
<i>Eucosma</i> sp.?	adult
Pyralidae	
Pyraustinae	larva
<i>Crambus</i> sp.	adult
Thorax of moth	

HYMENOPTERA

Braconidae	
<i>Bracon vulgaris</i> (Cress.)	adult
Hylaeidae	
<i>Colletes kincaidii</i> Ckll.?	adult
Andrenidae	
<i>Agapostemon angelicus</i> Ckll.	adult
<i>Halictus (Chloralictus) pruinosiformis</i> Crofd.	adult
Sphecidae	
<i>Tachysphex tenuipunctus</i> Fox	adult
Formicidae	
<i>Myrmica scabrinodis sabuleti</i> var. <i>americana</i> Weber (MS)	workers and male
<i>Lasius niger</i> var. <i>neoniger</i> Emery	females and worker
<i>Lasius umbratus mixtus</i> var. <i>aphidicola</i> Walsh	workers

DIPTERA

Syrphidae	
<i>Sphaerophoria</i> sp.	adult
Asilidae	
<i>Asilus notatus</i> Wied.	adult
Chironomidae	
<i>Chironomus</i> sp.	adult
Limoniidae	
<i>Helobia hybrida</i> Meigen	adult
Bombyliidae	
<i>Anthrax moris</i> L.	adult
Sarcophagidae	
<i>Sarcophaga bullata</i> Parker	adult
<i>Sarcophaga</i> sp.	adult
<i>Wohlfahrtia meigenii</i> Schiner	adult

ARACHNIDA

Several spiders of the genera *Pellenes* and *Lycosa*.

It will be seen from the foregoing list that representatives of seven orders: Orthoptera, Homoptera, Hemiptera, Lepidoptera, Coleoptera, Hymenoptera, and Diptera include all the insect food collected.

In numbers of individuals, the Orthoptera formed the largest group, comprising about 26% of all insects taken. Most of the grasshoppers were brought to the nest in such a fragmentary condition that identification was difficult or impossible. One specimen was a tettigoniid, all the rest were Acrididae. Of the latter, three genera, *Psoloessa*, *Phoetaliotes*, and *Melanoplus* were represented, each with at least one species. Specimens of *Melanoplus* were most numerous and include the species, *bivittatus* Say, one of the two most injurious grasshoppers of the state.

Lepidoptera formed the second largest group, comprising about 22% of all specimens. Of the five families represented, Noctuidae led with two-

thirds of all individuals. Most of the Lepidoptera were larval stages; they probably were the easiest prey of the ants.

Coleoptera constituted about 17% of all insects taken. Eight families and nine genera were represented, the genus *Serica* being the most numerous. Except for one pupa, all of the specimens were adults. Many larvae and pupae were found inhabiting the soil beneath the nest, and it is possible they are eaten if found.

About 12% of the insects were Hemiptera. Five families were represented, Pentatomidae predominating. All were adults.

Homoptera also formed about 12% of the insect food. All of these were members of the family Membracidae. The destructive leaf hopper, *Ceresa bubalus*, in its nymph or adult stages constituted about three-fourths of all the specimens. No aphids were taken to the nest, either dead or alive.

Diptera constituted about 9% of the insect food. Six families were represented and all specimens were adult.

Hymenoptera formed the smallest portion, about 7%, of the insect food. Representatives of five families were present. All the specimens were adult. Only five cases of ants used as food were observed. A number of females of *Lasius niger* var. *neoniger* Emery were found in an *obscuripes* nest which had a colony of this species nesting in the margin. The position, apparently safe enough for the workers, was evidently dangerous to the sexual forms. Upon another occasion a dead worker *neoniger* was taken from *obscuripes* workers on their nest. The third case was the finding of two partially eaten workers of *Lasius umbratus mixtus* var. *aphidicola* Walsh in soil chambers of an *obscuripes* nest. Parts of *Myrmica scabrinodis sabuleti* var. *americana* Weber (MS) workers were found in refuse chambers. The ants were probably captured as they wandered near the *obscuripes* nest. The fifth record is of a dead male *americana* taken from *obscuripes* workers on their nest.

Several medium sized spiders formed the remainder of the natural food. Small spiders are frequent inhabitants of the nest and may be eaten when found.

2. CARRION

Carrion is sometimes eaten by these ants. Richardson ground squirrels, *Citellus richardsonii* (Sabine), have several times been shot and placed upon the nest. The ants would partially eat the carcass and then bury it within the nest, as they do any object too large or heavy to move away.

3. SECRETIONS OF APHIDS

The secretions of aphids constitute an important source of food and very likely are second in importance only to the bodies of insects. It is even probable that in some cases these secretions are the primary source of food.

Jones (1929, pp. 48-50) has listed nine genera with thirty-one species of aphids tended by *Formica rufa* var. *aggerans* Wheeler, *Formica rufa*

obscuripes Forel, and *Formica rufa obscuripes* var. *melanotica* Emery in Colorado. These three forms of *rufa* are here considered to be the same subspecies, *obscuripes*. The aphids were found upon twenty-one genera of plants. Two of these genera, *Populus* and *Artemisia*, include species which are similarly associated with *obscuripes* and aphids in North Dakota.

In McHenry County, where the habits of *obscuripes* were most studied, the identified aphids found tended by them were *Aphis symphoricarpi* Thos. and *Neothasmiis populicola* (Thos.). One colony of *symphoricarpi*, however, had, according to P. W. Mason, "one specimen which seems to be *Aphis medicaginis* Koch". *Aphis symphoricarpi* was frequently found on *Symphoricarpos occidentalis* Hook and on *Glycyrrhiza lepidota* (Nutt.) Pursh. in the vicinity of *obscuripes* nests. *Neothasmiis populicola* (Thos.) was found in large numbers with many males present in early June, 1932 on *Populus tremuloides*.

Mr. J. E. Goldsberry found *obscuripes* workers tending aphids on sagebrush (*Artemisia* sp.) in the southwestern part of the state, which were determined by the United States National Museum as apparently an undescribed species of *Bipersona*. Unidentified aphids, tended by *obscuripes* workers, were found in considerable numbers on the leaves of many plants of *Artemisia glauca* Pall. and, of a different species, on the petioles on young shoots of a willow tree (*Salix* sp.) in McHenry County. Unidentified aphids were also found on the roots of the widespread prairie rose, *Rosa pratincola* L. and on the young leaves and petioles of *Populus deltoides* Marsh.

The relations between the aphids and ants are apparently of mutual benefit. The ants are very pugnacious and rush to the defense of the aphids when molested. While of little avail against a large enemy they probably are valuable in driving away other insects which prey upon the aphids. Coccinellid beetles and syrphid flies, among the chief enemies of aphids (Jones, 1929, p. 10), were collected as food of the ants, which is an indirect way of protecting them.

D. FOOD IN CAPTIVITY

Workers have been kept six months or more, queens nine and one-half months, and workers have been raised from the egg stage in observation nests. The food given them was, therefore, apparently satisfactory.

Various insects have been fed to the ants in captivity with successful results. Meal worms cut in pieces were the staple insects food. Grasshoppers, moths, house flies, June beetles, and various beetle larvae were readily eaten.

Honey and sugar were the other staple foods. Apparently the ants could live for months upon either. Other sweets, such as corn syrup, maple sugar, and sorghum, proved acceptable.

XIV. MYRMECOPHILES

The myrmecophiles which I have collected from *obscuripes* nests, identified at the United States National Museum, may be classified, following Wheeler (1910, p. 380), into:

(a). Persecuted Intruders, or Synechthrans. Under this heading probably come the scavenger staphylinid beetles:

Philonthus agilis Grav.

Philonthus debilis Grav.

Philonthus theveneti Horn

Goniusa obtusa Lec.

Atheta sp.

Aderocharis corticinus Grav.

Paederinae (*Gastrolobium* or related genus)

Platymedon laticollis Csy.

(b). Indifferently Tolerated Guests, or Synoeketes. Most of the myrmecophiles which I have collected probably are of this type:

COLLEMBOLA

Unidentified small white collembolans

COLEOPTERA

Scarabaeidae.....	Scarabaeid pupa
Scarabaeidae.....	<i>Euphoria inda</i> L. in pupal cells
Scarabaeidae.....	<i>Serica intermixta</i> Bltch. adult
Scarabaeidae.....	<i>Phyllophaga</i> sp. (<i>P. lanceolata</i> ?, <i>P. corrosa</i> Lec.?)
Carabidae.....	<i>Amara</i> sp. adult female
Elateridae.....	<i>Melanotus</i> sp. larvae
Chrysomelidae.....	<i>Cryptocephalus</i> sp. larvae
Hydrophilidae.....	<i>Berosus</i> sp.
Cryptophagidae.....	<i>Atomaria</i> sp.
Histeridae.....	<i>Hetaerius?</i> adult

LEPIDOPTERA

Noctuidae.....	<i>Epizeuxis</i> sp.? larvae
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DIPTERA

Milichiidae.....	<i>Phyllomyza securicornis</i> Fallen larvae
Leptidae.....	!larvae
Anthomyiidae.....	!larvae
Therevidae.....	!larvae

ARACHNIDA

The spiders, identified by Mr. Nathan Banks, include adults and young of both sexes of the genera *Drassus* and *Erigone*. A specimen of *Xysticus ontariensis* Emert, and a male of *Thanatus lycosoides* Emert, were taken alive in nests.

Nearly all of the above myrmecophiles were found in a single large nest.

The relations of three ants found at various times in nests of *Formica obscuripes* are not clear.

Tapinoma sessile Say workers were found in the upper 3 or 4 inches (7-10 cm.) of what seemed to be a senescent *obscuripes* nest. The interior of the nest was damp, many of the twigs were moldy and gave off a musty odor, and the whole appearance of the nest was as if abandoned. These *sessile* workers were extremely timid and avoided the light. Below this top 3 or 4 inches (7-10 cm.) of the nest a number of rather sluggish *obscuripes* workers were found. A small but flourishing nest of *obscuripes* was 600 feet (183 m.) distant.

Live workers, males and deälated alpha and beta females of *Lasius latipes* Walsh were found in digging up an *obscuripes* nest at a depth of about two feet (61 cm.). They did not seem to be captive and were possibly an independent colony.

Workers of *Leptothorax hirticornis* Emery were frequently found in *obscuripes* nests. The following excerpts from my notes upon a *hirticornis* worker, collected with *obscuripes* workers and brood and kept together in an observation nest, may suggest its relationship:

"This ant, at the approach of the large workers, flattens out as much as possible though they never seem to notice it and even walk over it." And the same morning "a worker was observed to open its mandibles threateningly at the smaller ant in its path but without further sign of hostility." Then "a worker, coming upon the smaller ant, moved nervously around, seized it violently at the same time curving its abdomen and spraying it with formic acid. The *Formica* grasped the *Leptothorax* at different places and seemed desperately trying to kill it; . . . several other workers came up and displayed hostility to the smaller ant but could not interfere because of its small size and the larger size of its attacker. Finally, the worker released it, and it crawled off, apparently none the worse although its abdomen glistened from the formic acid." The next morning this *Leptothorax hirticornis* worker was found dead. One antenna was gone, the distal part of the abdomen was cut away, and the viscera had been removed.

(c). Ectoparasites. All the ectoparasites observed were mites. These were found to be common on the sexual forms of *obscuripes* as well as on the workers. The mites, identified by the United States National Museum, include:

- Parasitidae. . . . On males, females, and workers from at least five nests.
- Uropoda* sp. . . . On males, females, and workers from at least three nests.
- Tyroglyphidae. Hypopi or migratory nymphs on males from at least two nests.

The mites became abundant on ants kept in the laboratory; upon a queen kept for nine months I estimated that there were over 200 unidentified mites, distributed as follows:

Posterior surface of petiole entirely covered by mites
(at least 10).

About 18 on dorsal surface of abdomen.

At least 14 on each side of abdomen.

More than 50 on ventral surface of abdomen.

About 14 on dorsal surface of thorax.

At least 10 on each side of thorax.

About 5 on ventral surface of thorax.

About 10 on dorsal surface of head.

About 5 on each mandible.

Several on margin of compound eyes.

About 18 on ventral surface of head, completely lining
several sutures.

At least 5 on each leg.

The only place on the queen free from mites was the antennae. The ant was rather feeble and died five days later but, whether from the mites, lack of workers to care for it, or length of time kept, I cannot say.

A common position for the mites is on the legs. On a female *obscuripes* the sole mite present was on the tibia-tarsal joint of the left metathoracic leg. Such a position is common.

XV. RELATIONS WITH OTHER ANTS

A. RELATIONS WITH ANTS OF OTHER *Obscuripes* COLONIES

The two *obscuripes* nests most studied were 90 feet (27 m.) apart on opposite sides of a wolfberry patch. Both had paths extending fully ten feet (3 m.) towards each other through the bushes. When workers from one colony were dropped upon the other nest they were immediately seized and attacked.

It seems probable that these are typical relations and that workers from one colony are as hostile to workers of another as if they were entirely different ants.

B. RELATIONS WITH OTHER ANTS

The relations of *obscuripes* to other ants, as far as observed, are entirely hostile.

As mentioned before, ants of two other genera, *Lasius* and *Myrmica*, were found in *obscuripes* nests in a condition indicating their use as food. Only thoraces of workers of *Myrmica scabrinodis sabuleti* var. *americana* Weber (MS) were found in refuse chambers, but a male of the same *Myrmica* variety, dealated queens and a worker of *Lasius niger* var. *neoniger* Emery and workers of *Lasius umbratus mixtus* var. *aphidicola* Walsh were found entire or partially eaten.

XVI. COMPARATIVE ASPECTS

Our North American ant fauna is believed to have developed from forms migrating in preglacial times from Eurasia chiefly by way of Alaska (Wheeler, 1908, p. 407). Consequently we find the ant faunas of North America and Europe to be very similar. Furthermore, many of our most representative ants are merely varieties or subspecies of European species. Such an ant is *obscuripes*, a subspecies of the European *Formica rufa*.

The genus *Formica* is now found over the entire holarctic region. Its type species, *rufa*, parent stock of *obscuripes*, occurs from Siberia and the Caucasus throughout North and Middle Europe to Great Britain, south to the Pyrenees and southern Alps.

Mounds of the typical *rufa* are built of much the same materials and are of the same shape as those of our *obscuripes*. The numerous openings are similarly scattered over the whole surface of the mound. Donisthorpe (1927, p. 290) referring to *rufa* in Great Britain says: "This species nests in woods in shady places, in clearings, and on the borders of woods and forests—but also in the interior—on heaths and commons, but never far from trees, being more generally associated with fir trees, though it also occurs in oak, birch, and other woods. Forel states that in the Alps it is intimately connected with the fir trees, occurring as high as the last of these, but never higher." Nests of the subspecies *pratensis* pictured by Eidmann (1926) are in forests in rather shady situations contrasting with open exposures chosen by *obscuripes*. Indeed, the common German name of the several forms of *Formica rufa* is *die rote Waldameise*, or the red forest ant.

Yung, according to Wheeler (1910, p. 191), has found that the populations of *rufa* colonies vary from 19,933 to 93,694 individuals and that the population does not vary with the size of the mound. It seems probable, however, that in North Dakota *obscuripes* populations vary with the size of the mound, and have populations of somewhat smaller magnitudes.

The mounds of *rufa* nests are considerably larger than those of *obscuripes*. The average height, according to Donisthorpe (1927, p. 291), is about 3 feet (0.9 m.), fully twice as high as my highest *obscuripes* mound (18 inches or 46 cm.). He has recorded nests 5 feet high (1.5 m.) and a *rufa* nest pictured by Wheeler (1910) is 2.15 m. high.

The structure of the mound proper is apparently similar: "a large underground chamber, which is connected by galleries with other underground chambers and other parts of the nest" (Donisthorpe, 1927, p. 291).

The age of some of these European *rufa* mounds is known and gives an indication of the age our *obscuripes* nests may reach. Donisthorpe records a nest known to an observer for ten years, one known to himself for over twenty years, and one kept under observation by Forel for over forty years.

A comparison of the food of *obscuripes* and *rufa* is especially interesting.

Eidmann (1926) in studying the relations of *F. rufa pratensis* to the forests of Germany made many collections of the prey dragged to their mounds. His findings are similar to mine for *obscuripes*. Insects constituted the great bulk of their prey and belonged mostly to the same orders and families. These, represented in both of our collections, are: Hemiptera (Pentatomidae), Lepidoptera (Noctuidae), Coleoptera (Elateridae, Carabidae, Scarabaeidae, Coccinellidae, and Chrysomelidae), Hymenoptera (Formicidae), and Diptera (Asilidae and Syrphidae). A large proportion of the prey was coleopterous. On one occasion he collected a captured female *Lasius niger brunneus* Latr.: I found females and a worker of the North American representative, *Lasius niger* var. *neoniger* Emery, similarly used as food by *obscuripes*. He collected a very few Diplopoda and earthworms which were not found here as the prey of *obscuripes*.

Colony founding in *Formica rufa* has been observed by Donisthorpe (1927, p. 300). He saw a *rufa* female after "several fights with some of the workers" actually enter a *Formica fusca* nest. He has recorded a number of observations of his own and of others showing that the *rufa* queen may enter a *fusca* nest and be adopted by the workers. The *fusca* workers rear her brood, which eventually supplants them. In some cases the *rufa* queen decapitates the *fusca* queen. Sometimes the *rufa* queen selects a queenless *fusca* colony. Nests of *fusca* have been excavated in varying degrees of supplantation, some containing a *rufa* queen and *fusca* workers and brood, some with a *rufa* queen, *fusca* workers and both *rufa* and *fusca* brood, and others with a *rufa* queen, *fusca* workers and *rufa* brood.

Another method of colony formation is discussed by Donisthorpe (p. 292). "A certain proportion of a colony will emigrate and form a new nest with one or more queens, and a colony thus split is enabled to spread in the immediate vicinity where the conditions are favorable and the same, rather than to send off swarms to less favorable localities."

The only record of the actual mating of the sexes of which Donisthorpe was aware in 1927 was an observation made by himself in England in 1911 when he witnessed the coupling of the sexes. "A number of *rufa* males and females were seen flying about in a timber yard, running about on a large mound of sawdust in the hot mid-afternoon sunshine, flying off and settling on it, the males appearing to rise more easily than the females. Copulation took place on the mound; I never saw a single pair together in the air."

These observations on colony formation and mating of the parent stock, *rufa*, suggest strongly the methods whereby *obscuripes* colonies are founded. *Formica fusca* forms cover the range of *obscuripes* and it is very likely that *obscuripes* will be found to be a temporary parasite like its Palearctic congener.

XVII. SUMMARY

1. *Formica rufa obscuripes* Forel is a widespread ant of western North America, ranging from Illinois to the Pacific Coast states and from the western Canadian provinces to Texas. It is found throughout North Dakota from the Red River "Valley" to the Badlands.

2. The taxonomy of this ant has been confused. *Formica rufa obscuripes* Forel, *F. rufa aggerans* Wheeler, and *F. rufa obscuripes* var. *melanotica* Emery are here considered together as one form, *F. rufa obscuripes* Forel.

3. The climatic environment influences the activities of this ant in the following ways:

a. The climate of North Dakota is such that *obscuripes* is active from April to November.

b. The wide range of temperature from between -40°F. to -50°F. (-40°C. to -45°C.) to between 100°F. to 110°F. (38°C. to 43°C.) within the state is tolerated.

c. The ant thrives in regions of the state having an annual rainfall of 10 inches (25 cm.) and in regions having an annual rainfall of 30 inches (76 cm.).

d. Relative humidities below about 25% when coupled with temperatures above about 90°F. (32°C.) cause a suspension of activities. Low humidities and high temperature with direct sunshine also cause the ants to remain below the nest surface. They are somewhat active at temperatures close to freezing and at temperatures as high as 103°F. (39.4°C.), provided the humidity is moderate.

4. Plants are an important factor of the environment: as hosts of aphids tended by these ants; as the source of their nesting materials; and through phytophagous insects as the ultimate source of their food; as a menace to the nest when the vegetation is luxuriant, through encroachment.

5. *Formica obscuripes* establishes its colonies in paraboloidal thatch nests of about 8 inches (20 cm.) in height and two to four feet (60 to 120 cm.) in diameter with many underground chambers extending to a depth of nearly five feet (150 cm.). The presence of the ants and their brood has no effect upon the nest temperatures; any differences in temperature between the nest and its surroundings are due to the inherent nature of the thatch. The mounds are made of twigs, grass blades, and herb stems from the nearby plants. An important feature of the nest is a large brood chamber in the center of the thatch mound in which all the brood is kept together.

6. From a representative colony 16,481 workers were taken. An additional 500 may have escaped and the brood (cocoons and callows) probably numbered about 2,000. The population of this colony was thus about 19,000.

7. The natural food of *obscuripes* is derived mostly from two sources: insects and aphid secretions. Not the slightest evidence was found to suggest that this ant might use plants as food. Orthoptera formed about 26% of all insects taken, Lepidoptera about 22%, Coleoptera about 17%, Hemiptera and Homoptera about 12% each, Diptera about 9%, and Hymenoptera about 7%. Among the insects collected by the ants are such injurious forms as grasshoppers and leaf-hoppers. Three species of ants used as food were collected: females and a worker of *Lasius niger* var. *neoniger* Emery, workers of *Lasius umbratus mixtus* var. *aphidicola* Walsh and a male and parts of workers of *Myrmica scabrinodis sabuleti* var. *americana* Weber (MS).

The aphid, *Aphis symphoricarpi* Thos., is tended by *obscuripes*, generally when on the wolfberry, *Symphoricarpos occidentalis* Hook. The aphid, *Neothasmia populicola* (Thos.), is tended by *obscuripes* on *Populus tremuloides* Michx.; another aphid, *Bipersona* sp., is similarly tended on sagebrush, *Artemesia* spp. The secretions of the aphids probably constitute a very important source of food. The relations between the aphids and ants are apparently of mutual benefit, the ants affording some protection in return for food.

8. Many myremecophiles live with the colony. Adults and larval Coleoptera and noctuid larvae take advantage of the favorable soil chambers for hibernation or development. Staphylinid beetles and the ant, *Leptothorax hirticornis*, may possibly prey upon the brood or isolated workers. Mites are frequently ectoparasitic upon the adults.

9. *F. obscuripes* colonies, if distinctly separated, are hostile to one another and are hostile to other ants.

10. This ant resembles its European congeners in nest structure, choice of food, and probably in life history; it differs in size of nest, population, and nesting sites.

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