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*A New Type of Social Parasitism
among Ants.*

By WILLIAM MORTON WHEELER.

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Article XXX. — A NEW TYPE OF SOCIAL PARASITISM
AMONG ANTS.

By WILLIAM MORTON WHEELER.

The observations recorded in the following paper were made during the summers of 1901, 1902, and 1904 at Colebrook in the Litchfield Hills of Connecticut, in the same locality in which I first observed the singular symbiotic relations of *Leptothorax emersoni* and *Myrmica brevinodis*, published in two previous papers.¹ The contents of the present paper relate to a hitherto unrecognized type of symbiosis between colonies of two very different ants, *Formica consocians* and *F. incerta*, and are of a nature to modify our views on some of the mixed colonies formed by other species both in Europe and America. Before taking up the relationship of the two species to each other it will be advisable to devote a few paragraphs to their taxonomic and ethological peculiarities.

Formica incerta is regarded by Emery as a variety of *F. schaufussi* Mayr, which, in turn, he regards as a subspecies of *F. pallide-fulva* Latreille, a very variable and distinctively North American form. In reality, *incerta* may be said to represent a transitional form between *schaufussi* and the subspecies *nitidiventris* Emery, having the coloration of the latter, and, to a limited extent, the pilosity of the former subspecies. In other words, *incerta* is apt to be somewhat darker than *schaufussi*, but has a few erect hairs on the lower surface of the head and the margin of the petiole.²

All three of these forms construct the same kind of a nest, which is almost invariably under a stone. For this purpose a flat stone, not too deeply embedded in the soil, is preferred. There are a number of broad chambers and passages in the surface soil and a few vertical galleries extending down from these to a depth of about a foot or eighteen inches. The walls

¹ The Compound and Mixed Nests of American Ants. Am. Nat., Vol. 35, Nos. 414, 415, 417, and 418, 1901, and Ethological Observations on an American Ant (*Leptothorax emersoni* Wheeler). Journ. für Psych. und Neurol., Bd. 2, Heft 1 u. 2, 1903.

² See Appendix A.

of the galleries and chambers are smoothly finished off and can hardly be mistaken for the work of any of our other species of *Formica*. The instinct, so pronounced in our other species of this genus, especially in the *rufa* group, of banking the edges of the stones with vegetable débris, is absent or extremely feeble. The colonies are small. Even the most populous contain hardly more than 500 workers, and the number, especially in the case of *incerta*, is commonly not more than half as great as in the typical *schaufussi*. A single colony may contain from one to five queens. The pupæ are less frequently naked than in some of our other species. The males and winged females normally make their appearance during July.

As would be expected from the small size of the colonies, the workers are very timid and usually make no attempt to defend their nest. They run with great rapidity, so that within a few moments after the nest is uncovered, all the workers have disappeared into the galleries or the surrounding grass. From the apertures of the former they sally forth, snatch up their larvæ and cocoons and retreat without confusion or any loss of time.

In the Litchfield Hills, *F. incerta* is much more abundant than the typical *schaufussi*. Both show a marked preference for the sunny upland pastures sloping towards the east and south at an altitude of 1000–1400 feet.

F. consocians is a very different ant. It is clearly a variety of *F. difficilis* Emery, which was regarded by its author as a subspecies of *F. rufa* L. But the name indicates that Emery had some doubts concerning the taxonomic status of the form. He described briefly all three phases and called attention to the extraordinary characters of the female. This sex, in being very small and uniformly yellow, departs so widely from the females of other forms assigned to *rufa*, that I do not hesitate to regard *difficilis* as a distinct species. At the same time there can be no doubt that it is very closely related both in structure and habits to the ants of the *rufa* group. The new variety *consocians* is described at length in Appendix B.

Like *incerta*, *consocians* nests under stones, but prefers heaps or clusters of stones, the edges and interstices between which are filled by the ants with abundant vegetable débris. The galleries are small and irregular and often carried out among the grass-roots surrounding the nests. These galleries differ greatly in appearance from the finished excavations of *incerta*. When fully developed the colonies are so populous that they may contain many hundreds or even several thousand workers and, during August, a great number of worker pupæ, always, so far as I have observed, enclosed in cocoons. The males and winged females make their appearance during the early part of August. Numerous males were found in a large colony Aug. 12, 1901, but none of the winged forms could be found during the latter half of the same month of the current year.

The workers of small colonies are as timid as those of populous ones are bold and pugnacious. The latter furiously defend their nest with their mandibles and formic acid batteries. When employing the latter they rise on their hind legs and bend the tip of the gaster forward in the attitude so characteristic of *F. rufa*, *integra*, etc. The gait of the workers is rather slow and hesitating, just as it is in the various forms of *rufo*. The females, on the other hand, are extremely timid, highly heliophobic, and run rapidly and without hesitation. The slightest disturbance of the nest causes them to disappear into the grass or the lower galleries, so that seeking the deälated queens of *consocians* in a populous colony is if anything more difficult than trying to find a needle in a haystack.

Both *difficilis* and its variety are mountain ants, the former occurring further to the south (in North Carolina and Virginia), the latter to the north (in Connecticut and possibly also in New Jersey). In the Litchfield Hills the var. *consocians* was not to be found at a lower altitude than 1200 feet. It prefers the same sunny upland pastures or glades interspersed with thickets as *incerta*. I have taken it in only three localities: on Mt. Pisgah (alt. about 1440 ft.) and on two neighboring hills (1200-1300 ft.) where *incerta* happened to be unusually abundant.

Although I had seen the colonies of *consocians* and *incerta* during previous summers, I failed to perceive any relationship between the two species till the past August, when, on going to Colebrook for a fortnight's vacation, I began to look for the small females of the former on account of their resemblance to the even smaller females I had described for *F. microgyna* of Colorado and Utah.¹ While engaged in this search I happened on certain mixed colonies of the two species, and forthwith concentrated my attention on them to the almost complete exclusion of other ants. I give my field observations in very condensed form together with notes on four colonies from my note-book of 1901. At that time I mistook the small queens of *consocians* found in two *incerta* nests for microgynes of the latter species, and as such they were described by one of my former pupils, Miss Margaret Holliday.² In the following paragraphs the observations are arranged irrespective of dates, so as to present a sequence of stages from the establishment of the *consocians* colony till its complete development. All of the colonies were found under stones, and all, with the exception of Nos. 2, 6, 10, and 11, within an area of four or five acres on the southern and eastern slopes of Mt. Pisgah. All of the *consocians* females mentioned were deâlated and therefore presumably fertile queens.

1. Aug. 15, '04. A small colony of *incerta* comprising about 30 workers. On raising the stone about a dozen workers were seen dragging a *consocians* queen by all her legs and antennæ through one of the superficial galleries. She was still alive when rescued from her tormentors. On digging into the nest I found an *incerta* queen and several worker pupæ.

2. Aug. 25, '01. A small colony of *incerta* workers (number not recorded) and two *consocians* queens. There was no *incerta* queen.

3. Aug. 18, '04. A small colony of *incerta* comprising about 25 rather small workers, a few larvæ and pupæ of the

¹ Extraordinary Females in Three Species of Formica, with Remarks on Mutation in the Formicidæ. *Bull. Mus. Nat. Hist.*, Vol. 19, Nov. 21, 1903; pp. 645-649.

² A Study of Some Ergatogynic Ants. *Zoolog. Jahrb. Abth. f. Syst. etc.*, 19 Bd., 4 Heft, 1903, p. 313.

same species, and a single *consocians* queen. The latter was unearthed at a depth of 9 inches. The colony contained no *incerta* queen.

4. Aug. 23, '04. A small colony consisting of about 15 *incerta* workers and a single *consocians* queen. There were about 8 worker cocoons of *incerta*, but no queen of this species.

5. Aug. 19, '04. A small colony comprising only 11 *incerta* workers, a *consocians* queen, unearthed at a depth of 5 inches, but no *incerta* queen. There were a few *incerta* cocoons in the nest.

6. Aug. 19, '01. A small colony found at North Colebrook. It comprised a few small *incerta* workers and a single *consocians* queen.

7. Aug. 21, '04. A small colony comprising only 8 or 9 *incerta* workers, although the size of the nest showed that it must have contained a larger colony at some former time. On removing the stone a *consocians* queen was seen in the upper chambers but at once disappeared into one of the galleries and was unearthed at a depth of 9 inches. There were a few *incerta* cocoons, but no queen of this species.

8. Aug. 29, '04. A small colony containing 10 *incerta* workers of rather small size, one small *consocians* worker, and a few worker cocoons which gave rise to both *incerta* and *consocians* workers on being kept in an artificial nest. A *consocians* queen was unearthed at a depth of 6 inches. There was no *incerta* queen.

9. Aug. 15, '04. A small colony comprising about 75 *consocians* workers and a dozen *incerta* workers. There were numerous cocoons of *consocians* workers and a fine queen of this species. There was no *incerta* queen.

10. Aug. 6, '01. A small colony found under two large stones. Only workers of both species were found (number not recorded). There were no larvæ but several worker cocoons and callows of *consocians*. No queens were found. A *consocians* queen may have been present but was, in that event, overlooked.

11. Aug. 25, '01. A small mixed colony comprising *consocians* and *incerta* workers in the proportions of about 20 of

the former to one of the latter. There were some small larvæ (probably *consocians*). No queens were found, that of *consocians* having been probably overlooked as in the preceding observation.

12. Aug. 17, '04. A nest clearly of the *incerta* type, as shown by the flat superficial chambers and large vertical galleries, containing about 150 *consocians* and only 4 *incerta* workers. The latter were unearthed at a depth of 14 inches. There were a few *consocians* worker pupæ and callows. Failed to find a *consocians* queen, which may have escaped.

13. Aug. 29, '04. A colony containing about 200 *consocians* and 5 *incerta* workers. The nest was of the pure *incerta* type, but a small *consocians* nest inosculated with it at the edge of the stone where the galleries had been excavated between the grass-roots and covered with vegetable débris. The *consocians* workers slunk away timidly, even forsaking quite a number of their cocoons. The queens of neither species were found. It is probable that a *consocians* queen belonged to the nest but escaped my notice.

14. Aug. 18, '04. A well-excavated *incerta* nest, passing over at the edge of the stone into a typical *consocians* nest as in the preceding observation. The galleries of both nests were inhabited in common by about 50 *incerta* and 150 *consocians* workers. A female of the latter species was found without difficulty, but none of the former. There were many worker cocoons and callows, but all belonged to *consocians*. The stone was carefully replaced. When the colony was revisited on the following day (Aug. 19), all the *consocians* and some of the *incerta* had moved away with the cocoons, but about a dozen of the latter species were still loitering about the galleries.

15. Aug. 18, '04. A nest of the pure *incerta* type but containing only *consocians*, a single queen and about 200 workers, and several worker cocoons. After unearthing all the rest of the colony, the queen was found at a depth of 8 or 9 inches in the lowermost galleries of the nest.

16. Aug. 29, '04. A nest of the typical *consocians* type under a single large stone and containing about 300 workers

of this species. I failed to find the queen. Under the same stone and inosculating with the *consocians* nest were the unmistakable but completely deserted galleries of an *incerta* nest. Workers of the latter species were nowhere to be found.

17. Aug., 1900, 1901, and 1904. Several large and pure *consocians* colonies containing many hundreds of workers and their cocoons. These colonies were always located in piles of stones that had been banked with vegetable débris by the ants.

The colonies above described may be separated into six groups, represented respectively by No. 1, Nos. 2-7, Nos. 8-12, Nos. 13 and 14, Nos. 15 and 16, and No. 17. Colonies 1-7 show that the young fertilized *consocians* queen enters a small and either incipient or depauperate *incerta* colony. She is not always amicably received, as shown by the behavior of the workers in colony No. 1. But in the series this is the only one that contained an *incerta* queen. In all the other cases the relations between the *consocians* queen and the *incerta* workers were perfectly cordial, as was proved whenever the insects were kept in artificial nests.

Colonies 8-12 show that the offspring of the *consocians* queen are reared in the *incerta* nest, without doubt by the workers of the latter species. This series of colonies also indicates that the number of host ants dwindles or remains constant, or at any rate does not increase *pari passu* with the increase of the *consocians* workers.

Nos. 13 and 14 show that after the *consocians* colony has acquired a certain strength and status it begins to construct its own characteristic nest to one side of the *incerta* nest in which it was reared.

Colonies 15-17 show that the *consocians* colony, when it becomes sufficiently populous, emancipates itself completely from the host species, so that there is nothing to suggest its parasitic origin.

Finally, in view of the fact that *F. consocians* is by no means a common or dominant species, the above observations are sufficient to prove that the method of colony formation here suggested is neither abnormal nor accidental, but the regular

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if not the only method. Nevertheless field observations leave doubtful certain questions which can be answered only by recourse to observations and experiments on colonies kept in artificial nests. We should naturally wish to ascertain the effects of artificially introducing strange *consocians* queens into *incerta* colonies with and without their own queens. And these experiments should be tried with *consocians* queens that have been living under three conditions: first, as young fertilized individuals that have just left the parental nest, second, as females that have been living with other *incerta* colonies, and third, as old queens that have long been living in pure colonies of their own species. As the season was far advanced when I first discovered the symbiosis of *consocians* and *incerta* I had to confine my experiments to older queens.

The first experiment was made with an *incerta* colony consisting of three rather pale dealated queens, about a dozen workers, and quite a number of worker cocoons. This was part of a healthy colony that had not been infested with *consocians*. Aug. 19, two darker dealated *incerta* queens from another colony and a single *consocians* queen, found living with *incerta* workers (colony No. 5), were introduced into the same nest. The *consocians* queen passed out of the empty food-chamber, in which she had been placed, and forthwith joined the strange *incerta* as if she had merely returned to her own colony. She was received without the slightest animosity and soon set about licking the callow workers that were hatching from the cocoons. From time to time she begged the older workers for food and was generously fed. This colony has now been under observation for four weeks, but I have failed to see any signs of animosity between the *consocians* queen on the one hand, and the *incerta* queens and workers on the other. But the introduced *incerta* queens were recognized as aliens the moment they entered the nest and there were daily struggles between the three pale and the two dark queens and still more frequent battles between the *incerta* workers and the strange queens. The latter were dragged about the nest by the hour, tweaked, and sprayed with formic acid. One of them succumbed miserably Aug.

21; the other seemed to remain unmolested for several days, as if the workers had consented to adopt her, but she, too, died Aug. 31, possibly from the injuries sustained earlier in the month. At the date of this writing (Sept. 15) the *consocians* queen, the three pale *incerta* queens, and 22 workers are living together as a united and happy family.

A second experiment of a somewhat different character was begun Aug. 19 with a dozen *incerta* workers from an uninfested colony, a single *incerta* queen from another nest, and two *consocians* queens which may be called A and B. A was somewhat the smaller, and was taken from colony No. 15, which contained only *consocians* workers. B came from colony No. 14, which comprised workers of both species. The two *consocians* queens at once mounted the pile of *incerta* cocoons, begged the workers for food, and began licking the newly hatched callows. But they were promptly detected as aliens, pinioned by a leg or an antenna, and dragged about the nest. Whenever they could escape from the jaws of the *incerta* workers they ran back nimbly to the nursery, only to be again dragged away in a few moments. They offered no resistance and never attempted to attack either each other or an *incerta* worker or queen. They were, in fact, almost ludicrously humble and conciliatory, now vainly begging for food, now exhibiting the greatest interest in some newly hatched callow, and anon attending to their toilet, combing their hair and drawing their antennæ through their strigils. The strange *incerta* queen, however, was even more severely maltreated by the workers of her own species. They pulled her legs and antennæ by the hour and when this became monotonous they sprayed her with copious showers of formic acid. All of these insults she endured patiently for some days, but finally one afternoon I saw her turn in a fit of rage and punish one of her tormentors severely. For several days she seemed not to be molested, but her temper was thoroughly aroused. One day I saw her, without the slightest provocation, seize one of the *consocians* queens by the mandibles, then loosen her hold and slide her jaws back to the small queen's neck as if to cut off her head. The *consocians*, however,

slipped away. On the morning of Aug. 22 *consocians* B was found dead in the nest with an antenna extirpated. On the afternoon of the same day *consocians* A was also dispatched by a large *incerta* worker. This queen was the older of the two, since she floated in alcohol.¹ The *incerta* queen seemed to have made peace with the workers. Hereupon I introduced a *consocians* queen (from colony No. 7) that had been living with a few *incerta* workers only. This insect was very amicably received by the colony that had executed queens A and B. After a period of apparent adoption the *incerta* queen was found dying Sept. 4, and the next day was completely dismembered by the workers of her own species. At the present writing (Sept. 15) callows are still hatching from the *incerta* cocoons, and the colony with its single *consocians* queen is in a peaceful and flourishing condition.

Aug. 25, I introduced a female *consocians* that had been living with a few *incerta* workers (of colony No. 4) into an artificial nest containing a portion of a large pure colony of *consocians*. On entering the chamber the queen showed the greatest alarm. While she was running wildly to and fro she was repeatedly seized by different workers of her own species, so severely bitten and so thoroughly drenched with formic acid that I had to remove her from the nest in order to save her life.

These rather fragmentary experiments point to the following conclusions:

(1). A *consocians* queen that has been living with *incerta* workers is readily adopted by strange *incerta* colonies.

(2). A *consocians* queen is not adopted by *incerta* workers if she has been living previously with workers of her own species, unless, perhaps, she is a very young queen that has just left the parental nest.

(3). A *consocians* queen that has been living with *incerta* workers is violently attacked by a vigorous colony of her own species.

(4). Colonies of *incerta* are far less hospitable to *incerta*

¹ In aged dealated queens the wing-muscles degenerate and air takes their place in the thoracic cavity, so that such specimens float in water or alcohol.

queens from strange colonies than to *consocians* queens that have been living with strange *incerta* workers.

These conclusions were perhaps to be expected from what is known concerning the rôle of the nest and colony odors among ants. The last conclusion is the most significant in the absence of any experiments on young *consocians* queens that have just descended from their nuptial flight.

There still remain certain interesting questions which are only incompletely or vaguely answered by the above observations and experiments. First, why are all the natural *consocians-incerta* colonies without a queen of the latter species? Does the *consocians* queen normally seek out only small, either incipient or depauperate *incerta* colonies that have through some misfortune lost their queen or queens? Or if present when the *consocians* is adopted, how is the *incerta* queen disposed of? Is she killed by the parasitic queen or by her own workers in a fit of instinct perversion? That the *consocians* may, at least occasionally, seek adoption in *incerta* nests that have not lost their queens, is shown by the observation on colony No. 1, and the experiments on artificial nests point to amicable adoption by *incerta* colonies still in possession of their queens. The contrary, however, seems to be indicated by the offensive behavior of the *incerta* workers in colony No. 1 and by the fact that many of the colonies in which I found *consocians* queens were obviously depauperate. Some of these colonies comprised only a few small workers and must have been incipient, whereas others, as indicated by the contrast between the extensive excavations of the nest and the very small number of large workers were clearly decadent or moribund. Moreover, during my search for infested *incerta* colonies, I saw not a few pure colonies of this species without queens and apparently favorable to infection by *consocians* queens.

A second question is also suggested: How do the *consocians* eventually emancipate themselves from the *incerta* colony? Do the *consocians* destroy the remaining *incerta* workers? Or are the latter permitted to die off naturally and thereby depurate the colony? Or do the *consocians* simply move away

and establish a nest of their own apart from the *incerta* workers? The first supposition is unantlike, and therefore improbable. The second would seem to be indicated by such colonies as No. 12, which contained very few *incerta* living with many *consocians*. Colony No. 14 shows that the *consocians* are rather easily induced to move away from their nest, and I have observed this also in the case of much larger colonies. Some of the facts recorded on other ants (see p. 363 *infra*) seem also to indicate that the *consocians* colony may purify itself by migration.

It must now be shown why the *incerta-consocians* association may be termed a new type of social parasitism or symbiosis. With certain important exceptions, to be considered presently, the mixed colonies hitherto described group themselves naturally about three species: *Formica sanguinea*, *Polyergus rufescens*, and *Anergates atratulus*. In other words, these three European ants serve as types of as many forms of symbiosis. *F. sanguinea* and *P. rufescens* represent two apparently successive phylogenetic stages in the development of dulosis, or of the slave-making instinct. Wasmann¹ designates the former as facultative, the latter as obligatory in this respect. *Anergates* is the type of a small group of parasitic ants that have secondarily lost the worker caste. To this group probably belong also the American *Epæcus pergandei*, *Epipheidole inquilina*, and *Sympheidole elecebra*.² All of these cases of symbiosis, however, agree in being *permanent* consociations of two species.³ The case of the *consocians-incerta* colonies is clearly different in that the former species is parasitic only during the incipient stages of colony formation. It may therefore be designated as a *temporary* social parasite, a true cuckoo ant, which sponges on another species only so long as necessary in order to gain a successful start in life. In the classification which I have given of the compound nests and mixed colonies, it would constitute the type of a temporary,

¹ Neues über die zusammengesetzten Nester und gemischten Kolonien der Ameisen. Allgem. Zeitschr. f. Entomol., Bd. 6, 1901.

² See my paper: Three New Genera of Inquiline Ants from Utah and Colorado. Bull. Am. Mus. Nat. Hist., Vol. 20, Art. 1, pp. 1-17, pl. 1 and 2. Jan. 14, 1904.

³ With the possible exception of certain old and populous colonies of *F. sanguinea*, which seem to lose the power of or inclination for keeping slaves and may thus become pure colonies.

as distinguished from the stable, or permanent colacobiosis of *Anergates*.¹ It furnishes an interesting analogy to forms of individual parasitism such as we see in many insects that are parasitic in their larval but free-living in their adult stages.

Let us return for a moment to the particular case of the *consocians-incerta* colony, for the sake of asking a question which must have occurred to the reader of the preceding pages: Why is the incipient colony of *consocians* parasitic on the colony of another species of *Formica*? The obvious answer to this question is that the *consocians* female is unable to establish her colony without the assistance of mature workers. It is now well known that the queen ant of most species, after enclosing herself in a small chamber in the soil or in dead wood, proceeds to raise her first batch of workers entirely by herself, feeding them with her salivary secretions, which are in turn derived by metabolism from her fat-body and no longer functional wing-muscles. Weeks or even months elapse before the workers mature and go forth into the world to obtain food for themselves and their queen. This undoubtedly involves a great strain on the endurance of the mother insect, and many undoubtedly succumb without ever being able to establish a colony. For the queen of *consocians*, which barely exceeds the largest workers in size, it is probably quite impossible to bring up even a batch of very small workers, and recourse must be had to parasitism. Indeed, the diminutive and feeble organization of the queen *consocians* implies relative infertility and a very limited range of dissemination of the species during the nuptial flight. This is also borne out by observation. In all the mixed colonies offspring of the *consocians* queens were either completely lacking

¹ From κόλαξ, a flatterer; *κολακίς*, a female flatterer. Without, at the present time, entering into an elaborate defence of my classification of the various cases of social symbiosis, I may say that Wasmann's veiled disapproval of the Greek terminology introduced by Silvestri for termites and by myself for the ants, appears in a strange light when we see him, in the same breath, as it were, introducing such terms as *phylacobiopsis* and *echthrobiopsis*. I really care very little for the Greek terminology or scholastic definitions of my categories, which a less captious critic would have understood to mean naturally separable groups in the same sense as we regard the genera of the animal kingdom as coördinated categories, though it is well known that a genus of birds or mammals is logically more nearly the equivalent of a species in insects. Wasmann fails to see the impracticability of imposing a rigidly conceptual scheme on a body of intergrading phenomena like those comprised under social symbiosis, phenomena which are, moreover, very inadequately known. I shall return to this subject when I come to publish my observations on the American *sanguinea* and *Polyergus*.

or very few and in late stages of development, and during a month's captivity none of the queens in six nests have shown any disposition to lay eggs notwithstanding the fact that the insects have been well fed. The circumscribed range of dissemination during the nuptial flight is indicated by the sporadic or local occurrence of these ants. The production of such small queens cannot, however, be altogether disadvantageous. On the contrary, it is probably much easier for the adult *consocians* colony to produce these diminutive individuals than for colonies of *F. fusca* and *pallide-fulva* and their varieties to produce their much larger queens. We should even expect to find the number of queens produced by a large *consocians* colony greatly in excess of the number produced by *fusca*, *cinerea*, etc., colonies of the same size, for the same reason that the eggs of many parasitic worms (*Tænia*, *Distoma*, *Ascaris*, etc.) are much more numerous, though individually smaller, than in many non-parasitic species. The lateness of the season prevented me from investigating this interesting matter, but an observation recorded in the next paragraph would seem to indicate that the *consocians* colony sends off a great number of winged females. This, together with the fact that old *consocians* colonies contain an enormous number of workers, seems to imply that the old queens of this species must differ greatly from the young ones in being extremely fertile or that the large workers must be capable of producing both worker and female offspring.

The views advanced in the preceding paragraph gain in probability when we come to consider certain other North American ants that are very exceptional in their respective genera in having diminutive females. The most striking of these is *F. microgyna* which I have described from Colorado.¹ The adult colonies and nests of this ant are very similar to those of *F. consocians*. Winged females are produced in great numbers, as I find on consulting my Colorado note-book, in which I mention "many dozen females" as occurring in a single colony. On looking over my extensive collections of ants from the vicinity of Pike's Peak, I find the specimens and

¹ Extraordinary Females, etc., p. 645 *et seq.*

a record of three small mixed colonies of workers belonging to *F. microgyna* var. *rasilis* and *F. fusca* var. *argentata*. Two of these were taken in South Cheyenne Cañon at an altitude of about 8000 feet and at Broadmoor, the third at an altitude of 11,500 feet on Pike's Peak. In all of these colonies the *rasilis* workers were of small size and infuscated. I infer from these cases that *F. microgyna* is, in all probability, a temporary parasite like *F. consocians*.

In a lot of material collected in Nevada and Colorado, I have recently discovered two additional ants with diminutive females. Like *difficilis* and *microgyna* they are mountain-inhabiting forms belonging to the *rufa* group. They are described in Appendix C as *F. microgyna* var. *nevadensis* and *F. montigena*. Of the former I have seen only a single winged female, which differs from the same sex of the typical *microgyna* in being more pilose and in having a more shining gaster. Of the latter, which is allied to *F. dakotensis*, I have seen all three phases. It occurs on the higher slopes of the mountains about Ute Pass, in Cheyenne Cañon, and on Pike's Peak. In the first mentioned locality I saw several huge colonies, one of which consisted of four nests a few yards apart under pine logs banked with vegetable débris. Each of these nests was exceedingly populous, but seemed to contain only workers and worker pupæ, the latter nearly all naked. The insects attacked me with great fury. Among the colonies seen on Pike's Peak and in Cheyenne Cañon, two were mixed with *F. incerta*. Both were small and evidently incipient. The Pike's Peak colony was found under a stone and comprised about 50 mostly callow *montigena* workers and 7 or 8 *incerta* workers. There were a few worker pupæ of the former species. The other colony, which was also under a stone, comprised hardly more than a dozen small *montigena* workers and only five or six *incerta* workers. In neither nest did I find a queen of either species. I feel confident, however, that there were no *incerta* queens, and as it would be even easier to overlook a dealated *montigena* than a *consocians* queen, especially when one is not prepared to find so small and worker-like an insect, I lay no stress on this negative observation.

The two mixed colonies lead me irresistibly to the conclusion that *montigena*, like the preceding species, is a temporary parasite in the nests of another ant. In this case the host is the same as that of *consocians*, namely *F. incerta*, which seems to be quite as abundant in the Rocky Mountains as it is in the hills of New England.

In my paper cited above,¹ I called attention to the fact that there is still another American ant of a very different subfamily, namely the Myrmicine *Stenamma* (*Aphænogaster*) *tennesseense*, the queens of which are quite unlike the females of any other species of the genus in being very small and glabrous. Now in my paper on the compound nests and mixed colonies I published an observation of the late Rev. P. J. Schmitt, O. S. B., who found a mixed colony of *S. tennesseense* and *S. (A.) fulvum aquia* var. *piceum*. The queen of the colony belonged to the former species. Rev. Schmitt was impressed by the fact that the nest was under a stone, whereas *tennesseense* normally occurs only in dead wood at Beatty, Pennsylvania. This seems to be generally true of the species. In Illinois and Wisconsin I have never taken it except in the old logs in rather open forests. Since these observations were published I have myself found two mixed colonies of the same kind near Rockford, Illinois. The following is taken from my note-book under date Aug. 9, 1902:

"Found under a stone below the railroad embankment at the edge of a wood a mixed colony of *S. tennesseense* and *S. fulvum* var. *rude*. It was of small size and contained about two thirds as many *tennesseense* as *rude* workers. The former were mostly callows as shown by their light color. There were also some larvæ and several unmistakable *tennesseense* pupæ. On digging deeply into the earth a dealated *tennesseense* queen was found, but no female of *rude*. A large portion of this colony was taken home in a bag and placed in a Forel's arena surrounding an open Fielde nest. While moving into the nest the *S. rude* workers always carried the *tennesseense*.

"About a quarter of a mile from the locality in which I found this nest, I came upon another of a very similar char-

¹ Extraordinary Females, etc., p. 650.

acter. It, too, was under a stone, but contained more *tennesseense* than *rude* as nearly as I could ascertain. In this case also many of the former were callows. There were quite a number of larvæ, presumably belonging to *tennesseense*. No queen of either species was found."

In the light of the preceding observations on *Formica* species with diminutive queens, it seems very probable that the *S. tennesseense* queen must be similarly unable to bring up her own brood and therefore compelled to seek the assistance of an incipient or depauperate colony of some variety of *S. fulvum*. The fact that the *tennesseense* colony is first established under stones, but when populous is always found in rotten wood, indicates that it may depurate itself by migrating away from the *fulvum* workers. As bearing on the question considered on p. 360 *ante*, it should also be noted that the number of females produced by a single populous *tennesseense* colony is considerably in excess of the number produced by large colonies of our other species of *Stenamma* (including the subgenera *Aphenogaster*, *Ischnomyrmex* and *Messor*). Moreover, so far as my observations go, *S. tennesseense* is sporadic in its occurrence, and is found only in regions where *S. fulvum* or some of its varieties are unusually abundant.

Since all the foregoing species are alike in having diminutive females, we are naturally led to inquire whether temporary colacobiosis is peculiar to such species. This question must, I believe, be answered in the negative. In *Formica exsectoides*, the famous "mound-making ant of the Alleghanies," so familiar to the rural population of the Atlantic States from Massachusetts to North Carolina, we have an ant that agrees with most species of its genus in possessing large queens. Nevertheless an interesting series of observations can be adduced to show that this species is in all probability a humble temporary parasite. These observations, cited in my former paper, may be repeated here: "Forel found a small mixed formicary of these species [*F. exsectoides* and *F. subsericea*] at Hartford, Conn. Rev. P. J. Schmitt writes me that he has found at different times five different nests of *F. exsectoides* - *subsericea*. These invariably contained

females of the *exsectoides* only. All these colonies were, moreover, obviously incipient, as shown by the fact that they contained scarcely more than fifty ants, including both species." I have myself found two similar colonies at Colebrook, Conn. One of these is mentioned in a foot-note at p. 800 of my paper on compound nests, etc. In all, therefore, eight cases of small or incipient *exsectoides-subsericea* colonies have been found. This number is quite sufficient to suggest the temporarily parasitic nature of *exsectoides*, notwithstanding the much greater size of its queens.

At this point I feel tempted to leave the field of my own observations in order briefly to discuss certain mixed colonies observed by other myrmecologists. In my paper on the compound nests, etc., I combined a number of cases like those of *Stenammina tennesseense-fulvum* and *F. exsectoides-subsericea* in a single avowedly dubious category (synclerobiosis¹). To this I also assigned a number of cases observed by European authors and designated by Wasmann as accidental or abnormal mixed colonies. To-day I am willing to assign nearly all of these cases to temporary colacobiosis, or social parasitism, but that I was nearer the truth in embracing them in a single category than Wasmann in calling them accidental or abnormal and distributing them among his other categories, will be seen from the following paragraphs, in which I shall attempt to show that these various mixed colonies, at least in so far as they relate to ants of the *F. rufa* and *exsecta* groups, belong, in all probability, to the same type as *F. consocians* and *F. exsectoides*.

Among the species studied by other authors, *F. dakotensis* var. *wasmani* must first be considered. This ant was originally observed by Rev. H. Muckermann, S. J., in the vicinity of Prairie du Chien, Wis. His notes were published by Wasmann² as referring to the typical *dakotensis*, but Forel has since shown that the Wisconsin form is to be regarded as a distinct variety.³ Muckermann found in all some nine colo-

¹ From *συνγκληρώ*, to embrace in one lot.

² Neues über die zusammengesetzten Nester, etc., pp. 6-11.

³ Fourmis de British Columbia récoltées par M. Ed. Whymper. Ann. Soc. Ent. Belg., Tome 48, 1904, p. 153.

nies of this interesting ant, and five of these were mixed with *F. subsericea*; the four presumably much larger colonies, comprising altogether some twenty nests, were pure *wasmanni*. In the mixed colonies the ratio of the *wasmanni* to the *subsericea* workers was 7:3 or 7:4. When the ants moved to a new nest the workers carried only workers of their own species. In the mixed colonies Muckermann could find no females of *subsericea*, but only those of *wasmanni*. On one occasion, however, he came upon two dealated *wasmanni* queens and some callow workers of the same species living together with a dealated *subsericea* queen and workers under the same stone. From these facts, which constitute the substance of Muckermann's observations, Wasmann concludes that *F. wasmanni* is a facultatively dulotic ant, possessing a somewhat feebler slave-making instinct than *F. sanguinea*. This conclusion is, in my opinion, premature. Muckermann saw no slave-making expeditions on the part of the *wasmanni* and these would have to be witnessed before it could be regarded as a dulotic species. Moreover, as Wasmann himself admits, the small colony above referred to, embracing both *wasmanni* and *subsericea* queens, strongly indicates consociation by adoption rather than by dulosis. The fact that *wasmanni* is a pugnacious ant is no indication whatever of dulosis, as shown by cases like *F. consocians* and *montigena*. Thus there is really nothing in the facts observed by Muckermann that would prevent us from including *wasmanni* with the cases of temporary social parasitism, especially as this species seems to be rather closely related to *F. montigena*. Of course, this view must be tested by further investigations.

It will now be necessary to enter on the more delicate task of interpreting certain mixed colonies that have been observed in Europe. These consist of *F. fusca* as one component and ants of the *exsecta* or *rufa* groups as the other. In the "Fourmis de la Suisse" (pp. 371-373) Forel describes six colonies of this description: two of *exsecta-fusca*, two of *exsectopressilabris-fusca*, one of *truncicola-fusca*, and one of *pratensis-fusca*. With the exception of one of the *exsecta-fusca* colonies, all of these were small and incipient. The

perusal of Forel's notes shows that they closely resembled the American *consocians-incerta* and *exsectoides-subsericea* colonies. Wasmann¹ mentions another similar incipient colony of *pratensis-fusca*, and more recently² he has described two mixed colonies of *truncicola-fusca*. Each of these consisted of a number of *fusca* workers and a single deãlated *truncicola* queen. The similarity of these to such colonies as Nos. 2-7 of *consocians-incerta* is very suggestive.

In addition to these relatively simple cases, Forel and Wasmann have each described mixed colonies made up of three different species. Two of these colonies described by Wasmann consisted of *sanguinea-fusca-pratensis* and *sanguinea-fusca-rufa* respectively. He gives good reasons for supposing that in the former case a *pratensis* queen had been adopted by a queenless *sanguinea-fusca* colony. In all probability the latter case is to be explained in the same way. He also made the interesting observation that the *sanguinea-fusca* finally migrated away from the *pratensis*. Forel³ has recently described a remarkable mixed colony consisting of *Polyergus rufescens-F. fusca-F. pratensis*. It contained five or six deãlated-queens of *pratensis*, but no *Polyergus* queen.

Both Forel and Wasmann interpret these colonies, of, which some form of *exsecta* or *rufa* is a component, as colonies formed by adoption. In other words, we must suppose the female of the *exsecta* or *rufa* form to enter a simple *fusca* colony or one that happens to be living with *sanguinea* in a state of dulosis, for the purpose of establishing her own family. The cases are sufficiently numerous to show that there is probably as strong a tendency towards social parasitism on the part of the European *rufa* and *exsecta* as there is in the American members of these groups of *Formica* (*montigena*, *microgyna*, *exsectoides*, etc.). Indeed, I believe we may go even further and maintain that, when more attention has been devoted to a study of their incipient colonies, the Euro-

¹ Die zusammengesetzten Nester und gemischten Kolonien der Ameisen, Münster i. W., 1891, pp. 173, 174.

² Neues über die zusammengesetzten Nester, etc., pp. 20, 21, 77.

³ Fourmilière Triple. Bull. Soc. Ent. Suisse, 10, pp. 280-282.

pean *rufa* and *exsecta* will be found to be normal temporary social parasites in the colonies of *fusca*.

If I have not unduly expanded the conclusions derived from my study of the *consocians-incerta* colonies, it follows that nearly all the mixed colonies which Wasmann calls abnormal or accidental are, on the contrary, quite normal and regular cases of temporary social parasitism.¹ If, however, it should be shown that the European *rufa* and *exsecta* queens are perfectly able to start their own colonies, the tendency to parasitism would still be indicated by the above cases and these would be of considerable interest as representing an imperfect phylogenetic stage that has led to the perfected parasitic instincts of *F. consocians*. That this insect has become completely adapted to temporary parasitism is shown by the mimetic characters of its queen, so closely resembling the *incerta* workers in size and gait and, to a considerable extent also, in coloration.

The question will certainly be asked at this point: Are we to believe that that magnificent mound-builder among our northern ants, the fallow ant (*Formica rufa*), with its many subspecies and varieties, and the fierce *F. exsectoides*, which is said to form single colonies of as many as 1800 large mounds,² all begin their colonies as parasites in the insignificant nests of humble congeners like *F. fusca*, *F. schaufussi*, and their varieties? This does in fact seem like a preposterous supposition. But we may ask in turn: Has anybody in Europe or America ever found a solitary queen of the *rufa* or *exsecta* groups establishing her colony? I have collected assiduously

¹ I am far from denying the existence of what Wasmann calls 'abnormal' or 'accidental' mixed colonies. I can, in fact, cite a number of such cases from my own observation. But I should prefer to designate these as mixed colonies of uncertain meaning and retain them in my provisional category synclembiosis, since it is better frankly to admit our doubts than to clothe them in words like 'accidental' and 'abnormal' and attempt to distribute these cases among the better known categories of mixed colonies. Miss Fielde (Artificial Mixed Nests of Ants. Biol. Bull., Vol. 5, No. 6, Nov., 1903) has shown that there is probably a general law underlying the formation of artificial mixed colonies, and there is no reason to suppose that this does not obtain also in a state of nature. That Miss Fielde could make artificial mixed colonies from species belonging to different sub-families, whereas such colonies do not occur under natural conditions, may be explained by the fact that she worked with comparatively few individuals. I cannot but think that larger colonies of any one of these species would present a greater number of hostile variations among its component workers and union between representatives of different subfamilies be thereby rendered impossible. Even in a state of nature synclembiotic colonies of species belonging to the same taxonomic subfamily are small and feeble.

² See McCook: Mound-making Ants of the Alleghanies. Trans. Am. Ent. Soc., Vol. 6, 1877, p. 254.

during the most favorable seasons in regions like Colorado, which surpasses all other regions of the globe in the great wealth of its *Formica* fauna, without finding a single queen of the *rufa* group in the act of starting a colony, though I have often seen queens of the *fusca* and *pallide-fulva* groups thus engaged. And although *rufa* is a very well known and widely distributed ant in Europe, I have found in the works of European myrmecologists no account of the establishment of its magnificent colonies. This is, of course, purely negative evidence, and perhaps its only value in this connection, like the preceding discussion of the mixed colonies of uncertain meaning, may be to direct attention to the insufficiency of our knowledge and the desirability of making further researches.

That such vast colonies as those of *F. rufa* and *exsectoides* should have a parasitic origin—should, in fact, be a splendid example of the *ex humili potens*—need not surprise us when we stop to consider that the history of the paragon of animals is replete with even more extraordinary developments of might and insolence from insignificant and squalid parasitism. We may compare—*si parva licet componere magnis*—the timorous and conciliatory *consocians* queen and her tiny colony of workers which will eventually give place to the pugnacious and self-assertive adult colony, with the humble and inquilinous origin of certain historical families, political parties, and religious sects, and their insolent and aggressive attitude as soon as their numbers have sufficiently increased.

In conclusion I will endeavor to answer a question that has been asked by Wasmann in connection with the mixed colonies of dulotic ants: namely, Why does not social parasitism like that of *F. consocians* ultimately lead to the extinction of the host species? Including both the cases of dulosis and social parasitism in the answer, we may say that the host species do not become extinct, because

1. They are dominant, that is, very fertile and prolific species, abundantly represented by individuals over a wide stretch of territory. Only such ants would naturally be

selected by the parasite, since they are both the most opportune and favorable of hosts.

2. The parasitic species are local or sporadic, or, in any event, more restricted in their distribution than the host species. This may be due to deficient fertility or to greater dependence on a precise physical and biological environment, or to both of these factors.

3. Even within what may be called the area of infection of the host species by the parasitic ants, the former is able to maintain a foothold or even to increase in numbers on account of a certain margin of redundant vitality, which is commonly not completely exhausted by the inroads of the parasite.

4. These various conditions may enable a host to support parasites of several different species in the same or different portions of its range, especially if, in turn, the parasites are not necessarily restricted to a single species of host ant. This is clearly seen in *F. incerta*, which is preyed upon by at least three other insects in addition to *F. consocians*: the little thief-ant (*Solenopsis molesta*) and two Staphylinid beetles, *Xenodusa cava* and *Hesperobium flavicorne*. During the past summer I found several colonies of *incerta* containing numerous pseudogynes, which must have been produced by the presence of the beetle parasites, if Wasmann's theories may be expanded to embrace American ants. In a forthcoming paper I shall consider this subject in detail.

APPENDIX A.

Examination of large series of workers, males and females of two new varieties and of all the described forms of *F. pallide-fulva* from numerous localities, convinces me that Emery's table for the identification of the workers of this species should be modified to read somewhat as follows:

- (1.) Maxillary palpi, especially their two last joints, conspicuously long; lower surface of head and edge of petiole depilate.
- (a.) Color pale yellow, gaster slightly infuscated or sordid,
pallide-fulva Latreille s. str.
- (b.) Color throughout reddish yellow... var. *succinea* var. nov.

(2.) Maxillary palpi shorter.

(a.) Edge of petiole and lower surface of head more or less pilose; large forms.

(α.) Reddish yellow, with more or less infuscated gaster; pubescence and hairs long and abundant, subsp. *schaufussi* Mayr.

(β.) Reddish yellow throughout; hairs and pubescence longer than in the preceding form, especially on the gaster where the pubescence is very close and conceals the shining surface,

var. *meridionalis* var. nov.

(γ.) Color variable, sometimes like the typical *schaufussi*, sometimes like *nitidiventris* (vide infra); hairs on petiole and lower surface of head fewer and less constant than in *schaufussi* and *meridionalis*..... var. *incerta* Emery

(b.) Edge of petiole and lower surface of head depilate; smaller forms.

(α.) Reddish yellow, with black gaster; pubescence on the latter short and sparse so that the shining ground surface is clearly revealed,

subsp. *nitidiventris* Emery.

(β.) Head and thorax deeply infuscated, nearly or quite as dark as the gaster; surface of body usually more opaque than in *nitidiventris*,

var. *fuscata* Emery.

The new variety *succinea* occurs in Texas, where I have taken it in the sandy or pebbly soil of the post-oak woods at Austin, Montopolis, and Milano, and among the limestone hills about Bee Creek, Travis County. It rarely nests under stones but constructs mounds two to four inches in diameter, with a central opening $\frac{1}{2}$ – $\frac{3}{4}$ inches in diameter, made of coarse sand or small pebbles. These nests resemble those of *Myrmecocystus* in Colorado, Western Texas, and Mexico. I took the beautiful yellow males and winged females May 26.

The new variety *meridionalis* was found inhabiting obscure mounds in grassy soil in the cañons about Bull Creek, west of Austin, Texas. There are in my collection also three workers taken by the late Rev. P. J. Schmitt, O. S. B., in North Carolina.

Emery regards *fuscata* as a subspecies, but it seems to me to be hardly more than a variety. Color and pilosity are often

very variable even in workers of the same colony. Transitional forms occur between *schauinslandi* (typical) on the one hand, and *meridionalis* and *incerta* on the other, between *incerta* and *nitidiventris*, and between *nitidiventris* and *fuscata*; so that it might be permissible to reduce even *nitidiventris* to varietal rank.

F. pallide-fulva and all its subspecies and varieties appear to be absent from the states of the Pacific Coast.

APPENDIX B.

***Formica difficilis* Emery var. *consocians* var. nov.**

Worker. Length, 4-6 mm.

With the habitus of a small *F. rufa*. Mandibles 8-toothed. Clypeus rounded in front, not produced, carinate its entire length and with uneven surface. Maxillary palpi rather long. Head, excluding the mandibles, somewhat longer than broad even in the largest workers. Cheeks long, subparallel; occipital border not excised. Antennæ as in *F. rufa* and its various forms. Mesoëpinotal constriction very distinct, epinotum rounded in profile. Petiole narrow and thick, with a rather sharp edge, both its anterior and posterior surfaces distinctly convex. Seen from behind the edge is transverse in the middle and obliquely truncated on either side. Gaster and legs as usual.

Body subopaque and finely but distinctly shagreened; frontal area, clypeus, and mandibles somewhat shining, the last finely striated.

Entire insect covered with microscopic, grayish pubescence, which is most distinct on the gaster, though barely dense enough to conceal the smooth dark brown surface. Hairs sparse, obtuse, suberect, and pale yellow; most conspicuous on the mandibles, front and postocular regions, on the upper surface of the thorax, gaster, and edge of petiole. There are also prominent hairs on the lower surfaces of the head, coxæ, tibiæ, and on the middle and hind femora. Scapes of the antennæ depilate.

In large workers the head, thorax, petiole, nearly one third of the first gastric segment, and more or less of the venter and the tip of the gaster are deep yellowish red; remainder of gaster very dark brown. Mandibular teeth blackish, tips of antennal funiculi and sides of clypeus somewhat infuscated. In the small workers there is a more or less pronounced infuscation of the head, thorax, petiole, and appendages.

Female. Length: 5.5-6 mm.

Mandibles 8-toothed, clypeus and head resembling those of the worker; thorax distinctly narrower than the head. Petiole narrow

and thick at the base, its anterior and posterior borders convex, its edge blunt. Gaster small, legs rather long and slender.

Body subopaque, very finely shagreened, lustrous, head and lower and lateral surfaces of gaster more shining. Mandibles striato-punctate. Frontal area shining or subopaque.

Whole insect clothed with fine golden yellow pubescence, which is denser in some specimens than in others, especially on the gaster. Body and legs with rather long, suberect, obtuse, golden yellow hairs which are conspicuous on the femora, tibiae, head, thorax, edge of petiole, and upper surface of gaster. Antennal scapes depilate.

Rich reddish yellow; apical two thirds of antennal funiculi and posterior edges of gastric segments faintly infuscated. Borders of mandibles and alar insertions black. Wings lacking in all the specimens.

Male. Length: 5.5-6 mm.

Mandibles edentulous, or with very faint indications of teeth. Head very short, broadest through the eyes, cheeks short, somewhat concave, posterior corners broadly rounded. Thorax broader than the head, robust. Petiole thick, strongly convex in front, somewhat more flattened behind, its edge very blunt, transverse when seen from behind. Gaster and appendages of the usual shape.

Body subopaque, finely shagreened, especially on the upper surface of the thorax and gaster; mandibles and frontal area less, genitalia more, shining.

Pubescence gray, most abundant on the gaster, less abundant on the thorax, and very sparse on the head. Hairs whitish, suberect, distributed much as in the female but much shorter and less conspicuous. Eyes naked.

Body and antennae black; apical half of mandibles, palpi, legs, and genitalia pale yellow; fore coxae black, middle and hind coxae, fore femora, and palpi slightly infuscated. Wings rather deeply smoky; veins and stigma blackish.

Described from twelve females, three males, and numerous workers from several colonies.

Type locality: Colebrook, Litchfield County, Connecticut.

This variety differs from the typical *difficilis*, described by Emery from New Jersey and Virginia, mainly in pilosity, as I find by comparing the Colebrook specimens with a winged female from Virginia sent me by Prof. Forel and a long series of workers and one deälated female collected by Mr. W. Beutenmüller in North Carolina. I am unable to determine the exact status of New Jersey specimens, since the only two

workers from that state in my collection are much rubbed and somewhat broken. The following are the main differences between the typical *difficilis* and the new variety. The worker of the former is much less pilose. There are no erect hairs on the front and behind the eyes, and the hairs are far less abundant on all the other portions of the body, including the legs. The petiole is more distinctly produced upward in the middle and even large workers have a greater tendency to infuscation of the upper surfaces of the thorax, head, and petiole. The female, too, has a sharper, more produced petiole, and fewer hairs on the legs. Emery describes the male as having the "Mandibeln kräftig gezähnt," which is certainly not the case in the males of the Connecticut variety.

F. difficilis (with var. *consocians*) is undoubtedly very closely related to *F. microgyna* Wheeler (with var. *rasilis*) in the worker and male phases, but the female of the former species is very distinct in color and pilosity, in having a much blunter petiole and a more elongate thorax. When more is known of our western species of *Formica*, it may be necessary to reduce *microgyna* to the rank of a subspecies under *difficilis*. See Appendix C, which contains a description of another variety of *microgyna*.

APPENDIX C.

Formica microgyna Wheeler var. *nevadensis* var. nov.

Female. Length: 4.5 mm.

Differs from the female of the typical *microgyna* in the following characters: The erect silvery white hairs covering the body, legs, and antennal scapes are somewhat longer and more abundant, the pubescence, on the contrary, is much sparser, especially on the gaster, where it fails to conceal the surface, so that this region is very smooth and shining. The mesonotum is not spotted, but, together with the scutellum, paraptera, and metanotum uniformly dark brown and rather sharply marked off from the remaining paler portions of the thorax. Occiput slightly infuscated. Gaster very dark brown, anal region red. Wings grayish hyaline with brown veins and stigma.

Described from a single specimen taken by Mr. C. F. Baker in Ormsby County, Nevada, during July, 1903.

Formica montigena sp. nov.

Worker. Length: 4-6 mm.

With the habitus of a small *F. rufa*. Mandibles 8-toothed. Palpi rather short. Clypeus carinate its entire length, rather convex, its anterior border nearly straight, not produced. Head, excluding the mandibles, about as broad as long, sides subparallel, posterior corners broadly rounded, occipital border slightly concave in large workers. Antennæ as in the forms of *rufo*. In profile the mesonotum is straight, but rises in front rather abruptly above the pronotum. Mesoepinotal constriction pronounced, epinotal declivity concave below, rounded above, where it passes into the flat basal surface. Petiole thick in profile and very blunt above, its anterior surface convex, its posterior somewhat more flattened; seen from behind it is narrow with a horizontal upper border that passes over rather angularly into the sides. The latter are straight and converge below, so that the whole petiole is spade-shaped. Gaster and legs as usual.

Head, thorax, and petiole rather opaque, frontal area, upper portion of clypeus, frontal groove, and a little of the region between the frontal carinæ, smooth and shining. Mandibles sharply and densely striated. Whole body finely but sharply shagreened. Gaster and legs shining, the former with the appearance of "watered" silk.

Hairs suberect, short, golden yellow, and sparse. They are scattered over the upper and lower surfaces of the head, thorax, coxæ, and along the edge of the petiole. On the legs they are few and confined almost exclusively to the flexor surfaces of the fore femora. On the thorax and gaster they are obtuse and much scattered, on the latter mostly confined to the basal and apical segments. On the second and third segments there are only one or two transverse rows of hairs. Pubescence very sparse but distinct, especially on the legs and gaster where it produces the "watered" silk effect in conjunction with the finely shagreened surface.

Head, thorax, and petiole red, mandibles and corners of clypeus darker; teeth of the former and the gaster, black. Antennal funiculi, palpi, coxæ, and legs dark brown or blackish. In the smallest workers there is a tendency to infuscation of the occiput and the upper surface of the thorax and petiole, or to a more general deepening of the red ground color, involving the whole head, thorax, petiole, and the antennal scapes.

Female. Length: 7 mm.

Mandibles and clypeus like those of the worker. Head robust, as broad as long, its sides straight, slightly converging in front, posterior angles rounded, posterior border slightly concave. Thorax distinctly narrower than the head. Petiole extremely thick and blunt, its upper border seen from behind somewhat concave in the middle. Gaster and legs of the usual shape. Wings as long as the whole body (7 mm.).

Body and legs very glabrous and shining. Mandibles coarsely striatopunctate. Clypeus delicately longitudinally striated in front. Antennæ subopaque.

Hairs suberect, sparse, yellowish, longest on the gaster, especially towards its tip, shorter on the head and thorax and confined to the flexor surfaces of the femora and tibiæ. Pubescence grayish, very sparse and inconspicuous except on the antennæ.

Rich yellowish red. Mandibles, corners of clypeus, tarsi, and antennal scapes darker. Mandibular teeth, funiculi, and gaster black. Scutellum, metanotum, a triangular anterior and two elongate parapsidal blotches on the mesonotum dark brown.

Male. Length: 6.5-7 mm.

Head very short, narrow in front, broad behind, posterior corners prominent and rounded; cheeks short, concave. Mandibles with 2 or 3 distinct basal teeth. Clypeus sharply carinate. Thorax broad and robust. Petiole thick and very blunt above, with a distinct median excision in its upper border. Gaster, legs, antennæ, and wings of the usual shape.

Body subopaque, the head and pronotum and especially the genitalia and the upper surface of the gaster more shining. The surfaces are rather coarsely shagreened and those of the head and thorax have a very finely punctate appearance.

Hairs and pubescence sordid yellow, sparse and inconspicuous, especially on the upper surface of the gaster. Eyes naked.

Black. Genitalia reddish yellow. Legs sordid yellow, the femora, especially the anterior pair, more or less infuscated. Wings whitish hyaline, with brown stigma and paler veins.

Described from four males, a single female, and a great many workers taken from several nests in the following localities: Ute, Ute Pass; North Cheyenne Cañon; Pike's Peak, just below timber line (11,500 ft.) and at the printing office (10,000 ft.). The single female and several workers were taken by Prof. T. D. A. Cockerell in the locality last mentioned, Sept. 17, 1903. For notes on the habits of this species, see p. 361 *ante*.

F. montigena, though obviously a member of the *rufa* group, is nevertheless a clearly marked species. In the peculiar sheen of the gaster of the worker it resembles *F. dakotensis* and *F. exsectoides*, and is not unlike the former species also in the shape of the petiole. It differs from *dakotensis* in pilosity and from *exsectoides* in the shape of the head, petiole, etc. But it is especially the peculiar diminutive and highly glabrous female that gives the species its most distinctive character.