U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 122.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE ARGENTINE ANT.

BY

WILMON NEWELL, M. S.,

AND

T. C. BARBER, B. S. A.

Issued June 26, 1913.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

ARGENTINE ANTS UPON A TEA TABLE. (ORIGINAL.)

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BUREAU OF ENTOMOLOGY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., January 2, 1913.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 122, of the Bureau of Entomology, a manuscript entitled "The Argentine Ant," by Mr. Wilmon Newell, formerly a collaborator, and Mr. T. C. Barber, formerly an agent of this bureau.

The Argentine ant is an imported pest of great importance. It is unique among injurious insects of this country in the diversity of the damage that it causes. It is not only a household pest of the first rank, but it affects materially the interests of sugar planters, orange growers, and others. The territory infested by this ant is being rapidly extended. For all of these reasons it is important that there be placed on record a full account of the studies that have been conducted regarding it.

The work upon which this manuscript is based was begun by Mr. Newell as secretary of the Louisiana State Crop Pest Commission. Later Mr. Newell continued the work as a collaborator in this bureau, and Mr. Barber, an agent of the bureau, but working under Mr. Newell's direction, added to the results obtained.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE ARGENTINE ANT.

INTRODUCTION.

The Argentine ant (*Iridomyrmex humilis* Mayr), which is made the subject of the present paper, is the first among the Formicidæ to attain the front rank among injurious insects in the United States. In its field the Argentine ant is not excelled in destructiveness by even the gipsy moth, the boll weevil, or the San Jose scale. Though this ant is limited as yet to comparatively small areas, the observations and experience of the authors fully convince them that future years will see this insect steadily invading new territory and forcing its depredations upon the inhabitants of all southern California and most of the Gulf States.

The present paper aims to present, in as concise a manner as possible, the principal results of five years of almost constant observation and experiment by the senior author at Baton Rouge, La., and in the orange-growing section of the same State, together with observations made by the junior author at New Orleans in connection with his investigations of sugar-cane insects.

The junior author has prepared in their entirety the portions dealing with the "Area of ultimate infestation," and the "Relation of the ant to Coccidæ and Aphididæ," and to him is also to be credited the important discovery that mating of the queens may occur within the formicary or nest of the colony. The remainder of the paper, except where otherwise noted, is compiled from the notes and records of the senior author.

In the tedious work which accompanied the determination of the ant's life history, from 1907 to 1910, much assistance was rendered by the young men associated with the senior author in the work of the Louisiana State Crop Pest Commission, particularly Messrs. Harper Dean, A. H. Rosenfeld, G. A. Runner, M. S. Dougherty, G. D. Smith, and R. C. Treherne.

The writers are under obligations to Dr. W. M. Wheeler, of the Bussey Institution, Harvard University, for permission to use his redescription of *Iridomyrmex humilis* and for his kindness in reviewing the paragraphs upon "Systematic position" and "Resemblance to other ants."

Our thanks are also due to Messrs. R. S. Moore and John Meyer, extensive orange growers of Louisiana, for their liberal cooperation

and assistance in experiments carried out in the infested orange districts.

GENERAL CONSIDERATIONS.

Twenty years ago the Argentine ant was first noticed in New Orleans, La., by Mr. Edward Foster, reference to whose interesting account of the "Introduction of *Iridomyrmex humilis* Mayr into New Orleans" will be found on a subsequent page. The species had doubtless been introduced years before that time, but was gathering strength and establishing itself for a considerable period before its numbers became sufficient to attract attention. Mr. Foster mentions it as occurring in 1891 in "fair numbers." Since then it has increased from a few scattered and apparently insignificant specimens to armies and hordes numbering myriads of individuals. It has spread from a few blocks on the water front of the Mississippi River over practically the entire city, and has sent out vast numbers of colonists for hundreds of miles along the railways and waterways radiating from New Orleans. These pioneers have succeeded in founding scores of communities of more or less importance in the smaller cities and towns. Each of these communities is in turn furnishing its quota of migrants, and these are extending the affected territory in all directions from the original source of infestation. Thus, instead of the dispersion being from one source only, it is now taking place from hundreds of different points. From an unknown and little noticed insect this ant has developed into one of the foremost household pests in the world, and its ravages affect, directly or indirectly, the majority of the crops grown in the South. Former indifference to its movements has given way to concern at its approach, which, in the orange belt at least, means heavy depreciation in the value of property.

Continuous study for several years has served to enlighten us on most of the salient features in the life history and economy of the species. A considerable number of poisons and repellents have been tested and have given good results. Methods of isolating, ditching, and winter-trapping have been devised, and have proved their practical value in large experiments under field conditions.

Just how much territory this ant will ultimately infest we can not foretell with accuracy from the data at present available. It is quite safe, however, to venture the opinion that the species will eventually spread over a considerable portion of the Southern States—certainly over all of the orange and sugar-cane belts, and perhaps over all of the cotton belt. In California it is likely to cover the territory corresponding in temperature to the belts mentioned for the South, which will include the belts occupied by oranges and other tender fruits.

HISTORY AND DISTRIBUTION.

As stated on another page, this species was first described by Dr. Gustav Mayr from specimens collected near Buenos Aires, in Argentina. It is also included in the list of Argentine ants by Dr. Carlos Berg.[1] Its occurrence in the Argentine Republic is therefore unquestioned, and that Argentina is its native home is also borne out by the fact that it does not appear to be generally a pest of importance in that country. Dr. F. Lahille, of the Argentine department of agriculture, in a letter to the senior author, states that it "is uncommon in Buenos Aires and in Argentina generally, where it does not cause annoyance or trouble of value." Mr. Arthur H. Rosenfeld, formerly associated with the writers in entomological work in Louisiana and now located at Tucuman, Argentina, writes that he has been unable to find the species there. Rev. E. Wasmann, S. J., states that this ant "is a native of Brazil and Argentina," and Rev. Albert Biever, S. J., of Loyola College, New Orleans, whose careful studies of this species are mentioned on other pages, has corresponded with various priests in Brazil and Argentina, with the result that he finds that this species is a serious pest in parts of Brazil and evidently in Argentina also. For example, in a letter to Father Biever, Rev. J. Ferol, S. J., of the Colegio del Salvador, Buenos Aires, writes:

> The ants (*Iridomyrmex humilis*) of which your reverence makes mention are of no utility whatsoever, but on the contrary are voracious and destructive. Of means employed to destroy them the most effective, according to information given me, is the use of an instrument and ingredient of which inclosed herein I send a prospectus and instructions concerning its use and functions.

Forel[2] mentions its occurrence in collections from the States of São Paulo and Rio Grande do Sul, in Brazil. Wheeler[3] also mentions its occurrence in that country. Dr. Lahille also states that the Argentine ant occurs in Uruguay and is "especially common in Mercedes and Montevideo," cities not far removed from Buenos Aires.

According to Stoll[4] and Wheeler[5] the Argentine ant, after its accidental introduction into the island of Madeira, entirely exterminated another ant, *Pheidole megacephala* Fab., which was itself an introduced species that had exterminated the native ants before it.

In 1907 M. N. Martins[6] recorded the occurrence of this ant in Lisbon and Oporto, Portugal, and gave a vivid account of its ravages in those cities and their environs.

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1 Enumeración sistematica y sinonémica de los Formicidos Argentinos, Chilenos y Uruguayos. 1890.

2 Ameisen aus São Paulo (Brasilien), Paraguay, etc. Verhandlungen der k. k. zool.-bot. Ges. in Wien, 1908.

3 Entomological News, January, 1906, p. 24.

4 Zur Kenntnis der geographischen Verbreitung der Ameisen, Mitth. Schweiz. Ent. Ges., vol. 10, pp. 120–126, 1898.

5 Ants: Their structure, development, and behavior, p. 154, 1910.

6 Une fourmi terrible envahissant l'Europe (*Iridomyrmex humilis* Mayr). Broteria Revista de Sciencias Naturaes, vol. 6, pt. 1, pp. 101–102, 1907.

In 1908 Prof. C. P. Lounsbury recognized this ant in Cape Town, South Africa, where it had already become a household nuisance and had displayed its usual rôle of attending mealy-bugs and other insects. The general belief in Cape Town, according to Prof. Lounsbury, was that the pest had been introduced through the medium of forage, large quantities of which were imported from Argentina during the Boer War (1900–1902) and stored in Cape Town.

In July, 1910, the late Edwyn C. Reed, of Concepcion, Chile, in a letter to the senior author, reported the occurrence of the species in that country in large numbers.

In 1908 ants collected by Mr. J. Chester Bradley, of the University of California, were identified as *I. humilis* by Dr. W. M. Wheeler. Immediately following this discovery Prof. C. W. Woodworth, of the California Agricultural Experiment Station, visited the authors' laboratory at Baton Rouge, La., for the purpose of becoming familiar with the methods used in studying the insect and with the information which had been gathered concerning it up to that time. On his return to California he published a brief circular [1] concerning its occurrence in that State.

From the foregoing it is readily seen that during the past few years this ant has thoroughly established itself, as a nuisance of the first order, on four continents, and, owing to the readiness with which it is disseminated through the ordinary channels of commerce, there seems little reason for supposing that it will not eventually invade all of the semitropical countries of the globe.

INTRODUCTION INTO LOUISIANA.

As with most imported species, the original time and place at which a foothold was obtained by the Argentine ant in Louisiana must be largely conjectural. However, we are able to conjecture with rather strong circumstantial evidence to guide us. Not only does the testimony of inhabitants indicate New Orleans to be the original starting point of this species in the South, but its enormous numbers and the extent to which it has exterminated other species of Formicidæ confirm the opinion that it has been in New Orleans longer than elsewhere.

Mr. Edward Foster,[2] of the editorial staff of the New Orleans Daily Picayune, has given us the earliest record of its occurrence in New Orleans. He noted it in 1891 in St. Charles Avenue, 9 squares from the river and 12 from Canal Street. It was then

[1] The Argentine ant in California. Cal. Agr. Exp. Sta., Cir. 38 August, 1908.

[2] The introduction of *Iridomyrmex humilis* into New Orleans. Journ. Econ. Ent., vol. 1, No. 5. pp. 289–293, October, 1908.

present in "fair numbers." At that date it was very scarce in Audubon Park and below Canal Street, but was present in considerable numbers between Magazine Street and the river.

"Five or six years later" he found it in St. Peters Avenue, near St. Charles, but it was not abundant. This is about 40 squares north and west from the point on St. Charles Avenue first referred to by Mr. Foster.

In a personal letter to the senior author, Mr Foster writes as follows:

> I have known the species since 1891. At that time it was a rarity in Audubon Park, but was very common in the section immediately above Canal Street. Below Canal Street it was not at all plentiful. The boundary of the nuisance then was virtually from Magazine Street to the river. The coffee ships from Brazil, I understand, have always landed about where the wharves are now situated (on the river front, adjoining the area above mentioned), but from what we know of the spread of insect nuisances the first batch of immigrants must have come in years before I came across their descendants.

Mr. E. S. G. Titus,[1] quoting Mr. E. Baker, former superintendent of Audubon Park, states that in 1896 "they extended over but a small area, reaching approximately from Southport docks to Carrollton Avenue and from the river bank to Poplar Street," and that "in 1899 they were first noticed in Audubon Park." This area, from Southport to Carrollton Avenue, is located about 5 or 6 miles northwest of the area between Magazine Street and the river, noted by Foster to be well infested as early as 1891. Mr. Baker, therefore, had not been familiar with the original area of heavy infestation, but merely noted the species after it had invaded the part of the town where he resided. Mr. Titus's information that the species was first noted in Audubon Park in 1899 was of course secured from citizens, who failed to note the ant until it had reached prodigious numbers in the same place that Foster had found it a "rarity" in 1891. The dissemination to Audubon Park was undoubtedly from the heavily infested area between Magazine Street and the wharves already referred to.

The distribution of the species in 1904, as given by Mr. Titus,[2] was as follows:

> Across the river in Algiers and adjoining small settlements; at West End, Spanish Fort, and Milneburg, summer resorts on Lake Ponchartrain; Bay St. Louis, Miss., a summer resort between New Orleans and Mobile; along the Texas & Pacific Railroad at Donaldsonville, Cheneyville, and Alexandria; along the Southern Pacific at Thibodeaux, Schriever, Houma, Berwick, Morgan City, Franklin, New Iberia, and La Fayette, and at Opelousas.

There is every reason for supposing that this ant was introduced into New Orleans by means of the coffee ships which have for years

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[1] Bul. 52, Bur. Ent., U. S. Dept. Agr., p. 79, 1905.

[2] Ibid., p. 82.

passed back and forth between that city and Brazilian ports. This view is supported by the fact that large numbers of the ants were first noticed in the vicinity of the wharves where these ships unloaded their cargoes and also by the fact that these ships have been the only means of regular communication between New Orleans and the countries in which the ant is indigenous. That this and other species of ants are actually transported on ocean-going vessels has been frequently observed. Thus in July, 1911, the senior author, while a passenger on one of the largest coastwise vessels between New Orleans and New York, found colonies of this same ant occupying protected situations in the woodwork of the steamer. Dr. W. M. Wheeler also writes us that while returning from Guatemala aboard a fruit

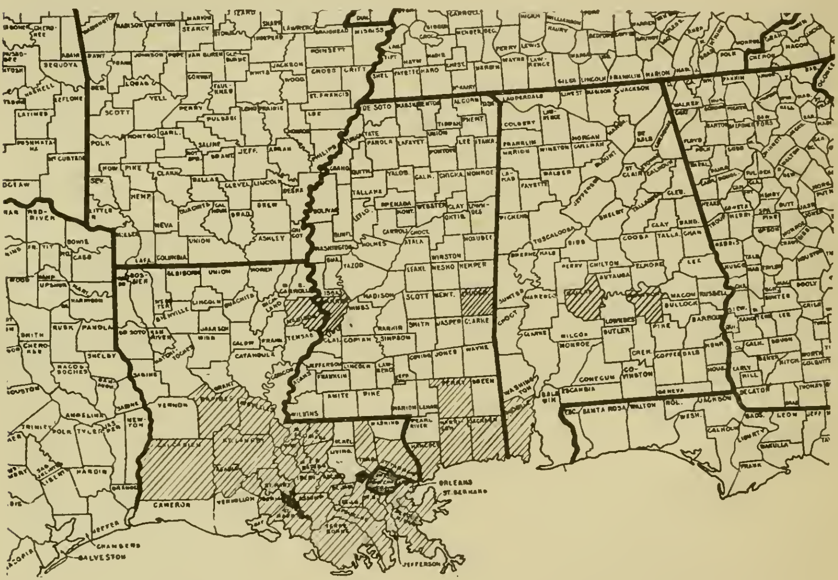

FIG. 1.—Map of Alabama, Mississippi, and Louisiana, showing counties in the Southern States which are infested by the Argentine ant, according to the authors' records. (Original.)

steamer in January, 1912, he found it infested with another common ant, *Prenolepis longicornis* Fab.

PRESENT DISTRIBUTION IN THE SOUTHERN STATES.

The area in the Southern States within which the Argentine ant is known to occur at present extends from Montgomery, Ala., to Lake Charles, La., a distance of about 380 miles east and west; and from Delta, La., to the mouth of the Mississippi River, a distance of about 250 miles north and south. (See fig. 1.) This section is not uniformly infested, but contains a great number of infested areas of more or less importance, ranging in size from many square miles of occupied territory, as illustrated by the infestation at New Orleans, to areas where the ants are so scarce that one not accustomed to their habits would fail to discover them. The latter condition prevails at present in Mobile, Ala. The only places remote from railroads where they have been discovered are upon the banks of the Mississippi River below infested localities. Their presence in such locations is easily accounted for by supposing that they have been carried thither on driftwood, which, carrying numbers of ants from infested places farther up the stream, has become stranded on the river banks, thus establishing new foci. In all other cases the infested territory is on a railroad, and usually on a main line running out from New Orleans. For example, nearly every town along the Southern Pacific Railway between New Orleans and Lake Charles is infested, and the same statement applies to points on the Louisville & Nashville Railroad between New Orleans and Mobile.

OCCURRENCE AND DISTRIBUTION IN CALIFORNIA.

The first specimens of the Argentine ant observed in California were collected in 1907 by Mr. J. Chester Bradley, at that time an assistant in the entomological department of the University of California. The identity of the specimens was not established until 1908, when Dr. W. M. Wheeler found them to be *Iridomyrmex humilis* Mayr.

As soon as the dangerous nature of the pest was known, Prof. C. W. Woodworth took steps to make a study of the species along the same lines as was being conducted in Louisiana at that time, and as a result of his preliminary work he issued a warning circular [1] to the public in August, 1908. In this circular he gave a brief outline of the habits of the ant and reported the following localities as infested: In the central portion of the State, East Oakland, Alameda, San Francisco, San Jose, Cupertino, and a point near Campbell; in the southern part of the State, Los Angeles, Azusa, and Upland.

In 1910 Prof. Woodworth published another small bulletin [2] giving the results of his two years' study of the insect. In this paper the infested territory was more clearly defined, and was estimated as consisting of a total area of 5,000 acres. About twice the area was reported infested in 1910 as in 1908, owing to the discovery of a few new colonies and the natural spread of the ones first discovered.

Our information as to the extent of the infested area in California (see fig. 2) has been obtained principally through the kind offices of Mr. Ralph Benton, of the California Agricultural Experiment Station, and Mr. P. E. Smith, of Santa Paula, Cal., as well as from the publi-

[1] The Argentine ant in California. Cal. Exp. Sta. Cir. 38, Berkeley, Cal., August, 1908.

[2] The control of the Argentine ant. Cal. Exp. Sta. Bul. 207, Berkeley, Cal., October, 1910.

cations by Prof. C. W. Woodworth, already referred to. All of these persons agree that the following California points are infested: Alameda, Azusa, Berkeley, Byron Hot Springs, Campbell, College Park, Cupertino, Fruitvale, Los Angeles, Melrose, Oakland, Riverside, San Francisco, San Jose, Stockton, and Upland.

FIG. 2.—Distribution of the Argentine ant in California. From data furnished by Messrs. Ralph Benton and P. E. Smith. (Original.)

AREA OF ULTIMATE INFESTATION.

Up to the present we have no exact data to indicate the final limits of the area which may become infested by these ants. They apparently thrive as well at Delta, La., at an elevation of 87 feet, as they do near the mouth of the Mississippi River, 300 miles to the south and almost at sea level. They seem to be little or not at all affected by the variation in the amount of precipitation annually as between different localities, for they seem to flourish as well at San Jose and Los Angeles, Cal., with average annual rainfalls of 14.8 and 15.6 inches, respectively, as they do at New Orleans, La., where the average annual rainfall is 57.6 inches. The range of temperature to which they have adapted themselves at different points does not vary so greatly, but is nevertheless considerable. They have succeeded in establishing themselves at San Francisco, Cal., where the mean annual surface temperature is 56° F., or 13° cooler than the mean annual surface temperature at New Orleans, La.

If we assume that the Argentine ant is unable to persist in localities where the mean annual temperature is below 55°, we will find that the isotherm of this temperature extends almost up to Columbus, Ohio, and past St. Louis, Mo., and will include over one-third of the United States, or more than 1,000,000 square miles. It is very unlikely, however, that this neotropical species will be able to endure the cold winters in the northern parts of this area. It will probably be more nearly correct to assume that its advance will be checked when it reaches the minimum isotherm of zero, or, in other words, where the thermometer drops to zero or below during the average winter. On constructing this isotherm we find that we have the following area within the United States liable in the course of time to infestation by the Argentine ant:

Starting at the Atlantic coast line; one-half of North Carolina, one-half of South Carolina, one-half of Georgia, Florida, a portion of Alabama, one-third of Mississippi, most of Louisiana, all of lower Texas, a corner of New Mexico, one-half of Arizona, a little of Nevada, practically all of California, and a coastal strip through Oregon and Washington. This would extend the infestation into fourteen States, more or less, and is undoubtedly a very conservative prediction, as already the ant is established at one point, Delta, La., which is above this line.

In spite of these considerations we are still in the dark as to the altitudes at which this insect will thrive, and it may be found later that altitude will severely limit the distribution of this species, as it does that of many other insects. Table I gives the elevation and climatological data for a number of infested points in the United States, and from this table it will be noted that the elevation of points now infested varies from sea level to 338 feet.

The climatological data given in Table I are taken from Bulletin Q, Weather Bureau of the United States Department of Agriculture, 1906, entitled "Climatology of the United States," by Alfred Judson Henry.

TABLE I.—*Data concerning various towns infested with the Argentine ant.*

Name of town.	Elevation.	Mean annual temperature.	Absolute maximum temperature.	Summer maximum, mean.	Absolute minimum temperature.	Winter minimum, mean.	Mean annual precipitation.
	Feet.	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*
Montgomery, Ala.	196	66	107	90	−5	40	50.8
Mobile, Ala.	11	67	102	89	−1	45	62.1
Vicksburg, Miss.	229	65	101	90	−1	42	53.8
Meridian, Miss.	338	64	104	89	−6	38	53.4
Hattiesburg, Miss.	154	67	103	92	−1	40	48.1
Biloxi, Miss.	24	67	100	88	1	43	61.3
Alexandria, La.	77	66	109	92	2	39	54.9
Baton Rouge, La.	62	67	103	90	2	42	54.6
Delta, La.	87	(1)	(1)	(1)	(1)	(1)	(1)
Lake Charles, La.	22	67	103	91	3	41	53.3
New Iberia, La.	15	68	101	89	6	45	53.7
New Orleans, La.	8	69	102	88	7	48	57.6
Sacramento, Cal.	29	60	108	87	19	40	19.9
San Francisco, Cal.	28	56	100	65	29	46	22.5
San Jose, Cal.	95	58	104	....	18	....	14.8
Los Angeles, Cal.	287	62	109	82	28	45	15.6

[1] Records not available.

NOTE.—"Summer maximum, mean" = the average of the total maximums for June, July, and August. "Winter minimum, mean" = the average of the total minimums for December, January, and February.

COMMON NAME.

The name "Argentine ant" was first used by the senior author for this species in 1908, when the public was on the point of accepting the name "New Orleans ant." The permanent use of the latter name would manifestly have been unjust to the Crescent City, for that city was in no way responsible for the introduction of the pest. As stated on preceding pages, this ant was originally described from specimens collected in Argentina, South America, and up to the present time we have no reasons for not believing that this is one, at least, of the countries in which this ant is native. The naming of this ant after the country from which it was first described is by no means without precedent. Many other common insects, such as the San Jose scale, American cockroach, Colorado potato beetle, Mexican cotton-boll weevil, etc., have received their popular names in the same manner.

Various common names have been suggested from time to time, among them "crazy ant," "tropical ant," "pernicious ant," etc., but all have the disadvantage of being as applicable to other species as to *Iridomyrmex humilis* and none of them is distinctive.

The term "Argentine ant" has been readily accepted, alike by entomologists and the press, is concise, and not likely to be confused with similar names; hence we believe it to be as good a name as can be adopted.

MEANS OF DISPERSION.

NATURAL SPREAD.

Under strictly natural conditions, the rate of dispersion of Argentine ants is very slow. Owing to their intensely social habits they spread but slowly from a locality until the number present becomes excessive for the food supply or unless adverse conditions, such as flooding, occur which compel them to seek fresh locations. They will then spread in all directions, but will go little farther than is necessary to give them sufficient foraging area to insure the food required. However, if a large food supply is discovered at a considerable distance from the colony, a heavy trail of workers will soon be formed between the food and the nest, composed of many thousands of tiny insects, each busy carrying a load of the coveted material back to the nest or going out for another load. Sometimes they will construct a new nest in the neighborhood of the food supply, and to this they will transport a number of pupæ, larvæ, and eggs from the parent nest. In the course of a day or so this new colony will be thoroughly established, with a full supply of queens, workers, and immature stages, and will then be capable of supporting itself and increasing in numbers without assistance from the parent nest.

Under normal conditions it is likely that the rate of spread does not amount to more than a few hundred yards each year. When food is plentiful, a well-traveled road or a paved street may restrict the spread for a considerable period, but when any much-desired food supply, such as the excretions of aphides or scale insects, is to be reached, nothing short of running water proves an effective barrier.

FLIGHT.

It is possible, but scarcely probable, that the queens may aid the natural dispersion by means of flight, but there are several reasons why this is doubtful. One of them is that the flight itself is a very uncertain event, as during the five years that these ants have been studied in Louisiana only one general flight has been observed. It has been established that the young queens can mate in the nest without taking a marriage flight at all, and apparently this is what usually takes place. Even should a fertilized winged queen fly or be transported by the wind to any considerable distance from the ant-infested territory, it is very doubtful whether any eggs she might lay would ever hatch. The queen has never been observed assisting in the slightest degree with the rearing of the young in the nest, nor have we succeeded in getting eggs to hatch when they were not cared for by the workers. As the workers are never winged, the queen would necessarily be alone, and it would be very unlikely that the queen would develop the instinct of attending to and caring for the eggs, larvæ, and pupæ in succession for several months. Also, the queens are quite helpless and appear to be entirely incapable of defending themselves against other insects. The writer has observed a queen ant being captured and bound by a minute spider, considerably smaller in size than her own head, without making the least attempt to struggle. It therefore seems improbable that a defenceless queen could maintain herself in a hostile country for several months without the assistance of workers.

Furthermore, we have several times kept Argentine ant queens isolated in small nests, sometimes singly and sometimes in groups, but have never yet succeeded in hatching eggs in these nests, or in rearing larvæ to the adult stage.

The fact that ditches of running water have proven sufficient barriers to prevent the spread of the species in orange groves appears to disprove the theory that queens returning from the nuptial flight can, without the assistance of workers, establish new colonies.

DISPERSION BY STREAMS.

As previously mentioned, driftwood is probably the most important agency in the natural dispersion of the Argentine ant. Along the Mississippi River, below the infested territory, we find a considerable number of larger or smaller colonies of the ants, and in places the batture [1] will be infested for miles, with practically no ants inside the levee. This can only be accounted for by ants floating down the river upon driftwood from infested localities. The river banks are covered with logs, more or less rotten, which have stranded during high water. In the infested territory these logs are found full of ants in all stages in enormous numbers. During high water some of these logs drift and lodge alternately, gradually working down the river, and distributing colonies in their wake.

The writer has several times seen complete colonies of ants on a floating log, unable to escape. All that was required was a little further rise of the water to start them down the river, with their cargoes of ants.

ARTIFICIAL DISSEMINATION.

Unquestionably the main distributing agent of the Argentine ant is man himself, by means of railway trains, boats, and other vehicles which he controls and utilizes in the transportation of freight and commodities of all kinds. The ants must necessarily have been introduced to this country by means of ships, and railways have been the

[1] The "batture" is that land lying between the true bank of the river and the levee. The batture is subject to overflow during high water, is ordinarily not cultivated, and is frequently overgrown with willows. The batture is said to be "outside" the levee, while land protected by the levee from high water is said to be "inside" the levee.

principal means of dissemination since they succeeded in establishing themselves. This is evident, as all the centers of infestation so far discovered, with the exception of those down the Mississippi River, the presence of which has just been explained, are located upon railway lines; in the Southern States, upon main lines running out of New Orleans.

The ants are easily transported in packing and freight of various kinds. Large numbers of potted plants are shipped out of New Orleans to the surrounding country, and in many cases complete colonies of ants are sent with them in the soil surrounding the roots. Boxes and barrels of groceries, packing placed around fragile material to prevent breakage, and shipments of household goods may all contain queens and workers when shipped from infested points. The writer has observed a queen and many workers inside an empty passenger coach, which had been standing on the track for several hours during a rainstorm.

The danger of promiscuous infestation is somewhat lessened by the fact that it is necessary for a queen ant to be transported with the workers in order that a new colony may be founded. In a large series of experiments conducted to determine this point we have never yet found any indication that the workers were able to produce eggs, or to reproduce their kind in any manner. Consequently large numbers of workers may be scattered broadcast over uninfested territory and, though they may live for a considerable time, they will ultimately die out if a queen is not present. It is probably due to this fact that these ants have not infested a great deal more territory than they have during the past 10 years, as it is a certainty that thousands of workers are being continually shipped from infested territory into uninfested localities. At the same time the danger that fertile queens will be transported is considerable, for we have frequently found deälated queens foraging with the workers. The fertile queens will "take up" with any workers of the species, and it is only necessary for a queen *and* workers to be present in a new locality in order to start a self-perpetuating infestation.

Steamboats plying up and down rivers, carrying freight from infested points, are responsible for spreading great numbers of ants. For example, between New Orleans and Baton Rouge, La., there are over a hundred steamboat landings. These are nearly all infested by the Argentine ant, and probably the insects were first introduced in the freight shipped direct to these points from New Orleans or Baton Rouge. Many of the river steamboats are so heavily infested by permanent colonies of this ant that the workers are almost as much of a nuisance in the cook's galley as they are in culinary establishments on shore.

ECONOMIC IMPORTANCE.

Up to the present time the Argentine ant has attracted most attention as a household pest. Particularly during rainy weather, when honeydew is scarce, the ants invade houses in myriads and drive the housekeepers almost to distraction. Nearly everything which is edible for human beings is attractive to them, and ceaseless attention and strenuous effort are necessary to keep them out of pantry and kitchen. The use of poisons and repellents must be continuous; if there has been a little carelessness in this regard the foodstuffs become filled with countless numbers of ants in a very short time.

Among the foodstuffs most eagerly sought may be mentioned honey, sirups, sugar, candy, cakes, cookies, jams, marmalades, preserves, fruit juices, cream, olive oil, lard, egg (either raw or cooked), fish (either fresh or canned), and various raw meats, such as chicken, veal, mutton, pork, beef, etc. Corn meal is sometimes the object of attack and wheat flour to a slight extent.

Aside from their invasions of food the ants are household nuisances generally. No corner or nook is safe from their explorations and the discovery of something edible is quickly heralded in the nest, whence come thousands of workers to carry away the plunder. In heavily infested sections it is often necessary to place bedposts upon panes of glass coated with vaseline or other repellent in order that the occupant may sleep in peace. To have ants running all over one's person is disagreeable enough, but what is more serious, they will not hesitate to attack any part of the body where skin or membranes are tender enough to be pierced by their mandibles.

Authentic cases are on record where it has been necessary to take babes from their cradles and repeatedly immerse them in water to rid them of the ants which crawled by hundreds over their bodies and into their mouths and nostrils. We have even received reports of infants being killed by the ants, but such reports we have not verified. Such a thing is not, however, outside the realm of possibility.

In groceries and stores they are kept out of sirups, sugar, molasses, and like products only with great difficulty. In restaurants and confectionery shops the closest vigilance is required to keep the ants out of the cakes, candies, ice cream, fruits, etc., as well as out of ice boxes, refrigerators,[1] show cases, and windows. Meat in butchers' shops is also a great attraction, and if left unprotected for even a short time thousands of ants will be swarming over it.

In nurseries and among ornamental plants the ants foster and protect countless thousands of scale insects and plant lice, the excretions of which furnish the choicest delicacy with which the ants

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[1] The temperature of the ordinary refrigerator is not low enough to deter the ants in their foraging.

regale themselves. This protective care results in rapid increase of these insects, with resultant damage to the plants infested. In florists' establishments the ants sometimes sever the petals of cut flowers in their search for nectar.

Visits to flowers of various kinds seem a natural habit, and when the ants do not find the nectar readily available they quickly cut their way to it in all cases where the plant tissue is tender enough to permit of it. In their attacks upon orange blossoms they are particularly severe, as they sometimes eat their way into the fruit buds even before the latter are fully open. The workers have also been noticed regularly visiting the extra-floral nectaries of cotton and other plants.

To truck growers the ants are very troublesome, owing to the manner in which they remove certain garden seeds before they have sprouted. Lettuce seed is especially subject to this attack, and in infested districts the rows of lettuce seed are covered with corn meal, which is also attractive to the ants. By the time the ants have removed the meal the lettuce seeds will have sprouted. The ants also assiduously attend plant lice on a number of vegetables, making the latter unpleasant to handle. Cabbage heads are often found through which plant lice and ants are completely distributed, the cabbage leaves merely serving as divisions between layers of the insects.

In the sugar-cane fields the ant again comes to the front, owing to its fondness for the excretions of the sugar-cane mealy-bug, *Pseudococcus calceolariæ*. (See figs. 3, 4.) In order to protect these insects from storms and enemies, the ants build protective coverings and shelters over them and attend them constantly. (See fig. 5.) As the result of these attentions the mealy-bugs thrive in numbers and destructiveness to an extent which is impossible where the ants are not present. Luckily the territory infested by the mealy-bug is as yet very restricted, but this insect threatens to become a serious problem in the future, owing to the manner in which it destroys the eyes of "seed cane" after it is planted, preventing sprouting and thus injuring the stand. The vacant rows in a field of cane, due to this injury, are shown in figure 3. The control of this mealy-bug therefore resolves itself into the problem of controlling the ant.

In cornfields it can be easily noticed that aphides are several times as numerous, and are also more generally distributed, in districts infested by the Argentine ant than in the noninfested districts. The ants are also found in great numbers attending plant lice upon cotton plants, and in a cotton field at Baton Rouge, where these ants were very numerous, it was noticed that the cotton aphides remained abundant throughout the entire summer and autumn, whereas during these portions of the year they are normally almost absent.

It is in the orange groves of southern Louisiana, however, that this ant has probably inflicted the most serious injury. This injury is discussed at length on a subsequent page. Suffice it to say that at present the Argentine ant is there regarded as the most serious insect problem, owing to the marked increase of scale insects which follows its introduction and spread. The value of land in that section depends to a considerable extent upon the presence or absence of the Argentine ant. The ant also does considerable damage to the fig crop by boring through the ripened fruit or entering the calyx end of the ripening fig and tunneling the interior. It also assists in the

FIG. 3.—Injury to the stand of sugar cane by the sugar-cane mealy-bug (*Pseudococcus calceolariæ*), which is attended by the Argentine ant. (Original.)

increase of the destructive mealy-bug, *Pseudococcus citri*, which injures figs to a considerable extent.

The ant is a veritable plague among honey bees, and beekeeping on any considerable scale is invariably abandoned after the ants become numerous.

In the poultry yard this ant is a pest that must be reckoned with. The ants find the nests of sitting hens particularly attractive, and if perchance an egg be broken the ants will come in such numbers that the fowl will abandon her nest. The blood and fluids from partially incubated embryos are particularly liked by the ants, and when the eggs are hatching the workers swarm over the young chicks in such numbers as to cause their death. Repellents which can be adapted to such a case are rare, even pyrethrum powder being practically ineffective. The only substance we have found which would at all protect the sitting hens is zenoleum powder, liberally sprinkled in the nest and among the hen's feathers from time to time during the brooding period. The nests of many birds are frequented by the ants in the same way, and the number of young birds destroyed in this manner must be considerable. The ubiquitous English sparrow, however, seems to flourish, as ever, in spite of the ants.

Another form of injury, though indirect, is due to the antagonism which exists between the Argentine ant and other species of ants, and which terminates only with annihilation of the native species. As the result of this, beneficial species of ants (such as the "fire ant," *Solenopsis geminata*, which destroys a considerable number of boll weevils in their immature stages) are exterminated, and their place is taken by the infinitely more troublesome Argentine ant.

FIG. 4.—Sugar-cane mealy-bugs on sugar cane. (Original.)

It may presently be found that the Argentine ant is an important agent in the spread of disease. The workers congregate in great numbers around garbage pails, privies, etc., and are frequently very hard to keep out of sick rooms, the odors seeming to attract them. They have been watched busily carrying away the sputum of a negro who was suffering from tuberculosis. There are many ways in which it is possible for these ants to assist in the distribution of various disease-producing organisms.

Rarely the activities of this ant take on a beneficial aspect. Father Biever states that they have in many cases completely exterminated the bedbugs in the hovels and tenements occupied by poor people in the city of New Orleans. The same authority several years ago called attention to the scarcity of the common "chiggers" or so-called "red bugs" in parks and yards heavily infested by the ant, and this latter observation has been verified by the junior author in the case of Audubon Park, New Orleans. At Baton Rouge, however, the senior author found the "chiggers" very abundant in premises heavily infested by the ants. The manner in which these ants destroy the sorghum midge is described on following pages.

SYSTEMATIC POSITION.

According to the classification adopted by Dr. W. M. Wheeler,[1] the Argentine ant is placed in the subfamily Dolichoderinæ, which

FIG. 5.—Covering constructed by the Argentine ant to protect the mealy-bugs. (Original.)

is one of the five main subdivisions of the family Formicidæ. The Dolichoderinæ are characterized by the cloacal orifice being slit-shaped and ventrally located instead of being circular and terminally located, as in the camponotine ants, by vestigial sting, by single-segmented abdominal pedicel, by a much shortened or bell-shaped gizzard (proventriculus), by the pupæ being always naked (not inclosed in cocoons), and usually by anal glands which produce a secretion having a very offensive odor. In the case of the Argentine ant, however, this odor is entirely lacking.

[1] "Ants, their structure, development, and behavior," 1910.

The subfamily Dolichoderinæ contains six North American genera: Dolichoderus (Hypoclinea), Forelius, Tapinoma, Dorymyrmex, Liometopum, and Iridomyrmex. Iridomyrmex is essentially tropical in its distribution and only two species are known to occur in the United States,[1] the native *Iridomyrmex analis* Ern. André, common in cotton fields of the South, and the introduced species, *Iridomyrmex humilis* Mayr, or Argentine ant.

DESCRIPTION OF THE SPECIES.

Three forms only of the adults are found in the colonies of the Argentine ant, the females or queens, the workers, and the males. (See fig. 6.) Major and minor workers do not occur, and no workers seem to act in the capacity of soldiers or scouts more than others. As previously noted, the species was first described as *Hypoclinea humilis* by Dr. G. Mayr, in 1868, from workers collected in 1866 near Buenos Aires in Argentina, the original description appearing in the Annuario della Societa dei Naturalisti di Modena, volume 3, page 164. Following is Mayr's description of the species kindly furnished by Dr. W. M. Wheeler, of the Bussey Institution, Harvard University, from the original edition:

Operia: Long. 2.6 mm. Sordide ferruginea, micans, mandibularum parte apicali flavescenti, abdomine nigrofusco, tarsis et nonnunquam tibiis testaceis; microscopice adpresse pubescens; absque pilis abstantibus; subtilissime coriaceo-rugulosa, mandibulis nitidis sublaevigatis punctis nonnullis; clypeus margine antico late haud profunde emarginatus; thorax inter mesonotom et metanotum paulo et distincte constrictus, pronoto fornicato, mesonoto longitrorsum recto, transversim convexo, metanoto inermi longitrorsum fornicato, pronoto paulo altiori; petioli squama compressa rotundata.

At the request of the senior author, Dr. Wheeler prepared the following redescription of the worker, and descriptions of the queen and male, thus making a complete and comprehensive description of the species:

Iridomyrmex humilis Mayr.

Worker: Length 2.2–2.6 mm.

Head oval, broader behind than in front, with its posterior margin slightly concave in the middle. Eyes flattened, in front of the middle of the head. Mandibles with two larger apical and several minute basal teeth. Clypeus short, convex in the middle, with broadly excised anterior margin. Frontal area and groove present but rather indistinct. Antennal scapes extending about one-fourth their length beyond the posterior corners of the head. Joints 1–5 and the terminal joint of the funiculus distinctly longer than broad; remaining joints nearly as broad as long. Thorax slender, narrower than the head; broadest through the pronotum which is convex, rounded and nearly as long as broad. Mesonotum nearly as long as the pronotum, sloping, laterally compressed, in profile evenly continuing the contour of the pronotum. Me-

[1] An undetermined species of Iridomyrmex, apparently introduced, has been found by Dr. W. M. Wheeler in a greenhouse at Boston, Mass.

soëpinotal constriction rather deep, extending obliquely downward and backward on each side. Epinotum short, nearly twice as high as long, convex on the sides, with a short convex base, and a longer, flatter and more sloping declivity. Petiole small, less than half as broad as the epinotum; its scale in profile, compressed, cuneate, inclined forward, with flattened anterior and posterior surfaces and rather acute apex; seen from behind its border is entire and evenly rounded or even slightly produced upward in the middle. Gaster small. Legs rather slender.

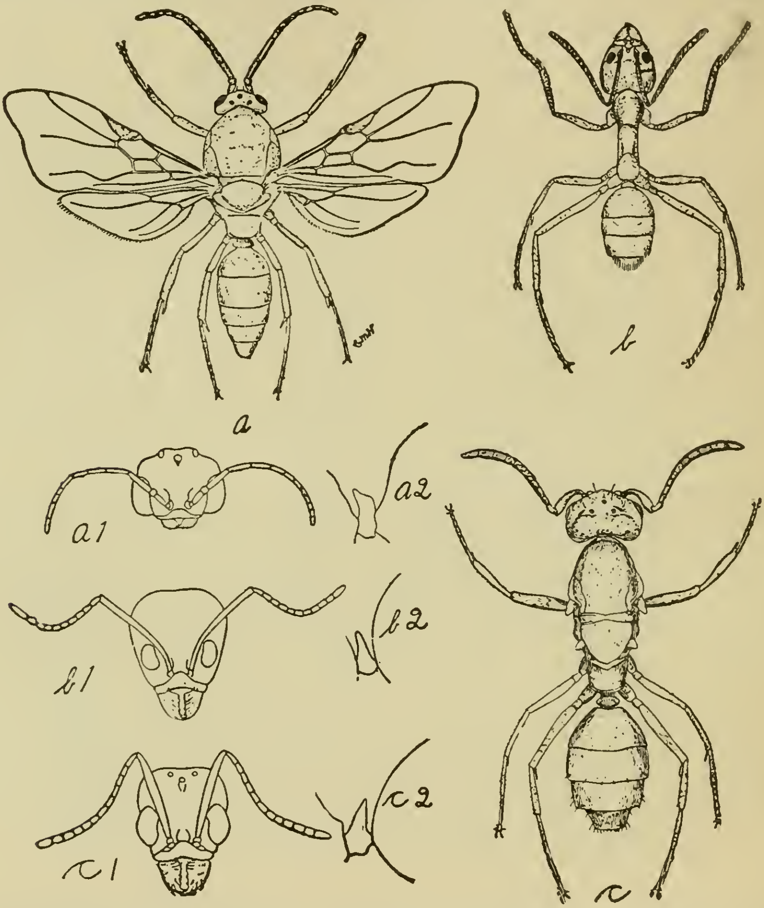

FIG. 6.—The Argentine ant, adult forms: *a*, Adult male; *a1*, head of male; *a2*, petiole of male; *b*, worker; *b1*, head of worker; *b2*, petiole of worker; *c*, fertile queen; *c1*, head of queen: *c2*, petiole of queen. All greatly enlarged. (Senior author's illustration.)

Body minutely shagreened or coriaceous, subopaque and glossy; mandibles, clypeus and anterior border of the head more shining. Mandibles minutely and rather obscurely punctate.

Hairs few, suberect, yellowish, confined to the mandibles, clypeus, tip and lower surface of the gaster. Pubescence short and uniform, grayish, so that the body has a slightly pruinose appearance.

Brown; thorax, scapes and legs somewhat paler; mandibles yellowish; apices of the individual funicular joints blackish.

Female (deälated): Length 4.5–5 mm.

Head, without the mandibles, but little longer than broad, with rather angular posterior corners, straight, subparallel sides and straight posterior border. Eyes large and rather convex. Mandibles and clypeus like that of the worker, scapes proportionally shorter and stouter. Thorax large, as broad as the head, elongate elliptical, nearly three times as long as broad. In profile the scutellum is very convex, projecting above the meso- and epinotum. Epinotum with very short base and long abrupt declivity. Petiolar node erect, more than half as broad as the epinotum. Gaster elliptical, somewhat shorter and a little broader than the thorax. Legs slender.

Sculpture like that of the worker but more opaque; mandibles and clypeus also less shining.

Scattered hairs more numerous than in the worker and also present in small numbers on the vertex, gula, mesonotum, prosternum, and fore coxae. There is also a row of short hairs along the posterior margin of each gastric segment. Pubescence distinctly longer, more silky, and denser than in the worker.

Dark brown; antennae, legs and posterior margins of the gastric segments reddish; mandibles, sutures of thorax and articulations of legs yellow.

Male: Length 2.8–3 mm.

Head much flattened; including the flattened eyes, as broad as long. Vertex and ocelli prominent. Cheeks short. Mandibles small, overlapping, with a single, acuminate apical tooth. Anterior clypeal border straight. Antennae slender; scape only between three and four times as long as broad; first funicular joint globose, broader than any of the other joints; second joint much longer than the scape; joints 3–5 growing successively shorter; joints 6–12 considerably shorter and more slender. Thorax very robust, elliptical, broader than the head, which is over-arched by the protruding, rounded mesonotum. Scutellum even more prominent than in the female. Epinotum with subequal base and declivity, the former slightly convex, the latter feebly concave, forming an angle with each other. Petiole small, its node with rather blunt margin, slightly inclined forward. Gaster very small, elongate elliptical, with small rounded external genital valves. Legs slender. Wings with a four-sided discal cell and two well developed cubital cells. The costal margin is depressed or folded in just proximally to the stigma.

Sculpture, pilosity and pubescence as in the worker; color more like that of the female, except that the antennae, legs, mandibles and internal genitalia are pale, sordid yellow. Wings smoky hyaline, with brown veins and stigma.

I. humilis belongs to a small group of neotropical species embracing also *I. iniquus* Mayr, *dispertitus* Forel, *keiteli* Forel and *melleus* Wheeler. The workers of *keiteli* and *melleus* may be at once distinguished by their color, the former having a yellowish brown head and thorax and the remaining parts brownish yellow; the latter being pale yellow with a blackish gaster and funiculus. In these and in *I. iniquus* and *dispertitus* the mesoëpinotal constriction is much deeper than in *humilis* and the meso- and epinotum are of a different shape. The mesonotum in profile does not form a continuous, even line with the pronotum and the epinotum is very protuberant and almost conical. *I. humilis* represents a transition from the above group of species to that of *I. analis* Ern. André, which is very common in the Southern States. This species has a shorter, more robust thorax, more like that of Tapinoma, and much less constricted in the mesoëpinotal region.

The above description was drawn from a number of workers, males and females taken from the same nest in Baton Rouge, La., by Mr. Wilmon Newell. The types described by Mayr were captured by Prof. P. de Strobel in the environs of Buenos Aires.

RESEMBLANCE TO OTHER ANTS.

There is little difficulty in distinguishing *Iridomyrmex humilis* Mayr from its nearest American relative, *Iridomyrmex analis* Ern. André. The latter species is quite common in cotton fields and other situations in the South, is much lighter in color than *humilis*, and possesses a very disagreeable odor which is entirely lacking in the case of *humilis*. The clearly marked trails of the Argentine workers, when on their foraging expeditions or when moving from place to place, have no counterpart in the case of *analis*, the workers of which in large measure forage independently of each other. *I. analis* constructs inverted cone-shaped mounds or craters on the surface above the underground nests, while what little dirt is excavated by *humilis* is scattered about the entrance to the nest in promiscuous fashion, the ants evidently desiring to rid themselves of the excavated pellets as expeditiously and conveniently as possible. The "wet-weather sheds" of the Argentine ant, constructed only during or just after prolonged rainy spells, bear no resemblance whatever to the craters of *analis;* but on the contrary are more or less flat, composed of fine particles of earth, unstable in structure and supported by grass or leaves.

However, the superficial resemblance of *I. humilis* to several species of other genera is even closer than to *I. analis* and is sufficient to make positive identification of *humilis* well-nigh impossible except by one skilled in detecting the characters used by myrmecologists for classification. Among the southern forms most likely to be mistaken for *I. humilis*, and vice versa, may be mentioned the "crazy ant" (*Prenolepis longicornis* Fab.) and *Dorymyrmex pyramicus* Roger. The workers of both these species are of practically the same size and color as those of *humilis* and the workers of all three travel and forage in much the same way. Prenolepis is distinguished from *I. humilis* by its camponotine characters, particularly the shape of the gizzard, by the cloacal orifice being round rather than slit-shaped, and by the presence of stiff, erect hairs upon the body. Dorymyrmex is easily distinguished by the conical or pointed elevation upon the epinotum (last dorsal segment of the thorax), a structure that is entirely lacking in Iridomyrmex, the epinotum of which is evenly convex.

The resemblance of *I. humilis* to still other species is sufficient to be confusing at times, but one can, by a process of eliminating certain easily observed characteristics, determine with reasonable probability whether a colony of living ants belongs to this species or not. First to be noticed is the size of the ants under suspicion. The workers of the Argentine ant are from 2.2 to 2.6 mm. in length, the largest individual we have ever seen measuring 2.75 mm. If workers are more than 3 mm. or less than 2 mm. in length, it may be safely concluded that the ant under observation is of some other species. The Argentine queen, however, is from 4.5 to 5 mm. in length. The color of the Argentine ants—all adult forms—is a very deep brown, almost approaching black, and the color is uniform over the entire body. The possession of head and thorax of one color with abdomen of a different color immediately eliminates a specimen from this species. A colony containing workers of more than one size is also eliminated, since all Argentine workers are of one size or caste. The fact that the petiole or pedicel (connecting joint between the thorax and abdomen) of *I. humilis* consists of only one segment readily distinguishes it from the species of Solenopsis and other myrmicine ants. The pupæ of our species is never inclosed in cocoons, but always naked, with legs, eyes, segments, etc., plainly visible. Argentine workers, when crushed between the fingers, give no perceptible odor, and this readily distinguishes them from their closest relative, *I. analis*, as well as from their more remote relatives, the species of Tapinoma. The Argentine worker does not possess a functional sting and does not even attempt to sting. This again separates the workers from those of a great many species, including Solenopsis, most of which sting viciously upon the slightest provocation. Upon being disturbed, particularly in the nest, some of the Argentine workers will attempt to bite, but by far the great majority devote their energies to escaping rapidly or to removing the larvæ and pupæ to a place of safety. What few do attempt to bite are not successful in piercing the skin of one's hands owing to their weak jaws. It is only when reaching tender places, such as the skin between the bases of the fingers for example, that they are able to make their bites effective.

If, therefore, ants suspected of being *Iridomyrmex humilis* meet the following qualifications, and in addition exhibit the habits already described, there is a reasonable probability that they belong to this species, and examples should be submitted to a specialist for examination:

Workers not over 3 mm. nor less than 2 mm. in length
Workers uniformly colored; deep brown, nearly black.
Workers of uniform size; no distinction as to caste.
Workers traveling in well-defined trails or lines to and from the nest.
Workers emitting no offensive odor when crushed.
Workers unable to sting and unable to bite effectively.
Pupæ not inclosed in cocoons.
Petiole or pedicel consisting of only one segment.
Petiole prolonged dorsally into a wedge-shaped scale, inclined slightly forward.
Epinotum devoid of a pointed or conical elevation.
Ocelli absent in workers, present in queens and males.

METHODS OF STUDY.

When the study of this ant was undertaken, two requisites presented themselves—a type of artificial formicary in which continuous observations could be made and individuals kept track of from the time of egg deposition until the adult stage was reached, and some method by which all individuals of a colony could be confined to their own formicary.

Space need not be taken to describe the types of artificial formicaries which were not successful.

The Janet cages proved successful only in the case of very large colonies, but in these the multiplicity of individuals made accurate observations impossible. It may be remarked that this type of cage is excellent for studying the community life as a whole and for making experiments with poisons or with parasitic fungi or bacteria.

Cages totally inclosed were not successful, for the reason that the ants, when deprived of the privilege of leaving their nest, failed to act in a normal manner.

The cage finally adopted was, with modifications, the one described by Sir John Lubbock on pages 2 and 3 of his classic work.[1] This consists essentially of two glass plates containing between them a layer of pulverized earth in which the ants may burrow at their pleasure. Considerable difficulty was experienced in getting the glass plates the proper distance apart; if too far apart the ants could make burrows which were not open to observation, and if too close together insufficient room was afforded the queen in which to stand and walk upright. As the queen is about twice as tall as the worker, it seemed for a time that a suitable cage could not be constructed. After repeated trials, however, it was found that if the space between the glass plates were made exactly 1.75 mm. the queen would have sufficient room and the workers could not construct invisible galleries.

This type of cage and its supporting stand are well illustrated by figures 7 and 8. Figure 7 shows the several parts of the cage; *3* is the cage proper, consisting of two plates of glass held uniformly 1.75 millimeters apart by strips of leather at all four edges, a door or opening being left at one corner. (See fig. 9.) Old negatives, the films removed with caustic soda, have been found the most desirable for making these cages, both because such glass is remarkably clear and free from imperfections and because it is of uniform thickness. The size of the cage may vary from $3\frac{1}{4}$ by $4\frac{1}{4}$ up to 8 by 10 inches or even larger. Leather was found more satisfactory for making the edges of the cage than either glass or wood. The strip of leather between the glass margins is about $\frac{1}{2}$ inch in width. It is extremely difficult to find a strip of glass uniformly 1.75 millimeters thick and it is also

[1] Avebury. Ants, bees, and wasps, 1881.

A SMALL COLONY OF ARGENTINE ANTS AS SEEN IN ONE OF THE ARTIFICIAL FORMICARIES. (ORIGINAL.)

difficult to attach one piece of glass to another firmly. Wooden strips present the disadvantage of quickly decaying and of warping, no matter what glue or cement is used to hold them in position. Since it is sometimes desirable to place moist earth in the cages, or to add moisture from time to time, a waterproof cement is most desirable for attaching the glass plates to the leather strip. The space between the glass plates is filled with finely pulverized earth after completion and drying of the cage, and in this the ants are permitted to burrow and construct galleries as they please. (See Pl. II.)

The cage proper is supported on a platform (*1*) which in turn rests firmly upon a standard (*2*) having a base (*4*). The platform must have its upper surface perfectly level and it must remain so for an

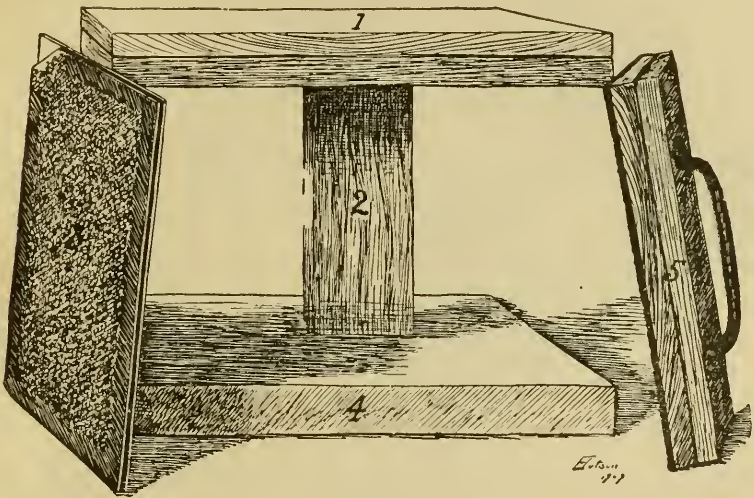

Fig. 7.—Artificial formicary or cage used in studying the Argentine ant: *1*, Supporting platform; *2*, standard; *3*, cage proper, made of glass and leather, containing earth; *4*, base; *5*, cover. (Senior author's illustration.)

indefinite time, otherwise the ants will take up their abode between the cage and platform rather than in the cage itself. The platform is therefore made of two pieces of even, seasoned cypress $\frac{7}{8}$ inch thick, screwed together with numerous screws and with the grain of the two pieces at right angles to each other. On this platform the cage rests without fastenings of any kind. The cover (*5*) is constructed of two pieces of cypress in the same manner as the platform, but in addition has an iron handle attached to its upper surface and has a piece of felt glued to its under surface, so that, when it is placed upon the cage proper, all light is excluded except at the entrance. The cover is of the same outside dimensions as the cage itself. To insure the platform remaining level it is often necessary to make the base of two pieces in the same manner as the platform, or to nail strips across it at right angles to the grain. Both platform and base are attached to the standard by long screws with heads countersunk. Food is furnished by placing it on a piece of cardboard at any point on the cover or platform. The base stands in running water, as explained below. This type of cage permits the ants to leave their nest within the cage and to forage over the platform, cover, and stand in natural fashion, but their escape from the stand is prevented by the very natural barrier of water, which they find when they approach the bottom of the standard. It is not possible for them to conceal larvæ or eggs where the observer can not find them and they can not bring

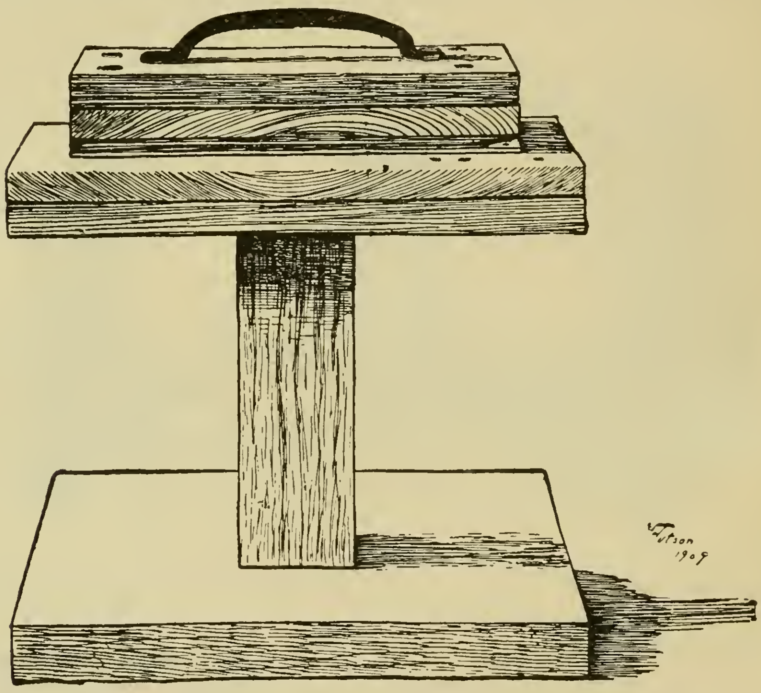

FIG. 8.—Artificial formicary with parts assembled ready for use. (Senior author's illustration.)

in larvæ or pupæ from outside sources to the annoyance and vexation of the student.

While the ants are very fond of sweets, we have found that sweets alone will not suffice for food indefinitely. Animal food is also required, and we find that by supplying the colonies with a "balanced ration" of honey and fresh beef or veal they will work in a perfectly natural manner for many months without other food.

The problem of confining the ants to the cage and its stand was not so easily solved. We first tried Sir John Lubbock's method of placing a moat of glycerine or water about the stand, but both liquids dried too quickly and were effective for only a few hours. Recourse was had to the proverbial chalk line without success. Bands or ditches of kerosene, crude oil, tar, oils of sassafras and citronella, tree tanglefoot, zenoleum, naphthaline, coal-tar disinfectants, whale-oil soap, sharp-edged tin, and fur were all failures. Certain powerful odors, such as those of zenoleum, sassafras, and citronella, act as repellents temporarily, but after a few hours of evaporation are no longer effective. Ordinarily these ants will not cross bands of cotton tape which have been impregnated with a saturated solution of corrosive sublimate and dried, but when attempting to leave an area to which they have been confined by this means they are much more persistent in crossing it.

Water with a film of whale-oil soap on it acted as a repellent for a few hours only, while a film of kerosene upon water merely afforded

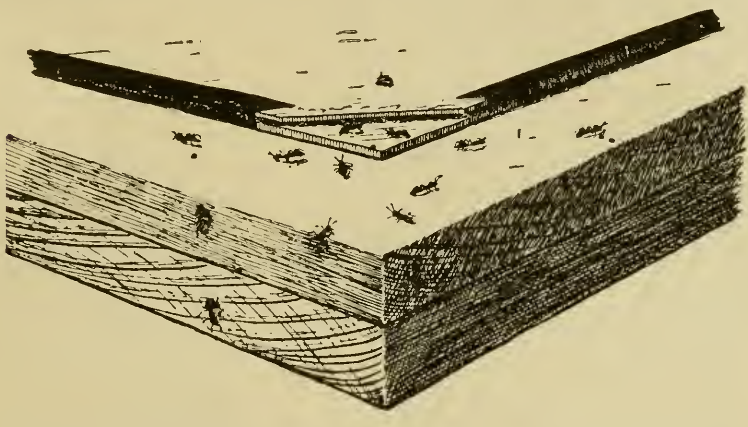

FIG. 9.—Entrance of artificial formicary shown in figures 7 and 8. (Senior author's illustration.)

a convenient floor upon which the ants could travel. The difficulty in confining the workers with any liquid or mucilaginous substance lies in the fact that they are exceedingly light,[1] and sticky substances shortly harden on the surface, so that the workers are supported. The surface film of clear water is in fact almost strong enough to support a worker not loaded. It is not unusual to see an ant alternately walking and swimming in crossing a narrow ditch of water which has been standing for a few hours. Minute dust particles collecting upon standing water shortly form a film upon which the workers pass with ease. Perfectly fresh water therefore served to confine the colonies to their cages, and at first our observations were made upon colonies in cages which were standing in dishes of water. This, however, necessitated frequent changing of the water, and observations were often brought to an abrupt finish by other duties which prevented the change of water in the vessels at the right time.

[1] The average weight of one worker is 0.0002077 gram.

In February, 1908, the senior author constructed, on the grounds of the Louisiana Experiment Station at Baton Rouge, a small building for the purpose of studying this ant more in detail. The building was 10 by 30 feet and equipped with benches having upon them galvanized iron trays $2\frac{1}{2}$ by 12 feet, 4 inches deep. In these trays the cages were placed and by means of suitable connections running water 2 inches in depth was kept passing through the trays day and night. As the ants would not voluntarily enter running water this arrangement worked admirably. The interior arrangement of this building is shown in Plate III. The iron trays and ant cages are shown upon the right, with work tables, chemicals, etc., on the left. The building was equipped with electric and extension lights for night examinations, and a combined thermograph and hygrograph recorded the temperature and humidity of the room at all times. For convenience this building was referred to as the "formicarium." Plenty of windows insured full ventilation at all seasons, and to avoid abnormally high temperature in summer a second or accessory roof was placed two feet above the main roof. This laboratory also proved a convenient insectary for the rearing of other insects.

The Argentine ant possesses a marked proclivity for attacking all insects which one has *under observation*, and all rearing experiments in cages, no matter what the insect, must be protected from the ants. The trays of running water therefore served to keep the ants away from general cage experiments as well as to confine them to the cages in which they themselves were being studied.

ESTABLISHING COLONIES FOR STUDY.

To establish a colony in one of the artificial formicaries or cages is comparatively easy. It is only necessary to secure a fertile queen from some thriving outdoor colony and place her on the stand, first placed in water, together with any desired number of workers which have been captured by attracting them to a sweetened sponge or piece of fresh meat. Any lot of workers will accept any queen and vice versa. When queen and workers are thus placed upon the cage and its stand, they usually, after a few hours, take up their abode in the nest proper. At first we experienced some difficulty in preventing them from collecting beneath the stand, but it was presently found that if a little dirt were removed from another colony and placed in the entrance of the new formicary the ants would enter at once and adopt it as a suitable home. After the establishment of such colonies the queen usually commences egg deposition in from 6 to 48 hours.

By establishing colonies in this manner, without immature stages present, it is easy to observe the daily rate of egg deposition, the incubation period of the eggs, and the duration of the larval and pupal

"FORMICARIUM," OR SPECIAL INSECTARY, CONSTRUCTED AND EQUIPPED FOR THE STUDY OF THE ARGENTINE ANT. (ORIGINAL.)

stages. In some of the records given below single individuals have been kept under observation from deposition of the egg, through larval and pupal stages, to the adult. In other cases the time from deposition of the first egg until hatching of the first larva was assumed to be the period of incubation, date of hatching of first larva to formation of first pupa the duration of the larval period, etc.

While these cages were invaluable in studying the life history of the ants, the small amount of space available for them between the glass plates made the number of ants they would contain very limited. For the purpose of studying the general habits of large colonies of ants a modification of the Janet cage was used. As its name implies, this cage was invented by Mr. Charles Janet,[1] and is described by him as follows:

> The apparatus (an artificial horizontal nest of porous mineral substance) described in this treatise gives, in reference to the raising of ants, remarkable results. Ants die in a short time when placed where they can not receive sufficient moisture; but (and this is the delicate point) this moisture must be maintained within certain limits. The apparatus invented up to the present do not solve this difficulty. Furthermore, they do not lend themselves easily to observation, nor do they permit one to withdraw with ease specimens when needed. The artificial nest is formed of a block of plaster, or any other porous substance, which has hollowed out of it a certain number of small cells, placed one after the other and communicating. These cells are covered with an opaque slab designed to keep the cells dark between the periods of observation. A cup of water placed at the end of the block allows it to absorb moisture. The cell nearest this cup is the dampest, and the one farthest away the driest. I leave this last always light so that it resembles, for the breeding under observation, a space outside of the nest. If the water-cell has been kept too moist, the ants go into the cell farthest away, that is to say the driest. When, on the contrary, the apparatus becomes too dry the ants return to the walls of the cell containing the water, which is always damper than the other parts of the nest. They can thus choose for themselves the part of the nest presenting the degree of moisture which suits them best.

The chief modification adopted was the use of a five-celled cage instead of one of four cells, as described by Janet. Also, the ants were not inclosed within the cage, but were allowed to enter or leave at will. To permit of this the Janet cages were placed upon platforms, which stood in running water. These platforms were considerably larger than the cages, and this gave the workers quite an area to forage over, simulating natural conditions quite closely. The food was placed upon the platform, outside the nest, and the workers thus had to carry it in and feed the larvæ in the same manner in which it was done outdoors. These cages had sufficient capacity for many thousands of ants. They were used for observing the behavior of large colonies and for the purpose of noting the effects of poisons and various control measures.

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[1] Studies on ants. Note 2. Apparatus for the raising and observation of ants and other small animals which require a moist atmosphere. Extract Ann. Ent. Soc. France, Mar. 10, 1893; vol. 62, pp. 467-482, figs. 11-12. (Translated by Miss A. O'Conor.)

LIFE HISTORY.

THE EGG.

(Pl. IV, *A*.)

The egg is elliptical, pearly white, lustrous, without markings, and the membrane is extremely thin and delicate. The surface is somewhat mucilaginous, so that when eggs come in contact they adhere to each other. This enables the workers to handle them en masse and also permits of their being deposited upon the walls or ceilings of the ants' habitations.

The average size is 0.3 mm. long by 0.2 mm. wide. The largest egg encountered while measuring a series was 0.34 mm. long by 0.24 mm. wide, and the smallest 0.27 mm. by 0.187 mm.

As time for hatching approaches the luster fades and the surface takes on a dull appearance. This is not sufficiently pronounced and uniform, however, to be taken as a safe guide to immediate hatching. When the embryo takes on the larval shape the membrane not infrequently adapts itself in a way to the general contour of the inclosed embryo, thus making it very difficult to distinguish between the eggs and the newly-hatched larvæ.

In the large Janet style cages the workers seem to take elaborate care of the eggs in order to secure for them just the requisite amount of humidity. Frequently they will be shifted several times in the course of the day, first being stored in one corner, then moved to the center of the compartment, afterwards carried to another compartment, and perhaps finally stuck to the glass ceiling. Sometimes the eggs are separated from the larvæ and pupæ; at other times they will be stored together in apparently hopeless confusion.

The care of the eggs by the workers seems essential to complete embryonic development. Eggs deposited in test tubes by isolated queens have gone through a portion of the embryonic development, but we have not been successful in getting them to hatch. This may be due in part to the ease with which the delicate embryos are injured in handling and to the fact that when placed on glass the condensing moisture may retard or stop development.

The queen appears to act merely as an egg-producing machine, and once the egg has been deposited she pays no further attention to it. The act of oviposition has been observed several times and does not occupy more than a few seconds of time. An attendant ant appears to be anxiously watching for the appearance of the egg, and it is immediately picked up and rushed off to the nearest "egg pile," sometimes before it has time to touch the floor of the nest.

Attempts to get fertilized queens, unattended by workers, to deposit eggs and rear the resulting larvæ to maturity have been unsuccessful. Such queens stop laying a few days after their isolation and seemingly pay no attention to what few eggs they do deposit.

Eggs are deposited at all seasons of the year. The large majority of them are produced during the summer, but a few are laid in warm spells during the winter months. The rate of deposition has not been determined, but one queen under observation in a cage deposited at the rate of 30 eggs per day, now and then suspending oviposition for several days at a time.

In outdoor colonies oviposition ceases when the daily mean temperature drops below 65° F., but is usually begun again when the mean temperature rises above this point, regardless of the time of the year.

No indication has been found of workers depositing eggs, even in colonies that were queenless for long periods; neither did queenless colonies ever rear queens from the eggs and larvæ present in the nest at the time queenlessness occurred.

PERIOD OF INCUBATION.

The period of incubation varies with the season of the year, and in proportion as the temperature remains high or low. The shortest incubation period observed has been 12 days, the longest 55 days, and the average is about 28 days. The longer periods are doubtless accounted for by the entire suspension of embryonic development during cool weather, and it is not impossible that the viability of eggs may be entirely destroyed by a temperature as low as 25° or 30° F., but on this point more data are needed.

The period of incubation has been determined, ordinarily, by placing a queen and workers, but no immature stages, in an artificial formicary and then noting the time from deposition of the first egg to appearance of the first larva. This period was assumed to be the real period required for incubation. In other cases single groups of eggs have been kept under constant observation throughout the entire period of incubation. The following table shows the variation in development at different seasons, together with the average daily mean temperatures prevailing:

TABLE II.—*Duration of the egg stage of the Argentine ant at different seasons—worker.*

Record No.	From—	To—	Days.[1]	Average daily mean temperature during period.	Average daily mean humidity.
				° F.	*Per cent.*
1	Oct. 1, 1907	Nov. 15, 1907	45½	(2)	....
3	Dec. 22, 1907	Feb. 14, 1908	55	(2)	....
4	Mar. 14, 1908	Apr. 9, 1908	27	70.3	70.2
6	May 1, 1908	May 23, 1908	23	74	68.9
7	July 20, 1908	Aug. 10, 1908	22	81	82.9
8	July 25, 1908	Aug. 12, 1908	19	81	81.5
12	June 30, 1908	July 18, 1908	19	81.1	74.9
14	July 24, 1909	Aug. 5, 1909	12	82.5	78.8

[1] Average days, 27.8.

[2] Cages kept in office; record of exact temperatures not available. The balance of the records were made in the "formicarium" and the recording instruments kept in the same room with the cages; hence the temperature and humidity records are correct for the exact location of the eggs under observation.

THE LARVA.

(Pl. IV, *B*, *C*.)

The larva when first hatched is not distinguishable from the egg without the assistance of a magnifying glass. For a time after hatching the body is considerably curved, the cephalic end being almost in touch with the caudal end, but as development progresses the larva assumes more and more of a straight form. The curvature is not entirely lost, however.

A recently hatched larva, measured with the compound microscope and eyepiece micrometer, was 0.49 mm. long by 0.32 wide. The fully grown larvæ (workers) average 1.7 mm. long by 0.66 mm. wide. The largest one under our observation measured 1.87 mm. by 0.765 mm.

With the exception of slight constrictions of the body, the larvæ are incapable of motion, thus being entirely helpless and relying altogether upon the ministrations of the attendant workers. The latter, however, perform their duties faithfully, and care for their charges with the greatest solicitude. They feed and groom the young larvæ continually and transport them from place to place whenever necessary. In case of danger their first instinct appears to be to remove the young to a place of safety, and they readily sacrifice their own lives in order to accomplish this.

The larvæ are fed often by the attending workers upon regurgitated and presumably predigested food. There is nothing in the appearance or actions of the workers which do the feeding to indicate that they are different from those which perform other duties, or that they are assigned to the particular and exclusive duty of being nurses. The feeding of the larvæ has several times been observed under a magnifying glass, and is as follows: The larva ordinarily lies upon its side or back. The attending worker approaches from any convenient direction, usually from one side or from the direction in which the head of the larva lies, and, spreading her mandibles, places them over the mouth parts of the larva, which are slightly extruded. The tongue of the worker is also in contact with the larval mouth. While the worker holds the body and mandibles stationary a drop of light-colored, almost transparent fluid appears upon her tongue. This fluid disappears within the mouth of the larva, but it can not be ascertained to what extent the larval mouth parts are moved during the operation, as they are obscured from view by the mandibles and head of the attending worker. Slight constrictions of the larval abdomen during feeding are sometimes noticeable, at other times not. The time required for feeding a single larva varies from 3 to 30 seconds, depending doubtless on the hunger of the "baby." The workers

IMMATURE STAGES OF THE ARGENTINE ANT. (ORIGINAL.)

A, eggs; B, larvæ and worker pupæ; C, larvæ, more enlarged; D, pupæ of workers; at center, male pupa. All enlarged. (Senior author's illustration.)

proffer food to, or at least inspect, each larva, for the worker doing the feeding will place her mandibles to the mouth of one larva after another, feeding those which seem to require it.

Both larvæ and pupæ are groomed or licked with the tongues of the workers; thus they are ever kept in a state of absolute cleanliness.

The most pronounced increase in size of the larvæ occurs during the first five days after hatching. As is the case with other ants, nothing is voided from the alimentary canal during the larval period, the undigested portions of the food being retained in the stomach, the latter having no open connection with the intestine. As the larva reaches its full growth this meconium, or mass of undigested material, becomes quite large and is distinctly visible as a dark object in the posterior portion of the body. At about this time communication is established between stomach and intestine and the meconium is voided. The larva then enters the prepupal or semipupal stage. While the insect in this stage is not very different in appearance from a full-grown larva, close examination shows a number of slight differences. Aside from the absence of the meconium, the cephalic and thoracic regions become markedly smooth and shining, with segmentation very indistinct, while the segmentation in the abdominal region is, if anything, more pronounced than before. The line of demarkation between abdomen and thorax is now in evidence, but without any very noticeable constriction. The mouth parts are protruded more than in the larva. The difference in appearance between larval and prepupal stages is not great but is sufficient to enable one to predict, with reasonable accuracy, the approaching transformation to the pupal stage proper.

In the later portion of the larval stage we have first been able to distinguish between the males and workers. The male larvæ grow to a somewhat larger size than do the worker larvæ, and it is thus possible to predict with some degree of certainty which of grown larvæ will transform to males and which to workers. In all other respects, however, they are apparently alike. The larval stage of the queen is unknown to us.

DURATION OF THE LARVAL STAGE.

The duration of the larval period has been determined by observation in the artificial nests in the same manner as the incubation period already described.

The following table shows the duration of the larval period at different seasons.

Table III.—*Duration of larval stage of the Argentine ant at different seasons—worker.*

Record No.	From—	To—	Days.[1]	Average daily mean temperature during period.	Average daily mean humidity.
				° *F.*	*Per cent.*
1	Nov. 16, 1907	Jan. 15, 1908	61	52.2	....
6	Feb. 5, 1908	Apr. 1, 1908	57	62.2	71.9
8	.....do.......	.....do.......	57	62.2	71.9
10	Feb. 15, 1908	Mar. 28, 1908	43	62	72
3	Feb. 29, 1908	Mar. 26, 1908	27	67	73
9	Apr. 10, 1908	Apr. 24, 1908	15	76.6	75.3
7	Apr. 12, 1908	Apr. 25, 1908	14	76.1	75.2
2	July 19, 1908	Aug. 1, 1908	14	80.5	82
11	Aug. 13, 1908	Aug. 27, 1908	15	81.7	71.7
4	Sept. 4, 1908	Sept. 14, 1908	11	81.1	73.6

[1] Average days, 31.4.

THE PUPA.

When the pupal stage is reached by the young ant all doubt is removed as to the sex of the individual, for one can tell at a glance which pupæ will transform into adult workers, which to males, and which to queens. The pupæ of these three forms are easily distinguishable and will be discussed in the order named.

THE WORKER PUPA.

(Pl. IV, *B*, *D*.)

The worker pupa immediately after transformation from the larval stage is pure white, without markings, except that the compound eyes are prominent as jet-black spots upon the head. The pupa is slightly larger than the grown larva, the average length being about 2 mm. The head is by far the most prominent portion. A pupa measuring 2.04 mm. in length was found to have a head 1.19 mm. in length (dorso-ventral diameter), while the thorax and abdomen measured 0.51 and 0.561 mm., respectively.

As time for transformation to adult approaches the pupa changes to a creamy color, then through a light brown to a dark brown, the latter shade being almost as dark as the body color of mature workers. The time of these changes varies with the duration of the pupal stage, but the following record of changes in color of a pupa which occupied a full 20 days from larva to adult (callow), is near the average:

First to seventeenth day—Pupa pure white, except compound eyes.
Eighteenth day—Turned to a light creamy yellow.
Nineteenth day—Became a light brown.
Twentieth day—The brown color deepened.
Twenty-first day—Reached teneral stage.

In some colonies there is more or less of an indistinct sorting of the immature stages, pupæ being placed in one portion of the nest and larvæ in another. This tendency is not perceptible in many colonies and is usually most noticeable in very large colonies.

The duration of the pupal stage has been determined in the manner already described for the incubation and larval periods. The range of pupal development is shown in the following table:

TABLE IV.—*Duration of pupal stage of the Argentine ant, individual workers. 1908–9.*

Record No.	From—	To—	Days.[1]	Average daily mean temperature during period.	Average daily mean humidity.
				° *F.*	*Per cent.*
1	Jan. 21, 1908	Feb. 14, 1908	25	56.5	68.3
2	Mar. 14, 1908	Mar. 27, 1908	14	67.5	71.8
5	Mar. 26, 1908	Apr. 11, 1908	17	73.8	68.9
6	Mar. 30, 1908	Apr. 14, 1908	16	73.8	70.2
3	Apr. 5, 1908	Apr. 15, 1908	11	76	73.5
10	do	Apr. 18, 1908	14	76.3	74
7	do	Apr. 20, 1908	16	76.7	74
8	Apr. 8, 1908	Apr. 23, 1908	16	76.6	74.5
9	Apr. 25, 1908	May 13, 1908	19	71	63.5
11	do	May 14, 1908	20	71.2	61.4
4	Aug. 1, 1908	Aug. 11, 1908	11	82.2	80
12	Aug. 6, 1908	Aug. 16, 1908	11	83	74.8
13	Aug. 10, 1908	Aug. 20, 1908	11	82.8	70.7
14	Aug. 28, 1908	Sept. 7, 1908	11	81.4	71
19	Apr. 5, 1909	Apr. 28, 1909	24	70.1	68.4
21	June 13, 1909	June 22, 1909	10	82.75	68.75
22	June 24, 1909	July 6, 1909	12½	84.08	76.08

[1] Average days, 15.

THE MALE PUPA.

(Pl. IV, at center.)

The male pupa is fully 50 per cent larger than the worker pupa and has, by comparison, an enormous thorax. The male pupæ vary in length from 2.78 to 3.23 mm., with an average length of 3.04 mm.[1] As the average length of the thorax alone is 1.19 mm., it is at once seen what a relatively large part of the body it constitutes. The male pupa is shown in the center of Plate IV.

When first transformed from the larval stage the male pupa is pure white, with exception of the compound eyes, which are faintly tinged with brown. Gradually the color of the compound eyes deepens and the ocelli become visible as minute dark spots upon the head. The male pupa, like the worker pupa, passes through gradations of creamy yellow, light brown, and dark brown to almost black before transforming to the adult stage. The color reached by the male pupa just prior to transformation is much deeper than that attained by worker pupæ. The males are assisted in their transformation to the adult stage by

[1] From measurements of 10 specimens by Mr. Arthur H. Rosenfeld.

the workers, and the pupal skin, or at least a portion of it, is worked backward to the tip of the abdomen and there shed entirely. Within a few hours after transformation the wings of the male become fully expanded. The following table shows the duration of the male pupal stage at different seasons.

TABLE V.—*Duration of pupal stage of the Argentine ant, individual males, 1908.*

Record No.	From—	To—	Days.[1]	Average daily mean temperature during period.	Average daily mean humidity.
				° *F.*	*Per cent.*
1	Apr. 11	May 1	19½	73.6	69.8
2	Apr. 14	May 4	20½	73.6	68.6
3	...do....	...do....	20½	73.6	68.6
4	Apr. 17	May 10	24	72.3	67.3
7	...do....	...do....	24	72.3	67.3
8	Apr. 18	May 11	24	72.2	66.7
9	...do....	May 13	26	72.8	66.5
5	Apr. 20	...do....	24	71.8	65.8
6	Sept. 24	Oct. 21	28	70.5	67.8

[1] Average days, 23½.

The normal time of appearance of the male pupæ is in the spring, but the appearance of a relatively small number in autumn is not uncommon. During April and May they are usually abundant, gradually disappearing in the latter part of May and early June. Only in one case have they been observed in midsummer, when three or four male pupæ were found at Baton Rouge, July 24, 1909, in a huge nest which contained thousands of immature stages.

THE QUEEN PUPA.

The pupa which is to become a queen is readily distinguished from the male or worker pupa by its size, as it is considerably larger than the male and more than twice as large as the worker pupa. The whole body is more uniformly developed than in the case of the male pupa. The head and thorax are not nearly so large in proportion to the rest of the body, the abdomen is much larger, and the dividing line between head and thorax is much more distinct. Apart from its size the queen pupa is readily recognized by the presence of the prominent wing pads.

Queen pupæ have been found only during April and May. The duration of this stage has not been worked out, as we have not been fortunate enough to secure larvæ which would transform into queen pupæ in our cages. Considerable numbers of these pupæ have, however, been collected in the field by the junior author and have been reared to the adult stage in the artificial formicaries, observations on them extending over a period of two weeks. The queen pupal stage seems to occupy relatively more time than is required for the worker pupal stage, but the gradual change in color from pure white to brown is about the same. It seems probable that the queen pupal stage extends over three or four weeks, depending upon the prevailing temperature. As many as 35 queen pupæ were collected from one colony in Audubon Park, New Orleans, La., on April 29, 1910; hence there is every reason for believing that the virgin queens are reared in large numbers.

Reasoning from what is known concerning the development of queens in the case of such insects as the honey bee, one would expect to find the queen ant developed from the same kind of an egg that produces the worker and that the queen would be developed as a result of special food given to the female larva. It is possible that the diet furnished to our colonies in confinement did not contain the requisite materials out of which the workers could elaborate a food suitable for rearing queens, and this may account for their failure ever to appear in the artificial formicaries, no matter how populous the latter were.

THE CALLOW OR TENERAL STAGE.

During the last few hours of the pupal stage, in all forms, the legs, mouth parts, and antennæ become more prominent and the pupa is assisted in its transformation by the workers, who attempt to straighten out the legs and antennæ. We are convinced that there is a very thin transparent membrane or skin surrounding the pupa, which is shed at time of transformation, but its existence is difficult to establish satisfactorily.

Immediately after transformation the young ant is colorless, almost transparent, but is otherwise identical in appearance with fully mature specimens. To this stage, following the custom of some authors, we apply the term "callow." The callow is at first very clumsy and walks with uncertain steps and staggering gait, reminding one much of a worker bee just emerged from the brood comb. During this stage the workers seem still to feel a responsibility for the callow's welfare, for when the colony is disturbed the callows, like larvæ and pupæ, are unceremoniously grabbed up by the workers and hustled to a place of safety.

The body of the callow deepens in color quite rapidly and in from 48 to 72 hours after transformation from the pupa becomes indistinguishable from that of other adults.

TIME REQUIRED FOR COMPLETE DEVELOPMENT.

By adding together the minimum periods required for the development of worker eggs, larvæ, and pupæ, as given in Tables II, III, and IV, we find that at least 33 days are required for development from egg to adult, and in a similar manner addition of the maximum periods gives 141 days as the maximum time required.

From the tables also it is seen that the average period of incubation of the eggs is 28 days, for development of the larvæ 31 days, and for maturing and transformation of pupa to adult 15 days. By adding together these averages we arrive at 74 days as the average period of development. This, of course, can not be termed the time required for the development of a generation, since workers do not reproduce, and the term "generation" can be used only in referring to the succession of queens.

The time required for complete development of males is, of course, still unknown, for male larvæ could not, in their earlier stages of growth, be distinguished from the worker larvæ; while the larval form of the queen is still unknown.

THE ADULTS.

There are only three adult forms in the case of this ant, namely, the queen, male, and worker. Of the immature forms there are three, egg, larva, and pupa, of each the queen, male, and worker. There is hardly sufficient difference between the virgin queen and the deälated queen after fertilization to justify considering them as distinct forms. A complete colony may therefore consist of a queen and workers only, of queens and workers, or of a queen (or queens), males, and workers. With each of these combinations may be associated any one or more of the three immature stages, corresponding to each of the three adult forms, or nine immature stages in all. Plate II shows a colony consisting of 1 queen, about 100 workers, and about 20 eggs, with no larvæ, pupæ, or males present. For a technical description of these adult forms the reader is referred to other pages. The following descriptions are general in their nature:

The Worker.

The worker measures from 2.25 to 2.75 mm. in length and is well illustrated at *b*, figure 6. As with the queen, the abdomen extends to about the tarsi of the hind legs when the worker is active or engaged in feeding. The abdomen is capable of considerable distension, and when the worker is fully engorged with sirup or other liquid its chitinous plates are forced apart, rendering the connecting membranes distinctly visible. The writer has often noticed workers returning from their attendance upon plant lice with abdomens so distended that they looked like little drops of silvery liquid. Particularly is this appearance presented when the returning workers are viewed with a strong light beyond them.

As would naturally be expected in the case of so small a creature, the weight of a single worker is very small. To determine it, 1,000 workers, freshly captured and killed with cyanid fumes, were carefully counted and weighed on an analytical balance. The thousand insects weighed 0.2077 gram, which gave the average weight of each worker as 0.0002077 gram, or two-tenths of a milligram.

As already stated, there is only one caste among the workers. In a large colony there seems to be something of a division of labor, certain ones engaging in foraging, others in nursing, and still others in excavating or sanitary work. However, any individual worker can assume the duties of any other, and does do so when exigencies demand. Worker callows, barely hardened into mature adults, go forth in search of food and the hardened veterans of many months' service seem to make as efficient nurses as even the youngest.

LENGTH OF LIFE.

The workers are particularly long lived. A colony of about 70 workers was made queenless and broodless on July 8, 1908. By October 10 the number of workers had become reduced to about 40, and some of the original ones survived until February 25, 1909, a period of 6½ months. As this colony was queenless, the workers in it were not under normal conditions. With a queen present it is ordinarily impossible to ascertain the length of life of individual workers, owing to the constant maturing of young. However, in one case we had opportunity to observe the survival of workers with queen present and with immature stages absent. A colony started on October 10, 1908, proved to have an infertile, deälated queen and was kept under observation to see how long the workers would survive. The last of these died on July 22, 1909, having lived for 9 months and 12 days after their capture. Their age at the time they were confined in the cage on October 10 was, of course, unknown; but it appears safe to conclude that under normal conditions the workers not infrequently live to an age of at least 10 or 12 months.

Mr. G. D. Smith was successful in keeping a queen and several workers for more than two months, during which time they had no food other than that which may have been contained in the drinking water furnished them. During this period of prolonged fasting the queen even deposited eggs, some of which hatched into larvæ.

The Male.

The appearance of the adult male is illustrated at *a*, figure 6. The males average about 2.8 to 3 mm. in length. The most noticeable feature about them is the manner in which the thorax is enormously developed. The abdomen is relatively small and the head short and blunt. The shape of the head alone permits distinction between the male and virgin (winged) queen without the aid of a glass.

The normal time of appearance of the males, of course, follows the appearance of the male pupæ, usually in the spring, but a few appear in the fall. They are plentiful in the colonies during the latter part of April and May, and numbers are still to be found in June. After the beginning of July, however, they vanish, and are very seldom seen during the hot months of the summer. A few are occasionally found during October, November, and December, and in one case a few males were found in a colony as late as January.

The males are essentially drones, and never exhibit any indications of industry or usefulness beyond their special function.

The Queen.

Adult queens are found in two forms, the winged and the wingless or deälated. The former is the virgin queen and the latter the fertile or egg-laying queen.

THE VIRGIN QUEEN.

When the queen reaches maturity she possesses long narrow wings which are rather opaque, gray in color, with the veins and stigma pale brown. In other respects she does not differ in appearance from the deälated queen, described on page 49. The wings are retained until after the queen has mated. Mating may take place during the nuptial flight in spring, but under some circumstances occurs within the nest without any flight being made. In the latter case the queen loses her wings shortly after fertilization and assumes her egg-laying duties in the home nest along with the older queens already there.

The earliest date at which we were able to find virgin queens in the outdoor colonies was April 1. Normally the first spring appearance of males precedes the first appearance of virgin queens by about three weeks.

Probably owing to the extreme shortness of the winged stage, winged queens are very hard to find in the outdoor nests. Although they must exist in large numbers every spring, they have been collected only occasionally. Most of our observations have been made upon specimens reared from pupæ in artificial nests.

An enormous and general flight of males and virgin queens was observed at Baton Rouge, La., in the spring of 1908, when large numbers of both sexes were captured in butterfly nets. On the other hand, during the spring of 1910 and that of 1911 no general flight was observed at New Orleans, La., although close watch was kept for one. Considerable numbers of males were seen flying around the city electric lights, and individual males were found flying aimlessly in various localities, but no queens were found with them, and no flight took place that could compare with the one noted at Baton Rouge in 1908.

At the same time a large number of queen pupæ transformed into winged queens in a large Janet style nest in the laboratory at Audubon Park, New Orleans, La. About an equal number of males were also present in the same nest, which the junior author watched closely for a flight. Nothing of the kind took place. On two occasions all ants were driven out of the nest—workers, males, and queens—to see if they could be induced to fly, but after wandering around for a time they all returned to the nest. The males could be seen actively pursuing the young queens inside of the nest, and although copulation was never actually observed, it must have taken place. In the course of time all the queens lost their wings and commenced to lay an enormous number of eggs. These eggs hatched, and finally developed into workers, proving that they were fertile. The males all died one by one, the last one disappearing when about two months old. It is therefore evident that the nuptial flight is not a necessity.

Under natural conditions the tendency toward a general flight may be partially controlled by the comparative numbers of males and young queens in the nests and colonies. The weather conditions about flying time may also exercise a very important influence upon the flying impulse; cool, cloudy, and rainy weather tending to restrain the inclination to flight, and warm, clear weather encouraging it. The severity of infestation may also be an important factor, as the ants would be more likely to fly in crowded communities than in localities where they are comparatively scarce.

The males are much more given to flight than the virgin queens. In the formicarium at Baton Rouge males were often found flying during their season, and seemed to have no preference as to time of flight. They were found flying on cloudy days as well as on clear ones and as frequently at night as in the day.

THE DEÄLATED, OR FERTILE, QUEEN.

The deälated queen is illustrated at *c*, figure 6. The deälated queen measures from 4.5 to 5 mm. in length, and queens measuring 6 mm. in length are not uncommon. It should be remarked here that during egg-laying periods the abdomen is much larger and longer than shown in the drawing. Normally the abdomen extends well beyond the tarsi of the hind legs. Unfortunately, a drawing can not show the delicate silky pubescence of the queen's body, and in life she is a far more beautiful creature than one would imagine from the drawing, correct though the latter is in anatomical detail.

The credit for first discovering and recognizing the queens of this species seems to belong to Mr. E. Baker, formerly superintendent of Audubon Park, New Orleans, and Prof. R. E. Blouin, formerly in charge of the Audubon Park Experiment Station.

The rate at which the queen deposits eggs varies with the prevailing temperature, and egg deposition is suspended entirely at low temperatures. In the artificial formicaries, already described, the number of eggs laid each day varied from 1 or 2 to as many as 50 or 60. Thirty per day is not far from the normal number in warm weather, when the food supply is abundant. It appears probable, however, that the queens deposit much more rapidly in large colonies, although from the nature of the case this can not be verified by direct observation. Egg deposition becomes very slow, or ceases entirely, in the artificial formicaries when the daily mean temperature falls below 68° F.

Practically all queens under observation have shown a disposition to suspend egg deposition entirely for longer or shorter periods, even when the occurrence of such periods can not be accounted for by low temperatures.

Fertile queens confined in test tubes without accompanying workers will often deposit a few eggs upon the walls of the tubes, but we have been totally unable to get colonies established by confining queens in artificial formicaries without workers accompanying them. This failure has not been due to any need of workers to feed or care for the queen, since she can feed herself from a supply of honey or sugar as readily as can a worker. Ordinarily she attends to her own toilet, and it is doubtful whether she is in reality "attended" by the workers in the sense that queen bees are attended.

Fertile queens do not confine themselves to the formicaries, either natural or artificial. Isolated deälated queens are not infrequently found wandering about buildings by themselves, and while the queens in artificial formicaries ordinarily stay within the nest proper, they have at times been seen outside of it. The finding of deälated queens wandering about, coupled with the fact that workers readily accept a queen from any source, seems to indicate that new colonies may sometimes be established in nature by workers associating with such wandering queens.

The length of life of the queen has never been determined, but there is no doubt that it extends over several years. Observations have been carried on with the same queen for considerably over a year.

The number of queens that may be found in a colony varies from one to several in the summer nests, and may reach into the hundreds in the large winter colonies. Queens never show the least hostility to each other or to the workers.

In the laboratory at Baton Rouge it was our custom to put all surplus queens into one colony, kept for the purpose, and leave them there until wanted. As many as several dozen queens were sometimes in this colony at once, all living peaceably together, and with the number of queens sometimes exceeding the number of workers.

Queens will frequently leave the nests with the workers, and will be observed in the foraging trails. Ten queens were collected in 30 minutes from a large trail of workers at New Orleans, La., during January, 1911. These were quite remote from the nearest nest. Any colony will immediately accept a strange queen without hesitation, and it is probable that a constant interchange of queens takes place between different colonies.

THE COLONY AS A WHOLE

In size the colonies may vary from a dozen to many thousands of individuals and the number of queens present in a colony may vary from one to many hundreds. Although the Argentine ant is particularly aggressive and a hard fighter when coming in contact with most other species of ants, there is no apparent antagonism between separate colonies of its own kind. In fact, in heavily infested areas the workers and queens are so intermingled that the individuality of colonies is entirely lost sight of and all colonies appear to become part and parcel of one enormous community. In this respect the species may be said to have a more perfect social organization than even the honey bees, colonies of which are very distinct and the individuals of which usually repel with alacrity any visitor from another colony.

SEASONAL HISTORY.

In order to connect the scattered and individual life histories already given into one united whole it may be well to take a glance at the changes which occur in the ant colonies with the different seasons.

WINTER COLONIES.

The tendency of the Argentine ants to segregate into large winter colonies is very pronounced, and during the winter small colonies are very scarce, while nearly every protected situation will reveal the presence of enormous colonies. The stages which are represented in the nest are queens, workers, eggs, larvæ, and worker pupæ. During cold weather very few changes occur. The egg and larval periods are very much lengthened compared to the summer rate of development. The workers themselves move very little, and a large colony will subsist upon a small supply of food for long periods. During warm days heavy trails of workers emerge from the nests and carry back anything available for food. Except for this the ants may be considered as almost in hibernation during the winter months.

When the temperature falls as low as 60° F. the ants become sluggish, and foraging is largely suspended. At from 50° to 55° F. there is practically no foraging, and when this temperature is reached within the nest all adult ants become inactive, moving only occasionally, and even then with apparent difficulty. Activity is not strictly limited by these temperatures, however. On one occasion we found workers foraging in a building the interior of which was at 43° F., but the colony itself was outside the building and at a higher temperature. Very few refrigerators are cold enough to keep out these invaders when the outside temperature is warm enough for them to forage normally. On the very hottest days of summer they will enter refrigerators and even crawl into the ice chamber itself in order to reach some much-desired delicacy.

The most ideal location for the large winter colonies is in piles of decomposing vegetable matter. This material gives off a large quantity of heat during the process of rotting and consequently furnishes the ants with automatically heated apartments. In the same manner in which the ants seek optimum humidity conditions during the summer months, so they will regulate their location to preserve an even temperature in their nests in the winter. In cold weather they will carry the young stages toward the center of the piles, while in warmer weather they will be found near the surface.

Of course all the ants are not able to find ideal locations for the winter months, and great numbers have to locate themselves as well as they can. In open fields great numbers will be found under large ridges, or along ditch banks, particularly those which have a southern exposure. Many will burrow into the ground at the bases of large trees, where their tunnels and galleries will sometimes attain a depth of 12 to 14 inches.

Under Louisiana conditions the winter colonies are in evidence during the months of December, January, and February. The segregating tendency becomes marked during November, and the "divisional migration" normally occurs in February, but may not take place until March if the spring is cold and wet.

SUMMER COLONIES.

As soon as the weather gets warmer in the spring and food becomes abundant the large winter colonies break up into a great number of smaller colonies. These usually consist of one or more queens and a considerable number of workers, and they establish themselves in any good location where a supply of food is available. In places where food is exceptionally abundant these summer colonies will still remain very strong in numbers. Under large magnolia or oak trees, for example, colonies with 10 or 20 queens and many thousand workers are nearly always present.

A short time after the "divisional migration" has taken place in the early part of March, the large amount of food brought in by the workers, acting in conjunction with the warmer temperature, appears to stimulate the queens to lay great numbers of eggs. Most of the young stages carried through the winter or which have slowly matured during winter have by this time transformed into workers, so that the colonies consist of many workers, with comparatively few immature stages other than the eggs. Hatching takes place during the latter half of March, and the larvæ resulting from these eggs, after developing, transform into three classes of pupæ, viz, queen, male, and worker. Of these the male pupæ preponderate, with the workers a close second and queen pupæ a very poor third. The male pupæ appear in great numbers several days before the queen pupæ appear, which may possibly indicate a slightly longer larval period for the queens than for the males.

The adult winged males appear during the latter part of April and in May, and are in evidence in the nests until the beginning of June, when they begin to disappear. The winged queens appear a few days later. For some reason the winged queens are extraordinarily difficult to find in the nests, although their large size and long narrow wings should make them very conspicuous. However, only three winged queens have as yet been located in the nests under natural conditions in Louisiana. Fortunately the queen pupæ are not so difficult to discover, and a considerable number have been reared to the adult stage in Janet style nests in the laboratory, where most of our observations upon this stage have been made.

The appearance of the winged queens and males may or may not be followed by a nuptial flight. In either case, after the queens have become fertile they lose their wings and immediately start laying great numbers of eggs. These eggs develop into workers, with the exception of a few eggs which are laid in the late autumn and develop into males. It thus follows that the most rapid and conspicuous increase in numbers occurs during July, August, and September, when the eggs laid by the army of young queens complete their life history and transform into adult workers.

From then on to late in the fall the history of the colonies is very similar and devoid of incident. The numerical strength of the ants is constantly on the increase, and it is probable that the greatest natural dispersion occurs during the fall months, after the nests have been excessively crowded by the activity and increase of the summer.

During the latter part of October and in November the nights begin to get cool and we find the first inclination toward the formation of the winter colonies. The nests in exposed open situations are gradually deserted, and strong colonies accumulate in well-protected situations. This becomes more pronounced during the latter part of November, and in the beginning of December we find that the winter colonies with which we began are once more restored and that large united colonies are the rule, with small colonies the exception.

COMPOUND COLONIES OR COMMUNITIES.

Mention should not be omitted of the pronounced manner in which the social habit is extended beyond the limits of the individual nest or formicary. During the summer season of activity, and in heavily infested areas, communication between adjacent colonies is commonly observed. Not only the workers, but even fertile queens, travel from one colony to another. So closely are adjacent colonies associated in their activities that one can not do otherwise than consider a heavily infested area as one enormous "compound colony" or community.

MIGRATIONS.

Four distinct types of migration are exhibited by these ants, without including the long trips which they take in columns to and from the nests in search of food.

GENERAL MIGRATION OR DISPERSION.

By general migration is meant the slow but steady spread of the ants from infested points into adjacent uninfested territory. This is practically continuous, and while under natural conditions it may amount to only a few hundred feet per year it is greatly accelerated by artificial dissemination of the ants by man and his agencies.

MIGRATION TO FOOD SUPPLY.

When the supply of food becomes scarce in the immediate vicinity of a colony and a plentiful supply is discovered at a distance by the foraging workers, movement of the colony in toto to the neighborhood of the latter is not infrequent. Trees or plants harboring large numbers of scale insects are invariably surrounded by many populous colonies and the housewife who grows careless, permitting the ants to get food in plenty within her domicile, is soon repaid by having the premises overrun with the pests. One can easily note this form of migration by keeping a constant supply of honey or sirup in one place for several days and providing a suitable nesting place—such as a decaying log—near it. The latter is shortly occupied by one or more colonies.

CONCENTRATING MIGRATION.

Concentrating migration takes place within the infested territory and consists of the coming together of a large number of smaller colonies to form a single large colony. This migration occurs under various adverse conditions. During floods the ants will concentrate in great numbers upon elevated ground, or many colonies will carry their young stages up the same tree in order to get protection from the rising water. The most pronounced concentration, however, occurs at the approach of cold weather in the fall, when large numbers of colonies concentrate at one point to form the large winter colonies, often consisting of hundreds of queens and many thousands of workers. These colonies are fully described elsewhere.

DIVISIONAL MIGRATION.

Divisional migration is the opposite of concentrating migration, and is always in evidence after a large number of ants have concentrated at one place. It is most conspicuous in the spring, when the large winter colonies break up into a great number of smaller ones. These small colonies usually consist of one or more queens and a supply of workers. They distribute themselves in all directions from the large colony, and locate in any place which affords suitable protection and an available food supply.

NESTS OR NATURAL FORMICARIES.

Almost any place seems to be suitable for the location of nests of the Argentine ant, provided that light and water may be sufficiently excluded. Some of the situations in which they have been found are within hollow trees, beneath the rough bark of growing trees, in forks of trees, in rubbish and compost heaps, in decaying logs and timbers, beneath boxes and boards, under and in brick foundations, in stored household goods, beneath shingles on roofs, in rolls of wrapping paper, between walls of dwellings, in flowerpots, in piles of brick and stove wood, in garbage cans, in bags of sugar, in birds' nests, in discarded tin cans, in moss packing about the roots of nursery stock, and in straw packing containing glassware or china, in beehives with colonies of bees, under discarded tin roofing, around the roots of cotton, corn, sugar cane, and other growing crops, in railway cars, in various places on river steamboats and ocean-going vessels, in old clothes, under street-car tracks, under brick and concrete pavements, in greenhouse benches, inside the husks of roasting ears, inside of cotton bolls, in hollow iron electric-light posts, in the cracks and crevices in telephone and telegraph poles, and in the cinder ballast of railroad tracks.

Most of the situations named are used as permanent nesting places so long as weather conditions do not force the ants to find more suitable quarters. With the advent of unfavorable conditions the ants move their colonies with alacrity.

Many permanent nests are located in the tops of trees, in rotten branches, or in places where borers or termites have been working. In rotten logs the ants will nearly always utilize old borer or termite tunnels for their nests, but do not appear to do any boring for themselves.

The facility with which entire colonies move is sometimes amazing. If a nest is disturbed the workers will frequently move all stages and establish another nest in a fresh location in the course of a very few minutes.

UNDERGROUND NESTS.

The ants seldom burrow to any great depth in the ground. The exceptions to this occur during hot, dry weather in the summer or during particularly cold spells in the winter. In the dry spells they evidently work downward in an endeavor to secure sufficient humidity for the young, while in the wintertime they sometimes go deep into the soil for the sake of protection from the cold. The deepest burrows which we have measured have been 14 inches in depth, but they usually average from 4 to 10 inches under normal conditions. These deep burrows are usually located at the foot of tree trunks, or under the ridges in cane, cotton, or corn fields.

Under more favorable circumstances, however, the underground galleries average from 1 to 4 inches in depth. In summer time the ants appear to do as little excavating as possible and seem to limit their efforts to excluding light and water. When the nests are located above ground, under boxes, boards, stones, etc., very little soil is used, and this is utilized in closing holes, etc., to keep out light and drafts.

WET-WEATHER NESTS OR SHEDS.

In wet situations or after heavy rains, when the ground has become soaked with water, the ants construct curious honeycombed structures around the bases of tree trunks. These are made of a great number of fine, loose particles of soil, usually supported by grass stems or loose leaves. They vary from one-half inch to as much as 5 inches in height, and sometimes cover an area of several square feet. They are built with great rapidity by the workers, and are extremely frail, falling in at the lightest touch. As a result of this weakness these nests disappear after a few days of dry weather, or are washed away by showers. They consist of a maze of covered galleries, in which large numbers of the larvæ and pupæ are placed. Their purpose appears to be to afford protection to the young stages until the ground gets dry enough for the underground galleries to be reoccupied, or they may be used to dry and "air" stages which have become wet, the loose construction permitting a liberal circulation of the air through the walls and ceilings. (See Pl. V.)

WET-WEATHER NEST OR SHED, ERECTED BY ARGENTINE ANTS DURING RAINY WEATHER. (ORIGINAL.)

GENERAL OBSERVATIONS.

AVERSION TO LIGHT.

The ants demonstrate in many ways their dislike of light, or at least their aversion to it. Their nests are always located in dark places, the ants are active all night, and their immature stages are never exposed to light except for brief periods in emergencies. If the opaque cover is removed from the top of an artificial ant nest for a considerable time, all the ants will come out and will refuse to return until the cover is replaced. Several experiments were made at Baton Rouge, La., in 1909, using different colored glasses for cage covers, but the ants were not satisfied unless the cover was absolutely opaque. While they will go anywhere into daylight in search of food, they will cover over as thoroughly as possible, with their protective "sheds," the colonies of scale insects, mealy-bugs, and aphides which they habitually frequent.

SENSE OF SMELL.

The workers exhibit a very keen sense of smell by the manner in which they locate certain foods. Meat which is wrapped in heavy wrapping paper will attract thousands of the insects, and they will work their way through the various folds and crevices of the paper in a surprising manner until they reach the meat itself. The workers readily secure entrance into the ordinary Mason or glass fruit jar, if one omits placing beneath the cover the rubber ring or gasket. No matter how tightly the cover is screwed on, the workers follow the spiral threading between cover and glass until the interior is reached.

Another illustration of the sense of smell is seen in the readiness with which trails are restored when broken or disturbed. If a line of ants be moving across a floor in a circuitous line, for example, and all ants be swept from the floor with a broom, the next on-coming workers will follow exactly the original course. This may be repeated indefinitely and the trail will always be established in the original location. If, however, some strong-smelling substance, like oil of citronella or kerosene, be placed upon the trail the ants become confused at once and by their aimless wandering about show plainly that they can not locate the original pathway.

SIGHT.

While the Argentine ants are extremely sensitive to light, it is doubtful if they possess the sense of sight. The action of light can generally be described as exerting a repelling influence upon them and they avoid it as much as they can. That they do not use eyesight in locating food substances has long been recognized. Their trails will frequently encircle the spot which they ultimately hope to attain. They will never attempt to avoid a hand threatening from any direction as a spider will do, but will continue going ahead until their antennæ touch the obstacle. The manner in which they religiously follow their trails and the confusion which results when these trails are destroyed proves that they do not trust to a sense of sight in traveling. This is illustrated again by the fact that they are active all night in the darkest situations.

HEARING.

The sense of hearing in these insects is not acute, even if indeed it be developed at all. The ants are not disturbed by ordinary noises, such as talking or working about the nests. If, however, one emits a loud shout within a few inches of the formicary, or fires a pistol near it, the ants are thrown into the confusion and excitement characteristic of them when disturbed. It seems not impossible that in such cases they have detected actual vibrations of the surface on which they are located, due to the action of the sound waves. Strangely enough, in situations where loud noises and vibrations are of constant occurrence, the ants become accustomed to them. Thus at New Iberia, La., we found ant colonies between and under the ties of a railroad track over which many trains passed daily.

CANNIBALISM.

Cannibalism in any form is extremely rare in the case of this species, and true cannibalism has not yet been observed. The only thing at all approaching it was observed in the case of a colony kept in our formicarium, the workers of which developed a habit of eating the eggs as fast as they were deposited by the queen. This colony was established in an artificial formicary on November 27, 1907, and from that time until the early part of July, 1908, larvæ were reared more or less continuously and in the usual numbers. In July it was noticed that the number of immature stages became steadily smaller, and on July 28 a quick removal of the cover from the cage disclosed several workers in the act of eating eggs. Thinking that this might be due to lack of sufficient food of an animal nature fresh meat was at once furnished the colony and was thereafter kept continually accessible. In spite of this the egg-eating habit continued until November 5, 1908, all eggs being eaten within a few hours after their deposition by the queen. By this time the number of workers in the colony had been reduced to six, and by November 11 the queen and remaining workers were dead, the colony having apparently been exterminated through lack of any maturing workers to replace those dying from old age and accident.

SANITATION.

All adult members of the colony keep themselves scrupulously clean, after the manner of most hymenopterous insects. Workers divest their bodies and legs of foreign matter by persistent rubbing of the body and antennæ with their legs, while the tarsi are cleaned by pulling them between the mandibles. At times we have seen the workers assisting each other in these operations, particularly when some gummy or adhesive substance became attached to the head and mandibles. On one occasion the senior author observed one worker industriously cleaning the mandibles of a companion. During this operation, which lasted for several minutes, the worker receiving the kindly ministrations stood with her head well raised, mandibles extended, and feet firmly braced, while the teeth of her mandibles were thoroughly cleaned by those of her sister.

The queen is occasionally cleaned and groomed by the workers, but for the most part she attends to her own toilet, being nearly as skillful and dextrous at the task as are the workers themselves. Larvæ and pupæ are groomed from time to time, this grooming being done with the tongues of the workers.

Dead adults or larvæ are not tolerated within the colony and are removed immediately. Dead adults are also invariably removed from the vicinity of any food supply which the ants are visiting.

Decaying animal matter is not tolerated in near proximity to the nests. If the ants are unable to remove it bodily they will carry particles of earth with which to bury it, much after the manner adopted by honey bees in covering with propolis any dead animal which they can not remove from their hives. The following example will serve to illustrate this habit: A small minnow, recently dead, was placed near the entrance of one of the artificial formicaries. It was immediately covered with workers, and in the course of a few hours all the soft portions had been torn apart and carried into the formicary, little remaining except the bones and skin. On the following day another fresh minnow was given the same colony. While this was torn apart the same as the first one, it did not receive nearly as much attention. When a third minnow was given the colony the workers paid no attention to it, having evidently had fish "a plenty." As soon as it commenced to decay the workers brought particles of trash and dirt from their nest and piled these up around the minnow. This work they continued for three days, by the end of which time the remains of the minnow were completely buried. Decaying fruit left near the artificial nests was treated in the same manner.

RATE OF TRAVEL.

One of our associates, Mr. G. D. Smith, made some interesting experiments to determine how rapidly the workers travel both in going to food and in returning from it with their loads. Sirup was placed on the comparatively smooth floor of an infested building, and when the ants were visiting it in large numbers a distance of 6 inches was measured off on one of the principal "trails." The rate of travel of individuals over this 6 inches was then noted. Mr. Smith found that the average time required to travel the 6 inches when going to the food supply was 12½ seconds, or at the rate of 29 inches per minute. When returning from the food, presumably with their stomachs filled with sirup, the average time required to travel the 6 inches was 21 seconds, or at the rate of 17 inches per minute. The rapidity with which the foraging ants can travel (29 inches a minute, or 145 feet per hour) explains their ability to keep thoroughly patroled all of the walls, furniture, and other contents of a building within their reach. It explains at the same time the reason for their so quickly locating food supplies left accessible to them.

The rate of travel over horizontal polished surfaces is, however, much greater than that cited above. On a tiled floor or on the top of a glass showcase their speed is two or three times as great as that just given. In fact, it is almost impossible to capture the workers on a tiled floor, so rapidly do they move. This same degree of speed is not attained on vertical polished surfaces, such as window panes.

STORAGE OF FOOD.

Only to a very small extent do the workers of this species provision their nests for future emergencies. They are given to carrying lettuce seed, and perhaps other seeds, into their colonies at times, but the bulk of these seed are used up in a short time, and in a few days all have disappeared. Apparently the desire to carry in a full supply of any desirable food is the cause for this storage, rather than any fixed instinct toward providing the colony with permanent stores. In like manner, when the ants have access to large amounts of granulated sugar, the granules are carried into the nest and deposited in various parts of the galleries, there being no place set aside, apparently, as a granary or storehouse. Like the seeds above mentioned, the supply of sugar is consumed within a few hours or a few days after its acquisition. Particles of meat are deposited in the galleries in similar manner, often to be neglected until they are too dry to be of much service. Even when dried, however, they seem to furnish a relish or variation in the diet, as workers may be seen, from time to time, rasping off small shreds with their mandibles and then masticating these with apparent enjoyment.

Liquid food, such as honeydew, sirup, etc., is not deposited anywhere in the nest, and if any liquid food is kept in reserve at all it is merely that which is retained in the stomachs of the workers. Apparently liquid food is consumed soon after being brought into the formicary, as evidenced by the following observation:

Some fresh honey was placed upon the food table of an artificial formicary, and when the first worker was observed to leave the honey the top of the formicary was removed and her actions observed. Upon entering the colony she was met by three other workers, all of which placed their mandibles to hers. As she regurgitated the liquid they sipped it up. When one of these workers had received a sufficient quantity she retired and another took her place, as many as four or five workers sometimes feeding at once. The foraging worker in this manner supplied about 15 others with food, after which, her supply being apparently exhausted, she left the group of assembled feeders and went her way, leaving some of them hungry and still unsatisfied.

RELATIONS WITH OTHER ARTHROPODA.

FORMICIDÆ.

It may be said in general that the Argentine ant will not tolerate the presence of other species of ants within its domains. There are a few exceptions to this rule.--In 1908 Mr. G. A. Runner and the junior author found a small colony of *Monomorium minimum* Buckley living in the same tree stump with a colony of Argentine ants at Baton Rouge. The Monomorium colony possessed a number of young stages and appeared to be unmolested by the Argentine ants. The following season, however, the Argentine ants were in full possession of the stump, and no trace of Monomorium could be found. During the same summer another small colony of *M. minimum* was noticed living in a fig tree in territory heavily infested with the Argentine ant. This was also at Baton Rouge. This colony was observed for several weeks, but finally died out, though it could not be determined whether the Argentine ants were responsible for its annihilation.

In another case a log was split open, disclosing vigorous colonies of both *Iridomyrmex humilis* and *M. minimum.* Whether the ants were occupying the same chambers or whether the nests were in close but disconnected chambers could not be ascertained, but the Monomorium workers were seen to pick up and carry away the larvæ of *humilis* with as much solicitude as they did their own. Just what relationship obtains between these two species we have not been able to determine, but certain it is that *humilis* tolerates this small species to a much greater extent than it does any other ant. At Baton Rouge *Monomorium minimum* still seems to maintain its normal abundance, and this certainly can not be said of any other species of ant.

An account of the methods used by the Argentine ants in overcoming other species of ants was published by the senior author[1] in the Journal of Economic Entomology.

Prof. W. M. Wheeler, in Entomological News for January, 1906, gives an interesting account of the way in which this species obtained a foothold in Madeira and supplanted another introduced species, *Pheidole megacephala* Fabr.

COCCIDÆ AND APHIDIDÆ.

The liquid excretions of the various species of scale insects and aphides form one of the chief sources of food for the Argentine ant. The large variety of trees and plants in the South gives support to a great number of coccids and plant lice, and these insects in turn yield sustenance to myriads of ants. In return for this food supply the ants shelter and protect these insects, with the result that the latter increase beyond all customary proportions. As the result of this symbiotic manner of living we find that a comparatively small area of land frequently supports enormous numbers of ants, scale insects, and aphides, while the plants themselves become so severely infested that some of them are killed and many more seriously injured.

All through the summer months, and also during warm days in winter, heavy streams of ants can be seen ascending and descending the trees and plants; the ascending ants empty, the descending ones heavily laden with the liquid excretion which they have obtained from the various scale insects and plant lice. During the summer this activity is well-nigh endless, and the ant trails can be observed at all hours of the day and night. All scales and aphides are closely attended, but some species appear to attract more of the ants than do others. The large unarmored scales and the plant lice appear to be the chief favorites, the mealy-bugs, however, following them very closely in this regard.

Aside from protecting the aphides and scale insects from ladybird beetles and constructing earthen shelters over them, the ants only rarely foster them directly. In one case only have insects of this character been actually found in the ants' nests. In January, 1909, Mr. G. D. Smith, in excavating an underground colony at Baton Rouge, found a number of barnacle scales, *Ceroplastes cirripediformis* Comst., on tree roots which passed through the formicary. These scale insects were full grown and vigorous. At this season of the year no live scales of this species could be found above ground. It may be remarked in passing that this is one of the species to which the ants are very attentive during the summer and autumn months.

[1] Notes on the Habits of the Argentine or "New Orleans" Ant, *Iridomyrmex humilis* Mayr. Wilmon Newell, Journ. Econ. Ent., vol. 1, no. 1, pp. 21–34, 1908.

Workers are often seen carrying plant lice and scale insects, and this fact, coupled with the observed phenomenal spread of scales in ant-infested territory, brings one inevitably to the conclusion that the workers carry and establish these pests upon new growth and upon new host plants.

During March, 1910, a considerable number of adult female scale insects were found embedded in a band of "tree sticky" placed around a magnolia tree to repel the ants. This band was located 4 feet from the ground. The scale insects were a species of Odonaspis [1] which is found upon Bermuda grass close to the surface of the ground. There was apparently no other way for these insects to get up the tree except through the transporting agencies of the ants.

On sugar cane the ants have frequently been seen carrying around small sugar-cane mealy-bugs. They do not appear to pick them up unless they are rudely disturbed or frightened, but the fact remains that they have been seen transporting them. Experiments made by the junior author showed that the ants would pay no attention to the larval mealy-bugs until after the latter had commenced to feed on the canes and produce exudations. The following three paragraphs are quoted from our notes:

Placed a piece of paper on which were about 2,000 "seed mealy-bugs" across a strong ant trail, and weighted it down flat, so that the ants could not get underneath it. At first the ants were bewildered at losing their trail, and ran over the paper in all directions. They absolutely refused to notice the young mealy-bugs, and after a while reestablished their trail *across* the paper, and commenced traveling the same as before. The mealy-bugs were swarming directly across the trail, but the ants paid no attention to them.

This seems to indicate that the ants have no dealings with the mealy-bugs until they begin to secrete the juices from the cane stalks. These young mealy-bugs had never fed, being taken directly from the tube in which they were hatched. Thus they would probably not have excreted any liquid. At the same time the ants did not show any hostility toward them.

The eggs are out of reach of the ants when they are enveloped in the egg mass, as the waxy covering appears to entangle the feet of the ants, being slightly sticky and adhesive. The egg stage and young larval stages are therefore removed from the sphere of the ants' influence.

Even though the actual transportation of plant lice, aphides, and mealy-bugs by the ants may not assume much economic importance, there is, nevertheless, no doubt that the ants assist these insects greatly in other ways. They build shelters over them, these consisting of fine particles of earth, protecting them from storms and hindering the attacks of parasites. These shelters have been noticed in many different localities. In Bulletin 52, Bureau of Entomology, Mr. E. S. G. Titus gives an illustration of a large shed built by the ants over the surface of a persimmon, protecting a number of Florida wax scales (*Ceroplastes floridensis* Comst.). These sheds are also present

[1] Determined by Mr. E. R. Sasscer.

in great numbers on sugar cane, Johnson grass, willows, and oaks, and, in fact, in all places where a number of coccids or plant lice are exposed to the weather.

The stimulation resulting from the attentions of the ants while collecting the sweet liquids appears to have the effect of greatly encouraging the numerical increase of the aphidids and coccids. During the summer of 1910 the junior author reared several generations of sugar-cane mealy-bugs on sugar cane planted in large pots. One-half of these pots were isolated from the Argentine ants, while to the others they were allowed free access. The mealy-bugs grew and multiplied in both lots of cane, but there was great difference between the thriftiness of the isolated and nonisolated insects. In the pots to which the ants had access the mealy-bugs multiplied so freely that finally they almost smothered out the sugar cane with their cottony egg masses. In the isolated pots, while the mealy-bugs increased in numbers, they were not nearly so numerous or healthy looking as in the ant-infested pots. At the end of two months the number of mealy-bugs in the ant-infested pots probably exceeded the number of mealy-bugs in the isolated pots to the extent of at least five to one.

That the same conditions exist in the cane fields is shown by the number of mealy-bugs which can be found in the fields infested by the Argentine ant as compared to their scarcity in fields not infested by the ant. Only one field under the latter conditions has been discovered as yet, but it has been watched closely for two years. The mealy-bugs have never become sufficiently numerous to attract the attention of the working hands, and they can be found only with considerable difficulty. On the other hand, in the fields where the mealy-bugs and ants are associated the former have become so numerous that the white cottony egg masses can be easily observed from the road while driving through the fields.

The same thing holds true with scale insects generally. In the orange groves invasion by the ants is followed by a rapid increase of scale insects, particularly the chaff scale (*Parlatoria pergandii* Comst.) and various species of Lecanium. So rapidly do these scales increase that, unless prompt measures are taken against the ants, the second year of infestation shows a severe curtailment of the crop, and the fourth or fifth year witnesses the death of many of the trees. The rapid decline of orange trees under conditions of heavy ant infestation is well illustrated by Plate VI, which shows a tree after exposure to attacks of the ants and chaff scales for three seasons.

The ants constantly attend the citrus white fly (*Aleyrodes citri* R. & H.), and a marked increase in this injurious pest always accompanies ant infestation.

ORANGE TREE AFTER EXPOSURE TO ARGENTINE ANTS FOR THREE SEASONS. (ORIGINAL.)

During a period of 18 months 48 species of scale insects have been collected in Audubon Park, New Orleans, all of which are attended by the Argentine ant. Many of these species, however, are visited sparingly, and are evidently regarded as sources of food when the more popular species fail to furnish a sufficient amount for the needs of the ants. A few species are particularly favored by the ants, and the trees and plants upon which they occur are always crowded with large numbers of the workers.

Among these favored species may be mentioned the Magnolia scale (*Neolecanium cornuparvum* Thro), which is found upon the various magnolia trees. This scale is very large and unarmored, and the young scales appear in great numbers during February and March. As this is the period during which the ants have the greatest difficulty in securing sufficient food it naturally follows that they concentrate upon the magnolia trees in immense numbers, and the soil at the bases of the trees is turned into gigantic ant nests. During June and July this scale is brought under control by the larva of a small black ladybeetle, and the number of ants in the magnolia trees falls off greatly. By this time, however, an abundance of scale insects and plant lice of many different species can be found everywhere, and the ants do not have to place such dependence upon the magnolia scale.

Another species which attracts great numbers of workers is the soft scale (*Coccus hesperidum* L.). This species has been collected upon a variety of plants in Audubon Park, among which may be mentioned the orange, banana, *Camellia japonica*, coral tree, cocoa tree, rubber trees, myrtle, and maidenhair ferns. This scale can be found in all stages at almost any time of the year, and is always heavily attended by ants.

Other important scale insects from the Argentine ant's point of view are the sugar-cane mealy-bug (*Pseudococcus calceolariæ* Mask.), the two barnacle scales (*Ceroplastes cirripediformis* Comst. and *C. floridensis* Comst.), and the black scale (*Saissetia oleæ* Bern.). The last three species are found upon a variety of plants.

A complete list of the scale insects and aphides which this ant attends would comprise a check list of these species for the entire ant-infested territory. The following list, however, includes the more important species upon various plants and crops which are the most eagerly sought after by the ants. Most of the determinations have been made at Washington, D. C., through the courtesy of Messrs. E. R. Sasscer, J. G. Sanders, and Theo. Pergande. So far as possible the species most attractive to the ants have been placed nearest the host plants, and they follow in order of preference within certain limits.

LIST OF COCCIDÆ AND APHIDIDÆ ATTENDED BY THE ARGENTINE ANT.

Upon bamboos: *Asterolecanium bambusæ* Bdv., *Odonaspis secreta* Ckll., *Odonaspis inusitata* Green.

Upon banana: *Coccus hesperidum* L., *Chrysomphalus aonidum* L.

Upon cotton: *Aphis gossypii* Glov.

Upon corn: Undetermined aphis (probably *Aphis maidis* Fitch).

Upon figs: *Pseudococcus citri* Risso, *Lecaniodiaspis* sp., *Aspidiotus camelliæ* Sign.

Upon hickory, elm, hackberry, and various shade trees: *Pseudococcus* sp., *Ceroplastes cirripediformis* Comst., *Ceroplastes floridensis* Comst., *Chionaspis longiloba* Cooley, *Chionaspis americana* Johnson.

Upon magnolias: *Neolecanium cornuparvum* Thro, *Aspidiotus camelliæ* Sign., *Toumeyella turgida* Ckll.

Upon mulberries: *Chrysomphalus tenebricosus* Comst.

Upon oaks: *Kermes galliformis* Riley, *Eulecanium caryæ* Fitch, *Eulecanium quercifex* Fitch, various aphidids.

Upon orange: *Coccus hesperidum* L., *Parlatoria pergandii* Comst., *Lepidosaphes beckii* Newm., *Lepidosaphes gloverii* Pack., *Chrysomphalus aonidum* L., *Aphis gossypii* Glov.; also the white fly, *Aleyrodes citri* R. & H.

Upon palms and other ornamentals: *Coccus hesperidum* L., *Eucalymnatus tessellatus* Sign., *Aspidiotus lataniæ* Sign., *Aspidiotus hederæ* Vall., *Chrysomphalus dictyospermi* Morg.

Upon peach, pear, and other fruits: *Aspidiotus perniciosus* Comst., *Aulacaspis pentagona* Targ., various aphidids.

Upon persimmons: *Ceroplastes cirripediformis* Comst., *Eulecanium corni* Bouché, *Pulvinaria vitis* L.

Upon strawberry: *Aphis forbesi* Weed.

Upon sugar cane: *Pseudococcus calceolariæ* Mask., *Aphis gossypii* Glov.

Upon sweet gum: *Cryptophyllaspis liquidambaris* Kotinsky.

Upon various shrubs: *Coccus hesperidum* L., *Saissetia oleæ* Bern., *Pulvinaria cupaniæ* Ckll., *Aspidiotus lataniæ* Sign., *Chrysomphalus aonidum* L.

Upon willows: *Eulecanium nigrofasciatum* Perg., *Pseudococcus* sp. (near *citri*), *Chionaspis salicis-nigræ* Walsh, *Aspidiotus perniciosus* Comst., various undetermined aphidids.

In considering the remarkable increase in scale insects and aphidids which invariably accompanies heavy infestation by this ant one can not avoid taking into account the persistence with which the ants drive away ladybird beetles which attempt to prey upon the insects fostered by the ants. So thoroughly are the Coccidæ and Aphididæ protected in this manner that it is rare that a ladybird can be found at all on the infested trees. The only exceptions to this rule thus far noted are a species of Pentilia, a few specimens of which the senior author found in an infested orange grove below New Orleans, and the coccinellid mentioned before as preying upon the magnolia scale.

ANTAGONISM TOWARD OTHER INSECTS.

The Argentine ant is strongly antagonistic to nearly all forms of insect life, with the exception of the Coccidæ and Aphididæ. The amount of damage it is able to inflict upon other insects, however, is governed by the strength, fleetness, structure, or habits of the insect attacked. Thus it is able to destroy house flies, butterflies, mosquitoes, etc., only when the latter are hurt or disabled, as under ordinary conditions they are much too swift for the ants to catch. In the same manner nearly all forms of beetles are strong enough to escape from the ants when caught, and their external covering is so hard that the ants can make no impression upon it; but an injured beetle of any kind is very quickly overcome by the numbers of the ants, and his body is finally cleaned out of the shell piecemeal. Newly emerged adult beetles of many species are often captured by the ants before their chitinous integument has hardened, and they are then an easy prey.

Cutworms and hairless caterpillars found upon the surface of the ground are destroyed in great numbers; but the ants will not burrow into the ground after hidden cutworms, and most hairy caterpillars appear to be invulnerable to them. Web-spinning caterpillars are also safe from their attacks, and the spiny, mealy projections surrounding coccinellid or ladybeetle larvæ appear to protect these latter very effectively. Insects and other small related animals which the ants can meet upon even terms are, however, almost always overcome; not so much on account of the individual valor of the Argentine ants as by reason of their overpowering numbers.

Nests of the social wasps, *Polistes* sp., which were brought into our laboratory as food supplies for cultures of Pediculoides, were quickly found by foraging workers, and the latter soon killed and removed all of the wasp larvæ and pupæ that could be reached. Many of the cells in the comb of Polistes were entirely or partially open so that the ants had ready access to the insects inside. As the prey in this case was too large to be handled by individual ants, as many as two or three dozen would unite in removing a single wasp pupa or larva. Even the adult wasps, just emerging from the cells, were set upon by the ants before they had attained sufficient strength to escape by flight. More and more of the ants would get on these adult wasps until the latter were helpless and were dragged away, still alive, by scores of the worker ants. So anxious were the ants to get at these wasps that when the latter were placed on top of a fruit jar standing in a tray of water the ants swam the 3 inches of fresh water, climbed the glass sides of the jar, and continued their attacks as before; nor could they be made to desist until oil of sassafras was placed upon the water.

The nests of mud-dauber wasps, *Pelopœus* sp., were also brought into the laboratory for the same use as the Polistes. The mud-dauber larvæ were of course inaccessible to the ants, but parasitic flies [1] which emerged from these were seized by the ants as fast as

[1] Identified by Mr. C. H. Tyler Townsend as a species of Pachyophthalmus.

they emerged and were summarily disposed of in the same manner as were the Polistes. Invariably the flies were seized before enough time had elapsed for their wings to expand and dry, and only a very small percentage of them escaped the ants.

Cockroaches are esteemed a great delicacy by these ants, and while the workers are not able to capture uninjured roaches, they attack in great numbers any roach so unlucky as to be injured. Dead cockroaches are also eagerly visited by the ants and all soft parts removed. It seems almost retribution that one of the few natural enemies of the Argentine ant should itself be a larval cockroach (*Thyrsocera cincta* Burm.), mention of which is made on a following page.

THE ARGENTINE ANT AND THE BOLL WEEVIL.

Prior to the advent of the boll weevil in the territory infested by the Argentine ant there was considerable speculation as to whether so combative an ant might not prove to be an insect of some value in protecting the cotton crop against weevil ravages. Any hopes of this kind which were entertained have not thus far been realized. In one rather unimportant respect the ants seem to annoy the boll weevils. At Baton Rouge the Louisiana Experiment Station had a few small plats of cotton, aggregating less than an acre, within the city limits and in a section where the Argentine ants were exceedingly abundant. The plats were bordered on one side by the Louisiana State University campus, with its large oak trees sheltering hundreds of ant colonies, and on the other side by the batture of the Mississippi River, which was likewise a seething mass of ant colonies. The ground in the cotton plats was therefore heavily infested by the ants, and when this field also became infested by the boll weevil the outcome was watched with considerable interest. During September, 1909, it was found that the ants, in their steady patrol of the plants while attending cotton lice, worried the adult boll weevils considerably. Whenever an ant encountered a boll weevil it would nip the legs of the latter, usually causing the weevil to fly to another plant or drop to the ground. In no case were the ants found killing fully matured weevils, though in a few instances they did attack and kill unhardened weevils which had just issued from infested squares. The great abundance of ants in these plats evidently resulted in many of the weevils being driven off, for something of a top crop was produced in the fall of 1909. It is worthy of note in this connection that the heavy ant infestation obtaining in these plats will not be duplicated in large cotton fields for many years to come, if, indeed, such will ever be the case. Conditions in large cotton areas are not such as to attract the Argentine ant in numbers. It was also of interest to note that the presence of the ants in these particular plats resulted in an abnormally heavy infestation of the plants by the "cotton louse," *Aphis gossypii* Glov., throughout the entire growing season.

Were the jaws of the Argentine ant powerful enough to pierce the cotton squares so that they could remove the boll-weevil larvæ, and were they so inclined, they might be of substantial service in destroying this pest. However, repeated experiments made by the senior author proved conclusively that the ants would not do this. The following experiment will serve as an illustration of those carried out:

On July 10, 1908, three weevil-infested squares were placed on the food table of an Argentine-ant colony in the insectary at Baton Rouge. The workers crawled over them constantly for three hours, but made no attempt to bite into them and evidently did not suspect the presence of food inside of them. Afterwards the weevil larvæ were removed from the squares and placed, alive and uninjured, on the food table. The ants attacked them, hesitatingly at first and then with avidity, and in the course of a minute one large weevil larva was dragged an inch across the food table, vertically another inch, and into the vestibule of the nest. Another lot of weevil-infested squares was placed on a board inside the insectary where the ants had been securing other food for several days. The squares were left here for five hours, during which time the ants crawled over them constantly, but made no effort to open them. The ends of the squares were then broken off so that the ants could enter them if they chose. None entered. Presently some of the weevil larvæ wriggled themselves completely out of the squares and they were then attacked by the ants and dragged away.

These and similar experiments lead one to the conclusion that the Argentine ant will never be of material value as an enemy of the boll weevil. In fact, in this respect it can not hope to approach in efficiency the common native fire ant, *Solenopsis geminata* Fab.

BENEFICIAL ASPECTS OF THE ANT'S ACTIVITIES.

In some few cases the predatory habits of the ant take on a beneficial aspect. In the summer of 1908 Mr. R. C. Treherne was associated with us in the investigation of the sorghum midge (*Diplosis*) *Contarinia sorghicola* Coq. In the course of his work Mr. Treherne placed heads of sorghum, milo maize, etc., in cages for the purpose of rearing the adult midges. In a very short time he found that the Argentine ants were invading the cages and were carrying away the adult midges almost as fast as they emerged. (See fig. 10, from drawing by Mr. Treherne.) To continue the observations it was necessary to isolate the cages over trays of water or oil. For the purpose of more closely observing the capture of the midges by the ants, about 200 of the former were placed inside a large glass bell jar. The jar was raised a trifle at its lower edge by the insertion of a match. In the course of three minutes two Argentine workers had found their way into the jar and each had captured an adult midge. Other workers soon followed. In about 15 minutes fully three-fourths of the flies had been captured and at the end of 30 minutes all had been either captured and carried away or were in possession of workers. The first midges captured were quickly carried to the ants' nest, but presently the workers seemed less appreciative of their prizes and spent much more time in playing with them, although in but few cases were the midges relinquished. Occasionally a midge would succeed in taking flight after a worker had taken hold of it; in such cases worker and midge tumbled to the floor, but without the midge being released. That the workers were unable to see the midges was made evident many times over in this experiment, for workers repeatedly passed within one-sixteenth of an inch of their prey without even changing the direction of travel. Only when the worker touched the midge with her antennæ could she locate the latter.

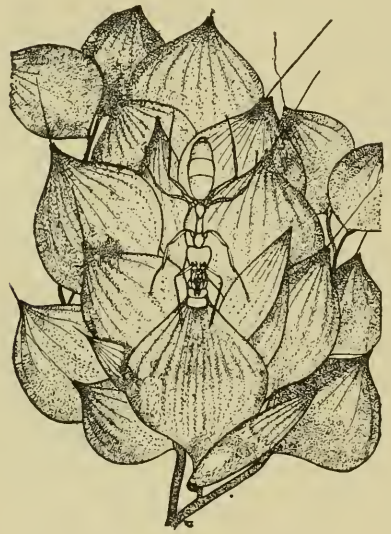


Fig. 10.—Argentine ant removing the pupa of a sorghum midge from between the glumes of a sorghum head. (Original.)

Later on it was found that the ants thoroughly patrolled the sorghum heads in the field and not only captured the midges as they were emerging from their pupal cases between the glumes but also removed the pupæ themselves. That this ant is by far the most important natural enemy of the sorghum midge in southern Louisiana there can be no doubt,[1] but its services in this regard do not begin to expiate its many other crimes.

The Argentine ant is a persistent enemy of the white ants, or termites, and will capture and kill them at every opportunity. Especially during the mating season of the termites every male and queen that falls to earth is quickly set upon by the ants. The latter cut off their wings, and frequently also legs and antennæ, and then bear them away, still alive, to their nests. Wherever colonies of termites are accidentally exposed the ants soon destroy them, carrying away all stages. Not infrequently one finds the Argentine ant colonies domiciled in the old termite galleries in logs and timbers, the assumption being that the ants had first destroyed the termite colonies and then taken possession of their domiciles. When winged termites were

[1] Dean, Harper, Bul. 85, Part IV, rev., Bur. Ent., U. S. Dept. Agr., p. 57, 1911.

furnished to the ants in our artificial formicaries the wings were quickly amputated, although the termite itself was not always carried into the formicary, possibly because, in such cases, the ants were already bountifully supplied with animal food.

The Rev. Albert Biever, of New Orleans, whose observations on the Argentine ant are elsewhere mentioned, is authority for the statement that these ants have in many cases entirely exterminated the bedbugs in the houses of many of the poorer people in New Orleans.

Father Biever also states that in some sections of the city the "red bug," or chigger, has entirely disappeared with the advent of the ants. The junior author's observations in Audubon Park, New Orleans, are of similar nature, the chiggers being entirely absent where once they were a plague. At the same time the senior author still retains some very unpleasant memories of daily attacks by chiggers on premises in Baton Rouge which were heavily infested by the ants. We are thus unable, as yet, to state with certainty that the ants always destroy these annoying pests.

The attitude of the Argentine ant toward other species of ants has already been discussed and its action in destroying other ants takes on either a beneficial or injurious aspect according to whether the annihilated ant is itself one of beneficial or injurious nature.

SYMBIOTIC RELATIONS.

The relationships which exist between the Argentine ant and those insects or other creatures which it tolerates in its nests or in the near vicinity can not be considered as symbiosis, yet mention of these may be permissible at this point. Despite the hostility which these ants exhibit toward most insects which are not directly of service to them, a few instances have been noted in which other insects and crustaceans were permitted to live in close proximity to their nests, or even within the nests themselves.

Certain staphylinid beetles have frequently been found in decayed logs which were full of Argentine ants. Efforts have been made to keep some of these beetles in the artificial formicaries along with colonies of the ant under observation, but the results have been variable. In experiments of this kind made by the junior author the beetles were invariably set upon by the ants in the formicary and either killed or driven out. In similar experiments by the senior author no apparent attention was paid to the beetles, so far as could be observed, and they were tolerated in the formicary for a week or longer, after which they evidently left of their own accord.

On August 17, 1909, a large ant nest was discovered in Baton Rouge under a large dry-goods box. About 20 specimens of "spittle insects" (family Cercopidæ) were also present in the same nest, attached to straws of grass. These were apparently protected from the ants by the wet, sticky secretion which surrounded them. This is the only instance, however, in which the presence of these insects has been recorded in the colonies.

Sowbugs (Oniscidæ) apparently go among the Argentine ants with impunity. These little crustaceans are often found in the ant nest, especially if they are located under boards or boxes in moist places. There does not appear to be any relationship existing, and the ants are apparently indifferent to their presence.

With the exception of two species of mites, which are true inquilines in the ant colonies, the Argentine ant does not pay much attention to the majority of mites and spiders. Mention is made on a later page of certain spiders which prey upon the ants to a limited extent. The cattle tick (*Margaropus annulatus* Say) flourishes with undiminished vigor in the ant-infested region, and the same may be said of the "red mite" of the orange and the red spider of ornamental plants (*Tetranychus bimaculatus* Harv.).

INQUILINES.

Only two true inquilines, both mites, have thus far been found in the colonies of the Argentine ant. These were first discovered at Baton Rouge by the senior author in 1908, and were subsequently found in various localities and in nests of various kinds, usually in those located in masses of decaying vegetation or litter. Soon after they were first found specimens were sent to Dr. L. O. Howard, who submitted them to Mr. Nathan Banks, of the Bureau of Entomology. Mr. Banks found them to be new, and his descriptions of them were published in the Journal of Economic Entomology, volume 1, pages 263 and 264 (1908), together with notes on their habits, by the senior author.

NATURAL CONTROL.

As compared with most injurious insects which reach great abundance the Argentine ant is remarkably free from natural enemies, and very few of these have been noted during the course of our investigations, while even these few are of little importance. No true parasites of this ant have been observed, and apparently the only enemies are predatory ones.

NATURAL ENEMIES.

INSECTS AND SPIDERS.

In 1909 Mr. Harper Dean observed a small cockroach capturing Argentine ant workers in a room in Baton Rouge, La. This insect from time to time caught up and ate workers which were traveling about the floor. The cockroach was captured and sent to the Bureau of Entomology, where it was identified by Mr. A. N. Caudell as a nymph of *Thyrsocera cincta* Burm., a species occurring in the southern United States, Mexico, and Central America. A similar habit by individuals of this species was subsequently observed by the senior author on one or two occasions, but the number of ants destroyed by this insect is certainly inappreciable.

A jumping spider of the family Attidæ was seen to capture a few workers, and various species of the cobweb weavers (Theridiidæ) had the habit of reposing beneath the stands supporting our artificial formicaries and there depleting the colonies under observation. In fact, so persistent were they that it was necessary to examine the stands daily and destroy these spiders. Among the most abundant of these was one which was identified by the late Prof. B. H. Guilbeau, of the Louisiana State University, as *Theridium tepidariorum*. Spiders of this family were not observed destroying ants in outdoor colonies, but it is possible that they do so.

BIRDS.

On one occasion Mr. G. A. Runner observed an English sparrow industriously picking up the Argentine workers from a trail which crossed a wide roadway at Baton Rouge. This habit is not, however, a common one with this bird.

The flicker or yellowhammer, *Colaptes auratus*, has often been seen industriously digging up shallow ant nests in lawns and grass plats, evidently for the purpose of obtaining the pupæ and larvæ, and should doubtless be credited with being the most important natural enemy which this ant has in the South. Our knowledge of the extent to which native birds subsist upon these ants is very limited as yet, and the subject is one well worth more complete investigation than we have been able to give it.

EXPERIMENTS WITH PEDICULOIDES.

The idea of finding some parasite which would destroy the ants naturally suggested itself early in our investigations. Owing to the readiness with which the small parasitic mite, *Pediculoides ventricosus* Newp., parasitizes the larvæ of wasps and beetles whenever it can obtain access to them it was thought worth while to see if this parasite could be successfully used against the ant. For our experiments we first reared enormous colonies of these mites on living wasp larvæ and thereafter placed these infested larvæ in the formicaries, where they could be closely observed. The following experiment will illustrate the results obtained:

For the experiment we selected a large populous ant colony which was domiciled in a plaster of Paris Janet cage of several chambers.

All immature stages of the ant were present in abundance. On March 14 the cover to one of the living chambers was raised and one of the mite-infested larvæ was dropped in among the workers and larvæ in the formicary. The workers set to work immediately to kill the hundreds of mites. The larval mites were picked up in the workers' mandibles, chewed a bit and then thrown aside. Adult mites were seized by the legs and vigorously pulled until they released their hold on the wasp larvæ, after which the workers would crush them in their mandibles. However, the subsequent developments were entirely unexpected. A worker was seen to mount the wasp larva, eagerly destroying mites and becoming at the same time covered with a dozen or more of the mite larvæ. Within a minute the worker desisted from destruction of the mites about her and turned her attention to the ones on her body, trying to dislodge them by rubbing head and abdomen with her legs. Failing thus to get rid of them, she resorted to various gymnastic performances, such as jumping and rolling over. Soon afterwards her movements became slow and feeble and finally ceased entirely, it being evident that she had either been killed or paralyzed by the bites of the larval mites. Observations were suspended until March 18, when it was found that the adults and larvæ of Pediculoides were greatly reduced in numbers. No mites could be seen on any of the ant larvæ or pupæ, and all of the latter had been removed from the chamber where the mites were introduced.

The workers in leaving the cage to forage were compelled to pass through the infested chamber, but in doing so they made the widest possible detour about the mite-infested material. This status of affairs continued for some time, the mites gradually decreasing in numbers until by April 28 they had all disappeared. On this date cultures of the mite were again introduced into the colony, but in much greater quantities than before. A spoonful of mite-infested wasp larvæ was placed in each chamber of the formicary. The ants did not this time attempt to kill the mites, but inside of two minutes after the introduction of the latter the colony had completely deserted the formicary, taking with it all eggs, larvæ, and pupæ. Not being able to find other suitable quarters on account of the water surrounding the formicary, the ants on the following day decided to return to the nest. They attempted to remove the Pediculoides, but the mortality among the workers was heavy, many being carried out at the entrance. On the following day the number of dead workers was too great for removal, and many of them remained in the cage. The continual warfare against the mites continued for several days, the ant colony becoming by May 6 severely depleted in workers as well as in larvæ, some of which were killed by the mites. At the same time it was evident that the Pediculoides were being destroyed much more rapidly than they could increase. After May 6 the ant colony appeared to recover slowly. By July 22 the colony had completely resumed its normal condition and the mites had been exterminated.

That the Pediculoides could live and breed upon the ant larvæ was established by placing the latter in a glass dish which was isolated from all workers and permitting them to become infested. On them the Pediculoides grew and increased as well, apparently, as on wasp and other larvæ. Such enormous cultures of the mite as were introduced into the ant colonies in these experiments could not possibly occur in nature, and it seems a safe conclusion that this parasite can make no headway against the ant under normal conditions.

EXPERIMENTS WITH FUNGOUS DISEASES.

During 1909, at Baton Rouge, several experiments were made in the attempt to inoculate the ants and their larvæ with the chinch-bug fungus, *Sporotrichum globuliferum*. Cultures were prepared from beef extract and corn meal, sterilized at a pressure of 18 pounds per square inch for 30 minutes at a temperature of 256° F., and these were then inoculated with the fungus from a dead beetle. After these cultures had been stored for about a week in a dark, damp place, they all showed a heavy white layer of fungous growth over the surface, and this layer was used in the experiments.

Large quantities of this fungus were placed in Janet cages which contained strong and healthy colonies of ants with many immature stages. For a short time the workers would busy themselves carrying out the fungus and dropping it over the side of the cage support, but after a time they apparently became accustomed to its presence. It grew and increased inside the apartments in which the ants and their young stages were domiciled until it formed a heavy white mass over nearly everything, but in not a single instance was an ant or a young stage observed which appeared to be in the least inconvenienced by it.

As a number of dead ants were found covered with fungi the various organisms on them were isolated and cultures made. The principal fungi obtained were Aspergillus and Penicillium. Cultures of these were also introduced into the ant colonies, but without effect. It was therefore concluded that they were purely saprophytic on the dead ants on which they were found.

Attempts were also made to infect colonies with *Bacillus larvæ*, the germ causing the disease among honey bees known as American foul brood. Owing to the fact that this bacillus attacks the larval stages of the honey bee, and considering the similarity of ant and bee larvæ, it was thought that this disease might attack the larval stages of the ant. The experiments were made in a locality where the ant infestation was very heavy but where honey bees were not kept. Honey was thoroughly mixed with broken and mashed brood combs containing bee larvæ badly infected with foul brood, and this honey was then fed in abundance to foraging workers. Subsequent examination of the colonies receiving this infected material failed to show any indication of the disease.

No attempt was made to experiment with this disease under laboratory conditions, on account of the danger of accidentally infecting honey bees in the neighborhood.

LOW TEMPERATURES.

The winter temperatures experienced at Baton Rouge, La., seemed not to produce any appreciable mortality among the ants. During the winter of 1909–10 a colony at Baton Rouge was kept out of doors all winter with no other protection than the plaster of Paris walls of the cage in which it was confined. This colony successfully withstood a temperature of 22° F., the lowest temperature recorded during the winter. It is safe to assume that in their underground nests and in well-protected situations they can withstand a much lower degree of cold than this.

FLOODS.

Heavy rains appear to be the only meteorological phenomena which produce any appreciable effect upon the Argentine ants, but even in this connection it is worthy of note that the most heavily infested sections at present are within regions of exceedingly heavy annual rainfall.

After sudden severe rainstorms it was noticed that the ditches and drains at Baton Rouge and New Orleans contained thousands of the dead ants, evidently washed from trees and ground before they could reach a place of safety. The sudden rising of flood waters over lowlands would appear to destroy many colonies and the larvæ in them, yet, strange to say, the batture along the Mississippi River, which is annually covered for several weeks with several feet of water, continues to be an area of approximately maximum infestation. So facile are the ants in migrating to higher grounds or in ascending trees, taking with them all larvæ and pupæ, that it is likely that the mortality from this source is much less than would be expected. The mere destruction of foraging workers by rains does not effect any appreciable diminution in the rate of increase since, if the colonies themselves remain unharmed, the deposition of eggs and the rearing of more workers continues unabated.

METHODS OF REPRESSION.

It is as a household pest that the Argentine ant has forced itself most into prominence, particularly in the infested cities and towns, although it is doubtful if the financial loss due to its inroads in this respect even begins to compare with the losses suffered by the florists, bee keepers, and orange growers. Early in the course of our studies we undertook experiments looking to the development of measures by which householders could obtain some relief from this pest.

A successful campaign against the Argentine ant is by no means devoid of work, but the control measures thus far devised are no more cumbersome or expensive than those employed in the warfare against many other insects, and their intelligent employment is found well worth the while in reduced annoyance from this pest.

Studies of the ant's life history early developed the fact that permanent relief can be obtained only by actual destruction of the ants themselves. The use of repellents only serves to permit the continued increase of the pests and to postpone the time when more laborious methods of warfare must be adopted. Not only is it necessary to kill the ants outright, but it is also necessary to adopt means which will kill the queens. It is hardly necessary to call attention to the difference between killing ants and the usual insects with which we have to contend. If one kills a female gipsy moth or boll weevil, for example, possible future progeny of that particular individual is made impossible. Such is not the case when one destroys a worker ant, for the rate of increase and the development of future generations are in no way interfered with. This is true for the reason that the workers take no part in reproduction, all eggs being deposited by the queens. That the destruction of foraging workers does not materially affect the domestic economy of the colony or retard the rate of increase by reducing the available food supply is shown by repeated observations upon the number of foragers required to keep the colony supplied with food. In the artificial formicaries counts were made of the number of workers going out for food during periods varying from five hours to several days, and in no case did the number of foraging workers out at one time exceed more than 1 per cent of the number of individuals in the colony. From this we naturally conclude that less than 1 per cent of the workers can keep the remainder, including the queens and immature stages, supplied with food. These observations were made in cases where the food supply was only a few inches from the nest and was always in abundance. In times of food scarcity, and when it is necessary for the workers to travel considerable distances in order to reach a food supply, a larger percentage would have to engage in foraging. Observations by the junior author upon a large number of field colonies leads him to the conclusion that even under the most adverse conditions not more than 10 per cent of the workers are required for foraging. Under normal outdoor conditions the food supply is abundant and at such times it is very doubtful whether more than 2 per cent of the workers are ever engaged in foraging at any one time. The futility of destroying the foraging workers is therefore self-evident, for the number of workers leaving a colony during any given period is little if any greater than the number reaching maturity within the colony during the same period.

In spite of these facts repellents are very desirable and their use is, under most conditions, absolutely imperative in the protection of foodstuffs, such as sugars, candies, cakes, molasses, honey, vegetable oils, fresh meats, etc.

EXPERIMENTS WITH REPELLENTS.

Our first experiments consisted in testing the various substances which had been used in successfully repelling other species of ants.

Experience with artificial formicaries and with the hives of honey bees very quickly showed that water would deter the workers for only a short time. In our first experiments with colonies kept under observation the nests were placed on platforms supported above trays of water. As soon as the water had stood for a few hours minute dust particles, settling from the air, formed a very thin, almost imperceptible scum on it, and this the workers traversed with ease. A scum which, when viewed by reflected light, is barely perceptible to the eye will support the workers. When such standing water was removed and fresh substituted for it the ants would plunge into it as before, evidently expecting the scum to be there still. Instead of drowning, as might be expected, the workers merely swam, or crawled upon the bottom of the tray until they reached the edge or the wooden support of the nest, when they proceeded to crawl out. Workers thrown into water can readily crawl up one's finger or up a stick if it is brought near them. The senior author has observed workers which had accidentally fallen into a glass decanter three-fourths full of water gain a foothold on the smooth glass sides and crawl out successfully, feet up and body down, on the wet glass. The workers will apparently not enter fresh water voluntarily, but evidence indicates that they will sometimes do so in the attempt to reach their nests or to reach some much-desired food supply. When running over a film of oil or dust upon the water the feet and legs do not get wet, but when the film breaks through, as sometimes happens, the worker swims with her legs and a portion of the body submerged. Running water, such as a stream in a ditch or trough, seems to be a successful repellent, but the practical uses of such a stream are very limited. The use of running water as barriers to prevent the spread of infestation in orange groves is more fully described upon a subsequent page.

Sir John Lubbock in his book, "Ants, Bees and Wasps," describes bands of fur which kept the ants within his artificial formicaries. The kind of fur used by Sir John Lubbock is not specified, but the finest we were able to secure was that from an ordinary "cottontail" rabbit. With this the following experiment was made:

Two devices were prepared, each consisting of a small wooden box nailed to the top of a rounded 2-inch stake about 2 feet in length. Around the support (stake) of one box a roll of the fur was tightly placed, arranged so that the hairs projected downward and so that the ants would have to crawl "against" them in going up the stake. Fur was not placed upon the other device. The latter was stuck in the ground and a supply of honey placed in the box. The ants visited the honey at once and as fast as they removed it the supply was renewed. This continued for several days, when this device was removed and the one with the fur was put in its place, also with honey in the box. The interruption of the "trail" confused the ants for a little, but within a minute's time they were going up the new device and working their way persistently among the hairs of the fur. In a short time they were able to get through it, when they continued to the food supply at the top and removed it as before. The workers were forced to make their way slowly through the fur, wrestling in turn with the hairs in their way, but at most the fur did no more than delay them a little; it did not repel them in the least.

Various experiments were made with certain proprietary and coal-tar disinfectants for protecting food supplies from the ants. Woodwork rubbed or painted with these substances was not crossed by the workers during periods of from 2 to 48 hours after the applications, but none of these substances was effective for more than two days. Oil of citronella seemed more distasteful to the ants and they would not cross woodwork treated with it as long as the odor remained. Evaporation of this oil is, however, quite rapid.

The use of zenoleum powder was found quite effective. Sprinkled heavily on the floors of infested houses it killed many of the workers with which it came in contact and answered fairly well for breaking up trails and causing the workers to seek food elsewhere. It was also found of some service in keeping ants out of the nests of sitting hens.

Pine tar was not effective. In an attempt to feed honey to bees in the open air the feeder was supported on a stick around which were placed two separate bands of fresh pine tar. The feeder was placed out in the afternoon and by 6 o'clock the next morning the ants had crossed both bands of tar and the honey was black with them. To stop them, two fresh bands of tar were applied. Within 30 minutes the ants which were trying to get out of the feeder had forced their way into the tar in sufficient numbers to form a bridge and over this the ants were soon passing freely to and fro, despite the strong odor of the tar itself.

The following experiment proved the inefficiency of tobacco dust: In the middle of a large iron pan with flat bottom was placed a dish of honey. This dish was surrounded by a layer of tobacco dust from

1 to 2 inches wide and thick enough to obscure entirely the bottom of the pan. This arrangement was made at 2 p. m., and by 5 p. m. the ants were crossing the tobacco dust and getting the honey with as much facility as they would have crossed an equal amount of soft dirt. The experiment was repeated, finely powdered sulphur being substituted for the tobacco. The sulphur was not crossed so quickly as the tobacco dust, but within 24 hours the ants were crossing it freely. On one occasion the senior author planted a small lettuce bed, and thinking to protect the seeds until they germinated, he spread over the surface of the bed a layer of tobacco dust covered in turn by a layer of powdered sulphur. The ants got the seeds.

Tree tanglefoot, when placed about the trunks of trees up which the ants were traveling, checked them for periods varying from a few hours to three or four days. However, a more dilute form of this material, used with much success in the gipsy moth work in Massachusetts by Mr. D. M. Rogers, has recently been tested by the junior author with the result that in one case it kept the ants off the trees for as much as two weeks without being renewed. There is therefore a possibility that this special form of tanglefoot may have a use in the protection of trees.

Kerosene acts as a repellent until the odor has largely disappeared, but a film of kerosene on water only affords a good floor for the ants to travel on.

Various devices in the form of inverted troughs of tin or other smooth surfaces have been tried without success.

Crude petroleum, of all the liquids tested, has proved to be the most effective repellent. When placed in dishes supporting the legs of tables, benches, etc., it will continue to repel the ants even after a great amount of dust and trash has accumulated in it. Its use indoors, owing to its oily nature and disagreeable odor, is of course impracticable. Out of doors it is useful for giving temporary protection to such food materials as sugars, molasses, honey, etc.

CORROSIVE SUBLIMATE AND "ANT TAPES."

The only repellent found to possess any merit (aside from sweetened arsenical solutions, described below) was dry corrosive sublimate. Woodwork or cloth which has been treated with a saturated water solution of corrosive sublimate and allowed to dry will not be crossed by the ants while any of the sublimate remains. This fact is utilized in a practical way by soaking ordinary cotton tape about 1 inch wide in the corrosive sublimate solution, wringing it out, and then drying it. When this "ant tape" is fastened around the legs of tables, edges of shelves, etc., the ants will not cross it for many months, provided only that it is not allowed to get wet. The explanation of this remarkable action of the sublimate may be found in the extremely irritating effect which it has on tender membranes and surfaces. The finely powdered sublimate and the minute crystals when inhaled cause a severe irritation of the throat and nostrils, giving rise to sneezing and nasal discharges. The continued or careless handling of freshly made ant tape will often have the same effect. It seems not improbable that the sublimate particles may have something of an irritating effect upon the sensory organs of the ants. The ants are quick to detect and avoid corrosive sublimate even when it is in solution and mixed with other substances. All attempts to poison them with this substance have been ineffectual, for they can not be induced to partake of their most favorite foods when the latter contain the poison in as weak a proportion as 1 to 500.

In some of the tests made by the senior author the corrosive sublimate tape has been found to retain its efficiency for over 11 months in rooms where, except when the temperature was too low for insect activity, workers could be seen at all hours of the day and night.

Our method of preparing the tape is first to heat corrosive sublimate and water in a *porcelain* or *granite-ware* vessel until the maximum amount is dissolved. This solution is allowed to cool to ordinary temperatures, filtered, and ordinary cotton or binding tape is soaked in it for several hours. The tape is then removed and pinned upon a wall to dry, after which it is ready for use. It is very important that no iron, tin, or steel come in contact with the solution, or with the tape itself after being prepared. The tape is effective for only a short time when used on metal surfaces. The extremely poisonous nature of corrosive sublimate must be continually kept in mind, both in the preparation of the solutions and tape and in the use of the tape itself. With this tape it is a comparatively easy matter so to isolate dining tables, kitchen cabinets, refrigerators, etc., as to protect all food supplies in the ordinary residence. The same method is constantly used by confectioners in infested sections for the protection of their candy cases and supplies.

EXPERIMENTS WITH FUMIGANTS AND CONTACT INSECTICIDES.

Following the announcement by Mr. R. S. Woglum,[1] of the Bureau of Entomology, in September, 1908, that he had succeeded in destroying colonies of other ants with a solution of potassium cyanid, considerable interest was aroused in the question as to whether the same method could be used with success against the Argentine ant. The senior author conducted a number of experiments at Baton Rouge to determine this point, among which the following illustrates the results obtained:

[1] Los Angeles Times, Los Angeles, Cal., Sept. 20, 1908.

A solution of potassium cyanid was made at the strength of 1 ounce of 98 per cent cyanid to 1 gallon of water. The site selected for the experiment was the area surrounding a few small cotton plants which were heavily infested with the cotton louse, *Aphis gossypii* Glov. Around the plants the earth was literally honeycombed by numerous small colonies of the Argentine ant, the workers of which were in constant attendance upon the aphides. The experiment was made at 11 a. m. on a bright day, with the temperature at about 77° F., when the workers were busily visiting the lice and foraging elsewhere for food and when the activities of the colonies were at about a maximum. The solution was sprayed onto the trails of traveling ants and the ground itself was sprayed until thoroughly wet with the solution. By the time the spraying was completed the odor of the cyanid was so strong as to affect the operator. In spite of this the solution did not immediately kill the workers with which it came in contact, but they appeared to succumb within about five minutes after the spraying. Five hours after the spraying the odor of cyanid was still very strong and the number of dead workers on the surface of the ground fully equaled, or exceeded, the number of living ones in sight at the time of spraying. Many live workers were busily engaged in carrying away the dead. The ground was examined and thousands of living ants in all stages—workers, pupæ, larvæ, and eggs—were found less than half an inch below the surface. Two days later the area was again examined and the ant colonies were apparently as populous as ever. This and other experiments seemed to demonstrate the impracticability of using this solution for destruction of the colonies, particularly as the earth would have to be treated with a sufficient amount of the solution to saturate it thoroughly to a depth of several inches. This would probably destroy all vegetation, would be expensive, and would involve the risk of injury to or loss of life by the operator and others. For species constructing compact nests having single or few openings the solution is doubtless effective but, owing to the multitudinous openings and galleries of the Argentine ant nest, destruction could be accomplished only by the use of enormous quantities of the solution.

The resistance of this species to hydrocyanic-acid gas was well illustrated in experiments made in attempting to fumigate the winter trap-boxes in orange groves. These trap-boxes are described more in detail on pages 95–96. They were about 2 feet wide, 2 feet high, and 3 feet long, made of rough lumber and filled with decaying cottonseed and hay. During the winter months these boxes contained enormous colonies. For fumigating them to destroy these colonies galvanized-iron covers were made (see Plate XII) which would fit over them easily. A 6-inch hole was made in the top of each cover-box for the introduction of the chemicals used in fumigating. Just beneath this opening, which could be closed practically air-tight, was placed the usual earthenware crock for holding sulphuric acid and water. Experimental fumigation of these boxes was commenced with a charge of ¼ ounce of 98 per cent potassium cyanid and the requisite amounts of water and sulphuric acid. This strength was found not to kill any ants in the box except those which were actually outside the packing at the time of fumigation. Gradually this charge was increased until as much as 4 ounces of cyanid were used at a time in the inclosed space of 22 cubic feet. Even at this strength, which corresponded to 18 ounces of cyanid per 100 cubic feet, ants more than 8 inches from the outside of the box were not affected by a confinement of four hours. In later experiments an iron rod was used to make holes all through the contents of the box and the same charge used as before, 18 ounces of cyanid per 100 cubic feet. After the gas had been confined for five hours the boxes were examined and it was found that only those within a couple of inches of the perforations were killed. Larger charges could not be used, simply because the cover-box would not contain a generator of sufficient capacity. Even had a charge heavy enough for effective results been found its cost would have been prohibitive in practical field work.

Experiments were accordingly undertaken with bisulphid of carbon for destruction of the ants in the boxes. Holes were made to the very bottom of the contents, bisulphid poured into these, and the metal cover placed over the box, its lower edges afterwards being mounded up with dirt. One-half pound of bisulphid, used in this manner and confined by the metal cover-box for five hours, destroyed all ants, and all stages, in the boxes. Mention is made of the use of this fumigant on page 96.

Other experiments made with the bisulphid of carbon showed it to be the most available fumigant for the destruction of colonies in accessible situations.

When colonies are so situated that they can be fumigated with bisulphid nothing is more effective for their destruction, but the difficulty of applying this measure lies in the situation of colonies in all sorts of inaccessible places (see list of nesting places, p. 55) and to the fact that in heavily infested areas the galleries of one nest are practically continuous with those of others, affording many ants the opportunity of escaping from the fumes.

Such substances as hot water, kerosene, crude oil, etc., will, of course, destroy the ants sprayed with them and often it is quite practicable to use these substances for the destruction of colonies that are discovered by turning over boards, pieces of wood, piles of trash, etc.

Many preparations have been sold throughout the infested sections for the purpose of destroying the ants. In nearly all cases these have been merely fluids which would kill the ants when coming in contact with them and the directions have stipulated that the ants should be sprayed with the solutions when on their foraging trails. In view of the foregoing statements relative to the small proportion of workers foraging at any one time it is not at all remarkable that such preparations have always yielded nothing but disappointment, even though enormous numbers of foraging workers were destroyed by their use.

EXPERIMENTS WITH POISONS.

The use of poisons is generally the first measure suggested for the destruction of an injurious insect, and experiments along this line were begun by the senior author early in the course of his investigations. An appreciation of the salient features in the life history of the pest soon emphasized the futility of using a poison which would destroy the workers only. Any poison, to affect the rate of production or to exterminate the species, must be one which will destroy the fertile queens and the immature stages, all of which are located within the nest and are supplied with food by the workers.

No way could be devised by which poison could be administered to the queens and larvæ except by having the workers carry it to them from sources of supply outside the nest itself. The problem therefore resolved itself into the search for some poison which would be fatal, but which at the same time would act so slowly within the workers' stomachs that they could transport it to the colony and there feed it to the inmates before perishing themselves.

Some small measure of success attended our experiments in this line but, incidentally, another and much more valuable use for poisonous mixtures was discovered.

Arsenate of lead, containing but little arsenic in soluble form, naturally suggested itself as the most promising substance for the purpose. Accordingly it was tried in various experiments, of which the following will serve to illustrate the results obtained:

A mixture was made of 1 part pulverized sugar, 1 part paste arsenate of lead, and 2 parts of honey. The ants carried this away rapidly and on August 11 exhausted the entire amount that had been put out. The supply was renewed, but on August 12 it remained untouched. An examination of the nest was then made and it was found to be entirely deserted; the colony had moved away, taking with it all immature stages. That this action had been taken to get outside the sphere of danger from the poison there can be little doubt, for this colony had occupied the same spot for many weeks, despite the fact that it had been frequently dug open for examination and had been entirely submerged at times during hard rains. No dead ants were found in the empty nest; any such, if present, were taken away at or before the time of vacating the formicary. The ants will not tolerate dead within their living chambers, the cadavers always being removed expeditiously and often to a considerable distance. This makes it extremely difficult to tell, by examination of a colony in nature, how many of the individuals have been killed by any poison fed to the workers. The action of the colony in moving outside the zone of danger was observed in many subsequent experiments in which poisoned food was used, and this gave us the clue to the use of sweetened arsenical mixtures as *repellents* for driving the colonies away from infested situations. The same phenomenon, improperly understood, has been responsible for the conclusion, arrived at by several experimenters, that the use of such mixtures was actually exterminating the ants, their absence after use of the poison being ascribed to their death and not to their migration to a safer place.

That the mixtures containing lead arsenate, such as those just described, do destroy the individuals within the nest and that their continued consumption by the ants would result in extermination if the colony did not move away from them, were established by experiments made with colonies kept in artificial formicaries where migration from the poison was made impossible. In one such experiment a small amount of the mixture last described (1 part lead arsenate paste, 1 part pulverized sugar, and 2 parts honey) was kept constantly on the food table of a colony in the formicarium. On the same table, but a short distance from it, food not poisoned was also kept at all times. The workers from this colony therefore had their choice between poisoned and nonpoisoned food. A few workers died each day, the larvæ all succumbing a few days after inauguration of the experiment. At the end of about 20 days the colony seemed demoralized and discouraged, the queen ceased to lay, and the workers did not work with their accustomed activity. At the end of 44 days all individuals were dead, the queen having lived until near the end of the period.

Many solutions and mixtures containing white arsenic (arsenic trioxid) were tested in various ways and the one which gave by far the best results was made by combining one-fourth gram of arsenic trioxid with 20 grams of granulated sugar in 100 cc. of water.[1] When placed in a small dish anywhere within the foraging range of a colony this preparation would be greedily taken for a few hours, after which the ants would not touch it as long as it remained in the same position. When the dish was moved a few feet away or placed in another part

[1] To give warning of its dangerous nature it is well to add to this mixture sufficient confectioner's color paste to dye it a brilliant red or green. Fruit juices, as of raspberry or similar fruits, may be added to accomplish the same end.

of the same room and "rediscovered" by the workers they seemed not to recognize its dangerous nature and would take it as before. After a few experiences of this kind the colony would move away from the vicinity. Only in rare instances were these migrations actually witnessed, as they seemed usually to take place during the night. A solution containing more than one-fourth of 1 per cent of arsenic did not give as good results for, in such cases, many of the workers died while sipping up the poison or on their way to the colony. Thus the poisonous nature of the substance was more quickly detected by the ants and work on it was stopped proportionately sooner. In all cases the ants removed the dead and dying from along their trails and from the vicinity of the poisoned mixture.

A number of experiments were made to determine whether or not the ants could distinguish between poisoned and nonpoisoned foods, with the result that they evidently could not do so; this perhaps being the reason that they moved their colonies away from the vicinity. One of these experiments was as follows:

On July 9 a fruit jar containing honey was placed on the floor of a small shed, where the ants had been very abundant for weeks. By the following day all honey had been removed by the workers and more was placed in the jar. Between the 9th and the 12th the jar was replenished several times, the ants during this time carrying away more than a half pint of honey. At noon on July 12 a small glass vessel containing a mixture composed of one-half of 1 per cent of arsenic and 20 per cent of sugar was placed about 3 inches from the honey jar. The ants commenced taking this solution at once, and in the course of five minutes the vessel was black with them. At 4 p. m. on the same day they were still working with undiminished vigor on both the honey and the poisoned solution. At 8 a. m. on July 13 there were only about one-fourth as many ants visiting the jars as on the previous day. They were still working on both the honey and the solution and many dead ants lay about. At noon of the same day very few were visiting the vessels, but many were engaged in carrying away the dead bodies of their erstwhile sisters. A few were still taking the arsenic solution, but it was evident that the ants did not know which of the food supplies was destroying them. At 2 p. m. on July 14 only two workers were in the vicinity of the vessels and neither of these was feeding. On July 15 all ants, both alive and dead, were gone, and not a single worker could be found in the building. Plenty of the nonpoisoned honey still remained in the jar. On July 16 and 17, also, no ants were to be found in the shed, even though heavy rainstorms in the meantime drove them indoors in many other buildings and decreased their available outdoor food supply. This experiment and many others demonstrated not only the effect of the poison in driving the ants from the vicinity, but also that food supplies could be protected merely by having the poison near them. In practical work it was found that the placing of two or three saucers containing a little of the arsenical solution about a room or under tables bearing honey, meats, etc., would effectually rid the vicinity of ants in from one to three days' time, and, what was more to the point, the ants would not return in numbers so long as the dishes of poison were kept there.

CONTROL OF THE ANT IN RESIDENCES.

No one measure will afford satisfactory relief from this pest, and the householder who would find permanent immunity from attack must plan a warfare based upon an intelligent appreciation of the facts above set forth. Of utmost and primary importance is cleanliness. By this is meant not merely absence of dirt in the usual sense, but that precautions must be taken not to leave particles of food where the ants can have access to them. Even crumbs of bread or cake left on a kitchen floor will attract the pests. Above all else fruits, sweets, oils, and meats must be kept where the ants can not reach them. The more abundant the food supply the more abundant will the ants become, and it has been repeatedly observed that there are many more colonies in residences occupied by shiftless owners than in those occupied by careful housekeepers.

Foodstuffs can not be isolated from the ants except by the use of repellents such as have been described, particularly ant tape. This last should be placed around the legs of all tables, benches, etc., on which food supplies are kept, and the tables must not be allowed to touch the wall or other objects by means of which the ants can find access to them.

The corrosive sublimate tape is, of course, poisonous, and when there are children in the house precautions must be taken that they do not get hold of it. At the same time we have never known of a case of poisoning resulting from its use. It is wise, also, to wash the hands well with soap and warm water after handling the tape.

To assist in repelling the ants the sweetened arsenical mixture, described on page 85, containing one-fourth of 1 per cent of arsenic, should be placed in small dishes or saucers in pantries and beneath tables, refrigerators, etc.

Along with these repelling measures colonies of the ants should be destroyed at every opportunity. Hot water, kerosene, or crude oil can be used for destroying every colony that is accidentally exposed to view by the overturning of leaves, boxes, pieces of wood, etc. For this purpose we have found a small compressed-air sprayer, filled with kerosene or crude oil and kept in a handy place, very useful. Colonies nesting in the ground can be quickly destroyed by thrusting a sharp stick into the nest and pouring in a sufficient amount of carbon bisulphid or gasoline, afterwards closing the hole with damp earth.

On most city premises the ants can be further reduced by making use of winter trap nests or trap boxes, such as are described on pages 95–96 under the caption "Experiments with winter trap boxes."

Mention should not be omitted at this point of the steps advocated by the Rev. Albert Biever, of Loyola College, New Orleans, who, by his constant advocacy of warfare against this pest, did much to enlighten the people of New Orleans concerning it. Father Biever's plan was to place sponges moistened with sweetened water in locations visited by the ants, and when these were covered with the pests to dip them into boiling water. The sponges were then recharged and the process repeated as long as the ants would visit them. By this persistent destruction of the workers Father Biever expected so to deplete the colony that not enough workers would remain to care for the queens and larvæ and the latter would perish from starvation.

A most novel way of destroying these ants was described by Mr. Edwyn C. Reed, of the Museo de Concepcion, Concepcion, Chile, in a letter to the senior author. Mr. Reed says:

> The only sure cure would be to take Biblical measures and root up the city infested, stone by stone, and strew it with salt. As such a radical cure is not practical, we must be content with palliatives, and I find the following very effective: This ant is very fond of olive oil, and so, in sardine tins, saucers, etc., I put a little olive oil in its runs. The ants flock to the oil and in eating it get clogged up, so that for a spoonful of oil I get about that quantity of ants, dead and harmless. In practice this so weakens the nests that I get rid of them. Last November I moved into a house sadly infested by them and at once applied the oil. They came to it by thousands and stayed there. In a month's time I could appreciate the result, and by the end of our southern summer very few were to be seen.

CONTROL OF THE ANT IN APIARIES.

The keeping of bees is made well-nigh impossible in sections heavily infested by the Argentine ant. Single colonies of the ants often contain more individuals than a colony of bees, and in addition the colonies of ants are by far the most numerous. The Argentine ants are not only exceedingly fond of honey but they attack the bee larvæ in the cells with a ferocity that is amazing. Thousands upon thousands of the ants will enter the hive, carrying away honey and attacking the larvæ. The bees themselves are unable to cope with such small enemies. The ants are too small for them to sting, and were they even to attempt picking up the ants in their mandibles and carrying them out of the hive they could make no appreciable headway against the thousands of intruders. The bees adopt what is perhaps the best method of defense under the circumstances, that

BEEHIVE ON ANT-PROOF HIVE STAND, THE LATTER RESTING UPON A CONCRETE BLOCK. (ORIGINAL.)

of trying literally to kick out the invaders. A worker bee will run in among the ants and, whirling about, will give repeated vigorous kicks with her hind legs, throwing the ants in every direction, even to a distance of 10 or 12 inches. The ants are not, however, killed by this rough treatment, and they shortly return to the attack. In a few hours after the attack has commenced the bees become thoroughly disorganized and give up further defense, sometimes swarming out as a last resort. At such times the normal hum of the hive gives place to an entirely different note, which the experienced bee keeper at once recognizes as that of distress.

The difficulties of extracting and handling honey in the presence of these pests can be readily imagined. In order to extract we first scrubbed the floor of the building, using copious amounts of carbolic acid in the water. The foundations of the building and a space about a foot wide all around the building were then sprayed with crude oil. The extractor, as well as the uncapping can, was placed in a large iron tray containing several inches of water. When all these preparations were complete, the supers were taken from the hives, and as fast as brought in were stacked on tables the legs of which were wound with the corrosive sublimate ant tape. Extracting was done as expeditiously as possible, but with all our pains the ants were all over everything before we could extract and bottle three or four hundred pounds of honey. Even our clothing was teeming with the workers and all human effort was helpless to keep them out of the honey.

The number of apiaries destroyed by the ant in southern Louisiana has been considerable, and one of our first lines of experimental work was to devise some means of protecting the beehives from the foraging ants. Among the various schemes that were tried the following were found most efficient:

Placing the hive upon a stand having four legs and placing each of these legs in a tin cup containing crude petroleum served to deter the ants for a time, but rain water soon displaced the oil in the cups, and then with the first accumulation of dust on the water the ants found their way across it. This device also had the disadvantage of killing all bees which attempted to crawl up the legs of the stand.

Another device, somewhat more successful than the open cups, consisted of a stand the legs of which had at their tops inverted troughs of galvanized iron so arranged that rain water could not enter them, and so fixed that the ants would have to cross the troughs containing oil in order to reach the hive. Stands protected with this appliance successfully repelled all ants for about two months but, like the open cups of oil, resulted in the death of some bees.

As our previous experiments had shown the repellent power of ant tape, already described, it occurred to us that this might be used in the construction of an "ant-proof" hive stand. Accordingly a four-legged hive stand was made with top and sides extending some distance beyond the legs and downward, so as to prevent rain water from reaching the upper end of each leg. The top and sides were made thoroughly water-tight and the ant tape wound several times about the upper end of each leg. Below the tape, fitting snugly around the leg, was a piece of zinc about 6 inches square to prevent water from splashing upward from the ground during storms. One of these hive stands, turned on end to show the method of construction, is illustrated in figure 11, and the details of construction are further shown in figures 12 and 13. These figures are from drawings by Miss Ethel Hutson. The two front legs of the stand were made an inch shorter than the rear two to give proper drainage to the hive. In putting on the tape we wrapped about a yard of tape about each leg, placing corrosive sublimate between the layers. Made in this manner these stands by actual test repelled all ants for 11 months without any attention being required except to prevent grass and weeds from growing up and touching the hive and upper part of the stand. With corrosive sublimate between the layers of tape the latter is effective until it disintegrates or until it gets wet, and bees crawling up the legs pass the barrier of tape without injury or inconvenience. Our stands were made of tongue-and-groove lumber, which made them rather cumbersome, but there is no reason why such stands should not be made with top and sides of galvanized iron. This would make them light, durable, and cheap.

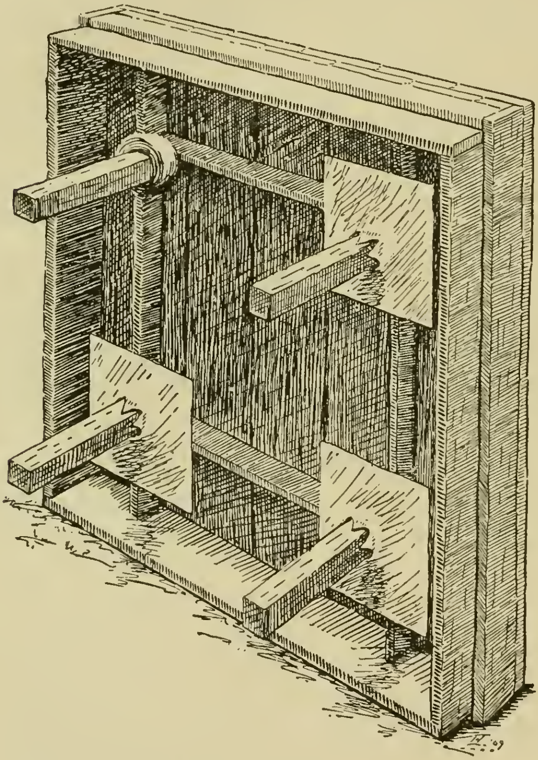


FIG. 11.—Ant-proof hive stand, upturned, showing method of construction. (Senior author's illustration.)

In spite of the fact that the hive stand was absolutely ant proof we experienced much difficulty in preventing grass from growing up under the hives and affording a passageway for the ants. To eliminate this difficulty we covered the entire apiary with about 5 inches of cinders and placed each hive stand upon a concrete block. (See Plate VII.)

Rev. Albert Biever, S. J., devised a unique method of protecting his bees from the ants. This method he describes as follows:

> Blocks of wood are obtained, upon which the legs of the bee stand rest. Then the cover of a lard can or large tin box sufficiently wide when placed in an inverted position on top of the blocks will overlap the block of wood on all sides. A paste consisting of vaseline mixed with kerosene and red pepper is then spread thinly over the inside of the can or cover, and the ants will never be able to reach the legs of the stand and gain access to the hives. An advantage of this method is that the paste need not be renewed more than once every year or two, and, being protected from the weather, it can not be washed off.

One can successfully keep a few colonies of bees in any portion of the ant-infested area by making use of the special stands described above, but eternal vigilance is the price of success, for when the ants do gain access to the bees the latter are likely to be disorganized within a few hours and the swarms will abscond. Along with the use of the ant-proof stands one should also use every means for reducing the ant colonies in the vicinity of the apiary.

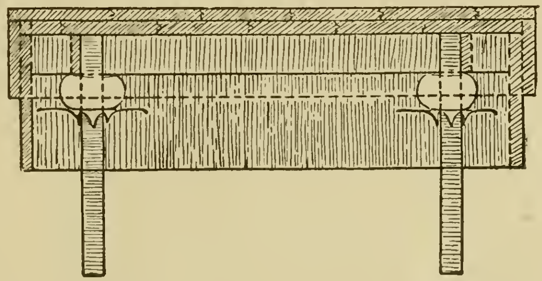


FIG. 12.—Sectional view of ant-proof hive stand, showing method of making top and sides water-tight by "breaking" the joints. (Senior author's illustration.)

The commercial apiarist can hardly continue keeping bees with profit after his apiary is invaded by this pest, the amount of labor in constructing hive stands and keeping down vegetation being almost prohibitive. In such cases the wisest course would be to remove the entire apiary to some locality where these ants do not occur. As already noted, the infestation is not infrequently confined to cities and towns, and small rural sections still free from this pest can usually be found within driving distance.

CONTROL OF THE ANT IN ORANGE GROVES.

The main orange-growing section of Louisiana lies along the banks of the Mississippi River below New Orleans and extends for a distance of about 50 miles. This section has the reputation of producing oranges of exceptionally high quality, and the industry has proven a paying one for many years past. A considerable number of localities have during the past 15 or 20 years become infested by the Argentine ant, due, no doubt, to drifting logs containing ant colonies that lodged along the banks of the river. The warm winters, coupled with the presence of considerable moisture at all times, have made possible very rapid increase of the ants, and the first result of their activities has been a greatly accelerated rate of increase by all scale insects, and particularly by the chaff scale (*Parlatoria pergandii* Comst.). Not only do the ants protect this scale from its natural enemies, but they colonize the larvæ upon the young growth of the orange trees and upon trees not previously infested.

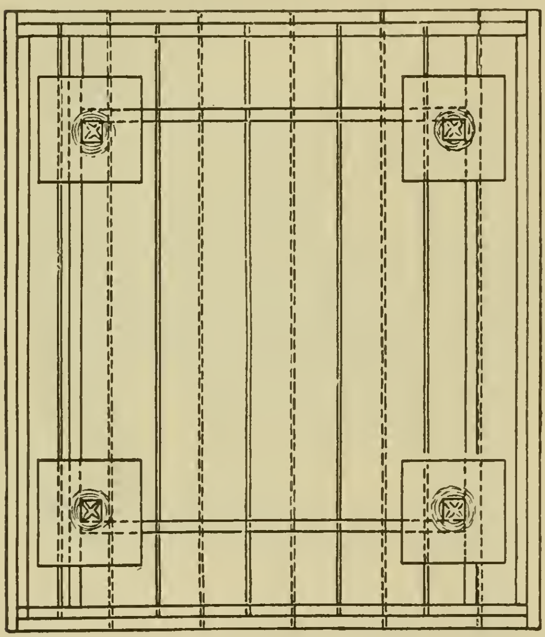
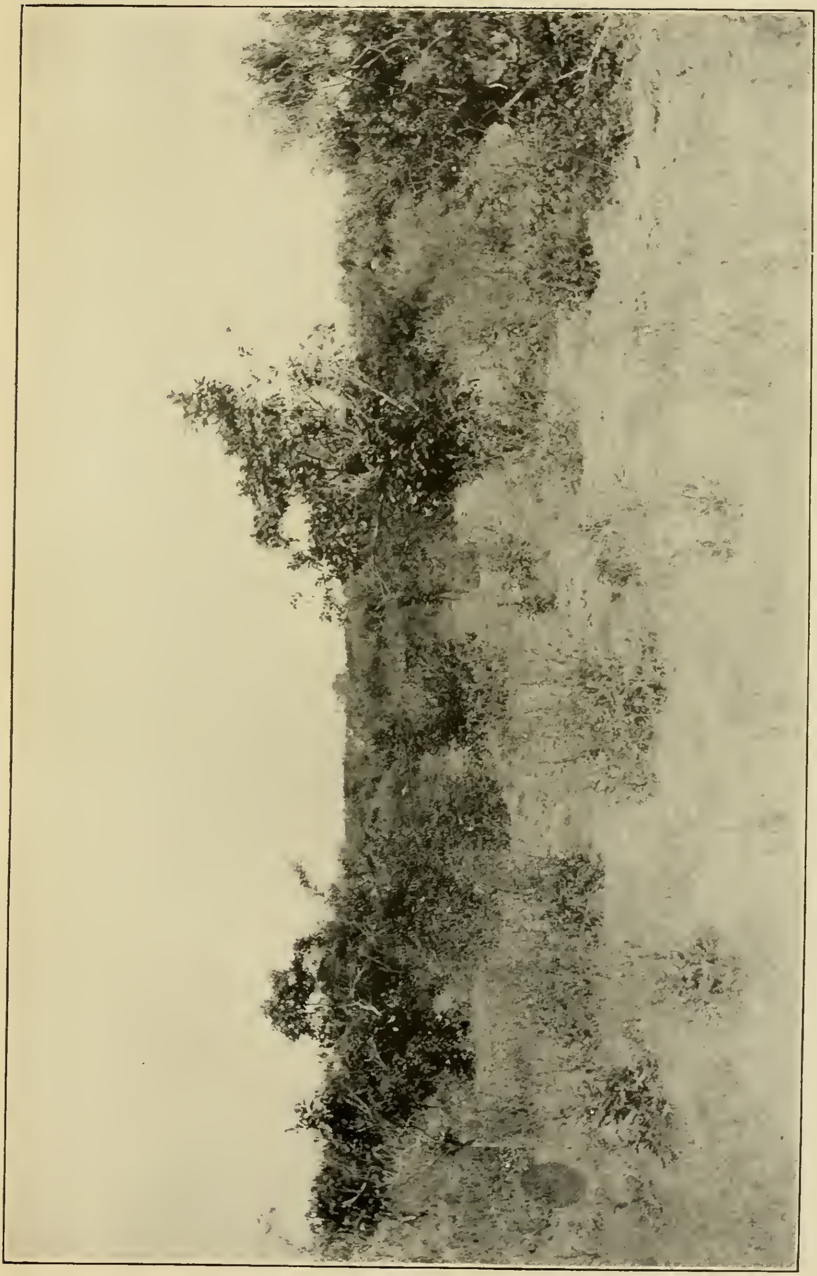
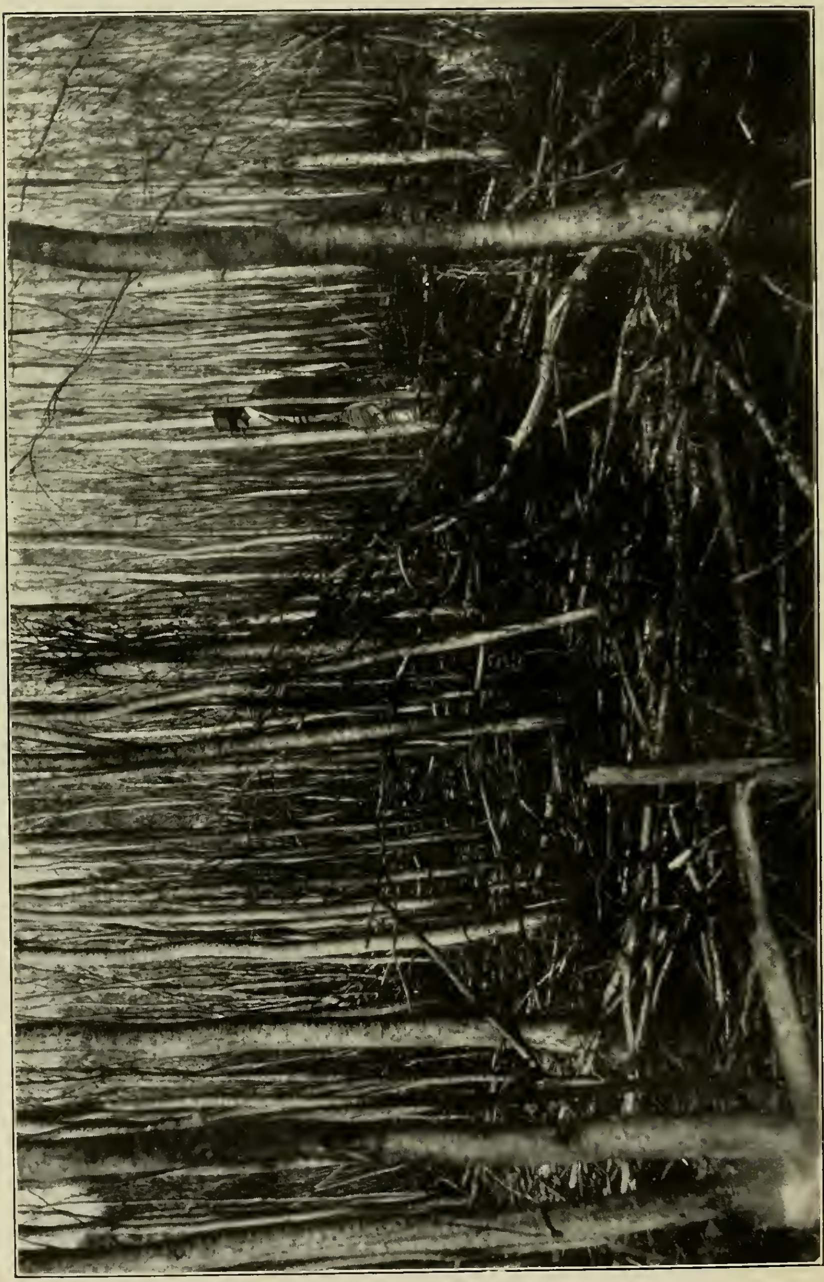


FIG. 13.—Sectional view of ant-proof hive stand from above, showing construction. (Senior author's illustration.)

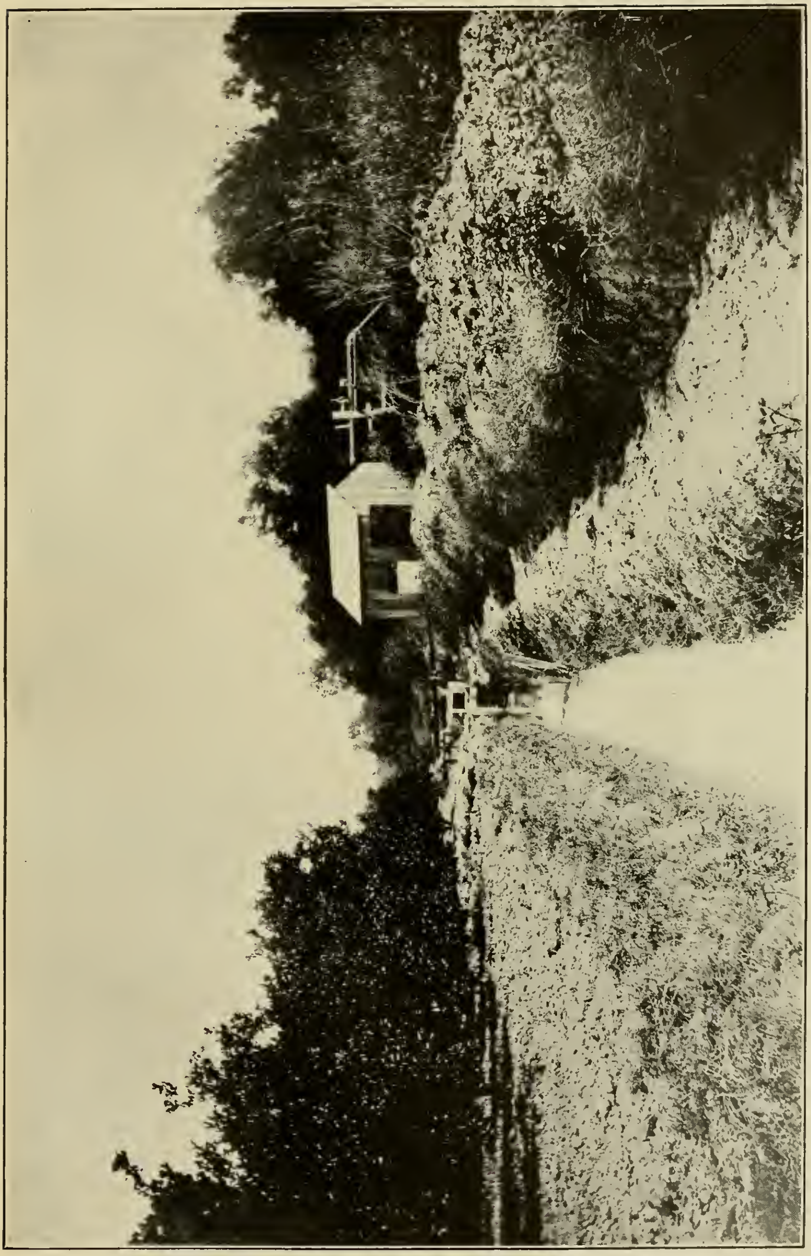
At times the ants eat into the orange buds, evidently in quest of nectar, and buds thus injured do not set fruit. This habit is not always exhibited by the ants, and it may be that it is more or less dependent upon the prevalence of scale insects on the trees. The secretions of aphides and scale insects are preferred to other food, and it seems not unlikely that when honeydew is abundant the buds are not molested by the ants. Whether or not the ants do any other direct damage to the trees is still an unsettled question, but certain it is that the bearing qualities of an orchard are seriously impaired by the second season of infestation, the crop is almost entirely lost by the third season, and the trees are dying rapidly by the fourth year of infestation. (See Pl. VIII.) One orchard which well illustrates the rate of destruction consisted of a 20-acre tract of young grapefruit trees, visited by the authors in March, 1910. The trees at this time were about 4 to 5 feet in height and appeared very vigorous and healthy. The ants were, however, rapidly infesting the field from adjoining orchards. During the summer of 1910 the ants increased



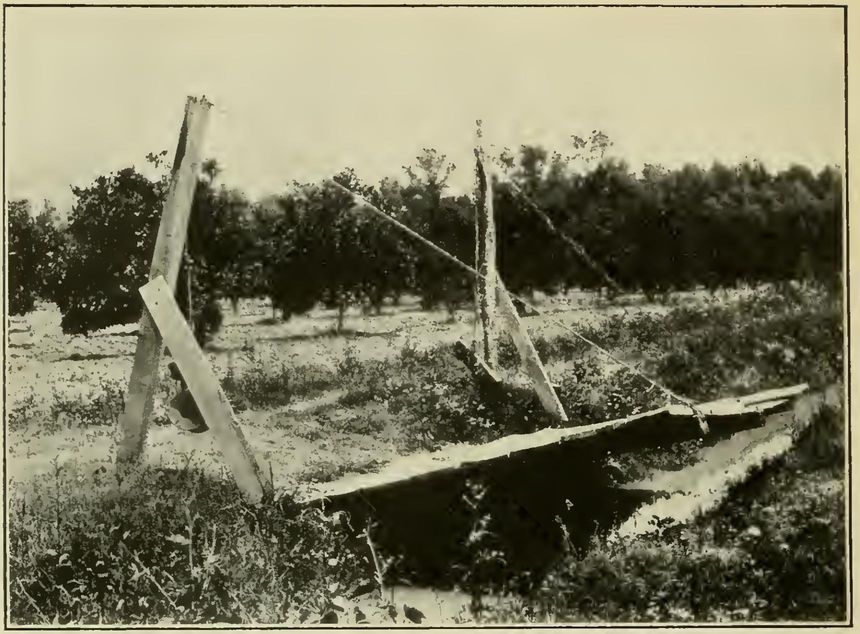
ORANGE ORCHARD DYING AS A RESULT OF INFESTATION BY THE ARGENTINE ANT. (ORIGINAL.)

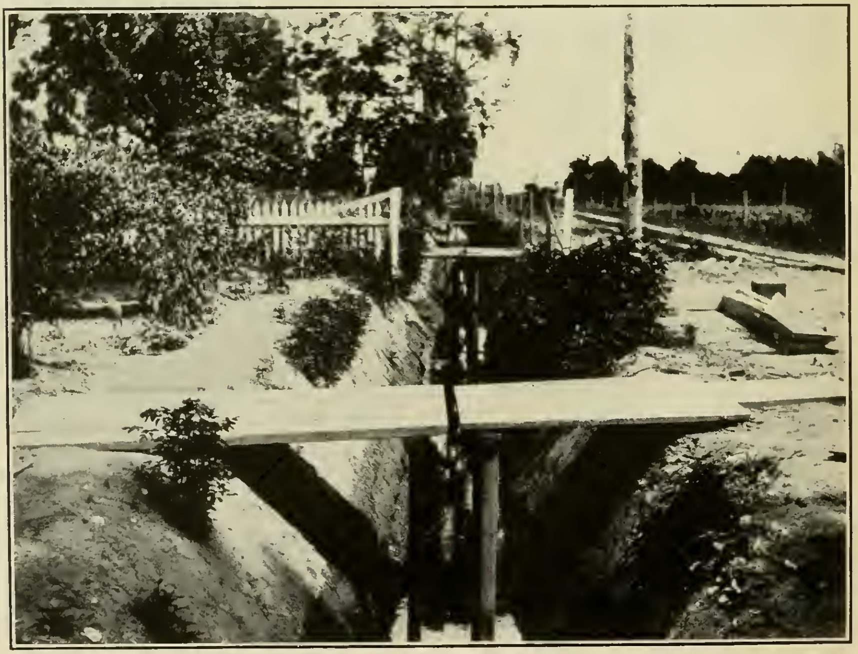


BATTURE OF THE MISSISSIPPI RIVER, 50 MILES BELOW NEW ORLEANS, OVERGROWN WITH WILLOWS AND HEAVILY INFESTED BY THE ARGENTINE ANT. (ORIGINAL.)



SIPHON, PUMPING PLANT, AND BARRIER DITCH USED IN LIMITING THE SPREAD OF THE ARGENTINE ANT. (ORIGINAL.)





BRIDGES WHICH THE ARGENTINE ANT CAN NOT CROSS. (ORIGINAL.)

rapidly, as did the Lecaniums, which were constantly attended by the ants. The owner sprayed industriously with whale-oil soap, but without apparent effect. During 1911 many of the trees died, and at the present time (March, 1912) the orchard is practically ruined and the owner has abandoned hope of saving enough trees to make the orchard profitable. The condition of dying trees is well illustrated by Plate VI, which shows a Louisiana Sweet orange tree that has been exposed to ant infestation for three seasons. This tree stood near the levee, outside the barrier ditches described below, and was exposed to the work of the ants.

Another orange orchard which we have had under close observation has been infested for 7 years, and during this time no measures have been taken to control the ants. In this orchard fully 60 per cent of the trees are dead and the remaining trees are heavily incrusted with both the chaff scale and the purple scale (*Lepidosaphes beckii* Newm.). So abundant are the ants here that a bit of earth disturbed by one's foot at any point in the orchard will reveal a seething mass of ants. A recent crop from this orchard consisted of but 250 boxes of inferior quality. Other orchards, of approximately the same size but not yet infested by the ant, produced in the neighborhood of 3,000 boxes. At Soccola Canal there is a small tract of land on which four orange orchards have been planted in succession, all of which have died before reaching bearing age. The entire neighborhood is heavily infested, and Mr. S. M. O'Brien, of Nairn, La., states that to his knowledge the ants have been abundant at Soccola for at least 17 years. The plat has now been entirely abandoned as an orange grove, the last of the dead orchards having been removed during 1911 and the land devoted to the growing of truck crops.

METHOD OF DISSEMINATION IN THE ORANGE SECTION.

As already indicated, the most probable sources of original infestations in the orange section were drifting logs in the river, these logs carrying living colonies of the Argentine ant. In times of flood these logs are thrown up on the batture (the space between the river bank and the levee) and remain there in large numbers. It is the history of practically all infestations in this section that the ants first appeared on the batture, then along the levee, and from the latter worked their way back from the river. At all the infested points the levee is found to be teeming with the ants and the batture itself is a constant breeding place. A portion of the infested batture, covered with a thick growth of willows, is shown in Plate IX. Here the ant colonies are found under every particle of driftwood and trash, and during almost the entire year they are in attendance upon Coccidæ and Aphididæ on the willows. For a number of weeks each year this batture is covered with several feet of water from the river, but the infestation seems not to be lessened thereby. During flood time many of the ant colonies migrate to the levee adjoining, while still others ascend the trees out of the water's way. Curious nests or sheds, constructed by the ants from particles of earth and trash, are of common occurrence in the tops of the willow trees.

In some few places it is evident that the railroad has been the means of introduction, the infestation having started at points on the railroad where considerable merchandise from New Orleans was constantly being unloaded.

EXPERIMENTS IN THE ORANGE GROVES.

The writers' first experiments with the pest in orange groves were commenced in the spring of 1910. At that time only one grower in the Louisiana orange section was attempting anything like a systematic campaign against the ants. This grower had adopted a novel and rather effective method of destroying them. The infested portion of his orchard immediately adjoined the levee and, as is usual with land along the river, was lower by several feet than the water in the river during flood stages. The water could therefore be siphoned over the levee to the orchard as rapidly as needed. (See Pl. X.) To prevent the spread of the ants to additional territory the infested block had been surrounded by a ditch, a section of which may also be seen in Plate X, in which water was kept at all times. During flood stages of the river the water was siphoned over for the ditches at small expense and through the ditch system drained away to the swamp in the rear of the plantation. At other times the water was kept in the "ant ditches" by use of a gasoline engine and pump installed on the levee, as shown in Plate X. It was, of course, necessary to take precautions that the ants should not find accidental and artificial means of crossing the ditches. Permanent bridges for the passage of teams could not be left, so a swinging bridge which could be lifted when not in use was devised. The ditching system for preventing spread of the ants was shortly adopted by many other growers, some of whom used an ingenious divided bridge (Pl. XI) which could be crossed readily by teams, but which had a 2-inch crack through the middle that effectually prevented the passage of the ants.

The grower referred to had put in practice the following method of destroying the ants: A small levee or ridge was made around the infested block of trees. Water was then admitted through the siphon from the river until the ground in the block was entirely covered. As the water slowly rose the colonies of ants moved up into the orange trees. Then the water was drawn off and the ants, descending, found the ground still too wet to live in, whereupon they migrated en masse to the surrounding small levee. The water was then turned on for the second time to keep the ants on this ridge, and here they were destroyed by exposing the colonies with a shovel and scalding them with hot water or spraying them with kerosene. At the senior author's suggestion a number of small boxes filled with hay and trash were placed at various points in the orchard. When the water was admitted it was found that the colonies moved into these boxes in preference to going up the trees. They could thus be destroyed with one flooding instead of two, as formerly.

It may be remarked in passing that the ditches, when pains have been taken to prevent the ants crossing them, have effectively limited the spread of the ants through the groves. This fact amply substantiates our observations, mentioned on pages 19–20, to the effect that colonies are never established by individual queens returning from a marriage flight. Were colonies established in this manner, the areas of infestation would not be sharply defined, nor would ditches retard the dispersion of the ants from heavily infested centers.

EXPERIMENTS WITH WINTER TRAP BOXES.

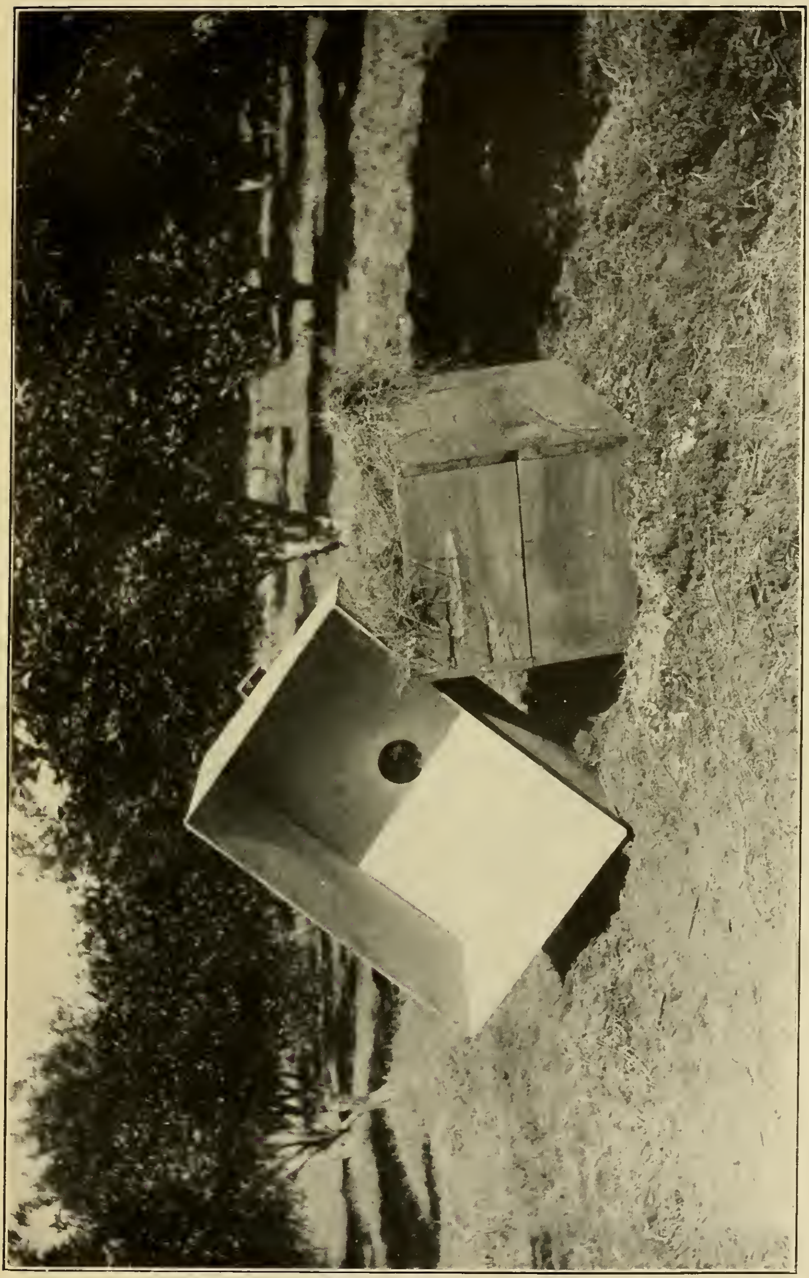
The success which had followed experiments at Baton Rouge in getting the ant colonies to concentrate during the winter in boxes of decaying vegetable matter induced us to try the same plan in an infested orange grove. Accordingly in November, 1910, a large number of boxes, each 2 by 2 by 3 feet, of rough lumber, were made and distributed throughout the infested block. Each was filled, during the latter part of October, with a mixture of cotton seed and dead grass. The top of each box was left exposed to the weather, so that rain would enter to moisten the contents and start decay. An examination of the boxes on November 16 showed that many colonies had entered them, but that many still remained in the ground. To afford the ants less natural protection the orchard was cultivated to remove the standing grass and weeds. In January, 1911, the authors again visited this orchard and found all boxes filled almost to overflowing with enormous ant colonies. Each box contained workers by the hundreds of thousands and queens by the hundreds. A close examination in various parts of the orchard showed, however, that not all colonies had entered the boxes. Some few colonies had remained in their underground nests, particularly where grass or weeds had been overlooked in the November cultivation and where, therefore, these colonies were afforded more protection than in the plowed portions. Whether the already crowded condition of the boxes had prevented other colonies from entering them we could not determine.

Experiments were now undertaken in destruction of the colonies in the boxes. Metal covers had already been constructed for confining gases in the trap boxes. (See Pl. XII.) Experiments were first made in fumigating the boxes with hydrocyanic-acid gas (see pp. 82–83), but these were not successful. Carbon bisulphid was next tried, with perfect success. Delay in obtaining a sufficient supply of bisulphid resulted in delayed treatment of many of the boxes, and doubtless some of the colonies escaped as the weather became warmer in the early part of February. Nevertheless, the number of queens and workers destroyed ranged into the millions. The owner wished to deal the ants the hardest blow possible, so early in the spring he flooded the orchard, drove the remaining ant colonies to the boxes, and fumigated these the second time.

The results of this work were eminently satisfactory. The orchard was first infested by the ants in 1909. In 1910 they reached enormous numbers; chaff and purple scales increased until the trees were almost encrusted, and many of the trees showed signs of failing. The foliage began to turn yellow, and the crop of 1910 fell off severely, in spite of the flooding that was done by the owner in the spring of 1910. During the summer of 1911, following the use of the trap boxes, the orchard improved remarkably, and the crop was up to the original production. It was found that when the boxes were left in the orchard ant colonies took up their abode therein during the summer months; for this reason these boxes were fumigated with bisulphid from time to time. An examination of the orchard in January, 1912, showed that the infestation by the chaff scale had been greatly reduced by diminution of the ants, even though the owner had done no spraying for destruction of the scale insects. The ant infestation showed some increase in the autumn of 1911, but the orchard had returned to its normal healthy condition, and it was evident that a continuation of these methods would insure good crops indefinitely. A view of this orchard, taken in January, 1912, is shown in Plate XIII.

One important point came to light in these experiments, and that was the necessity of placing the trap boxes in position early in the autumn so that the vegetation in them would be decaying well at the approach of cool weather in November. With considerable decomposition going on at the time the ants are seeking winter quarters, the warmth of the box becomes very attractive to them.

The use of arsenicals and other poisons in the infested orange groves was found impossible, for the reason that the secretions of scale insects and aphides are preferred by the ants to all other foods.



TRAP BOX AND FUMIGATING COVER FOR DESTRUCTION OF ARGENTINE ANT WHILE IN WINTER QUARTERS. (ORIGINAL.)

ORANGE GROVE IN WHICH CAMPAIGN WAS WAGED AGAINST THE ARGENTINE ANT—APPEARANCE OF THE GROVE AFTER RECOVERY. (ORIGINAL.)

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