



From the distribution of ants over all the world, even the coldest regions, with their wonderful power of multiplication, together with their attacks and raids over man's habitations, it is impossible that they should not attract man's attention. I believe - from the comparative study of the superstitions connected with the life histories of other animals - that ants must have fostered a great deal of man's superstitions. With the Jews, with the Arabs, perhaps with all the Semetic nations, and even with the savage tribes of Africa, as I shall show in the course of this book, ants have been held as ideals in industry, wisdom, and proof of God's creative power.

The earliest observation recorded on ants are those of Solomon. In the book of Proverbs (VI-6-8) Solomon says, "Go to the ant thou sluggard, consider her ways and be wise, which having no chief, overseer, or ruler, provided her bread in the summer and gathereth her food in the harvest".

Again in the same book (XXX : 24-25) "There are four things which are little upon the Earth. But they are exceeding wise: The ants are a people not strong .

of Syria and Palestine, either; *Aphaenogaster barbara* or *Aphaenogaster structor*.

It is really astonishing that in spite of the religious and ethical importance attached to these "little people", they did not stimulate the inquisitive powers of either the Jews or the Arabs to a larger extent. Even when these two learned nations became acquainted with the Greek culture and Aristotle's treatise on natural History, they did not make many observations on the subject, but copied almost verbatim what the ancient Greeks have recorded.

Unfortunately, prior to the 18th and 19th centuries, this cold and apathetic attitude towards these creatures, has been assumed by almost every nation. It was only at the dawn of the 19th century that ants impressed their superiority over many animals on man's mind; and as we approach the end of the century we see men of great talents and genius devoting a great deal of their precious lives for observing and experimenting on these "wonderful people".

The importance of the subject, in this twentieth century, has assumed such a magnitude, as to lead many naturalists in many countries in Europe ~~and Europe~~ and America, to devote all their lives for its careful study. In introducing the reader to the subject, to mention the ^rstating facts, that ants are the most intelligent social animals after man, that they have been even more successful than he in solving social questions

exactly similar to our own, and that their social evolution is comparable only to that of man, a fact to which biologists give the technical name of "Convergence".

CHAPTER 1.

MAN'S SUPERSTITIONS ON ANTS.


After considering the various superstitions connected with several animals, the writer of the article "Animals" in the Encyclopedia of Religion and Ethics, goes on to cite the unfounded popular beliefs which have arisen in man's mind among several tribes and nations. He says, "We learn from the Greek writers that ants were worshipped in Thessaly; the Myrmonides revered them and claimed descent from them. In Dahomy and Porto Novo, ants are regarded as the messengers of the serpent-God Danbe. In Jabim, New Guinea, it is believed that a second death after the first is possible, in which case the soul becomes an ant. We find in Cornwall the belief that ants are the souls of unbaptized children. In France it is held that it brings ill-luck to destroy an ant's nest. The ant is fed by the Hindus and Janis on certain days and is regarded as associated with the souls of the blessed dead.

In South America and California one mode of initiation was to allow the boy or girl to be stung by ants; it is said to make them brisk and impart strength. The Piojes submit to it in order to acquire skill with the blow-tube. The Athapascan Day-Ribs

believed that the gift of prophecy was acquired by secretly putting an ant under the skin of the hand. On the other hand, the Aruntas held that a medicine man must not go near the nest of the bulldog ant; for if he were bitten, he would loose his power of for ever. In Bulgaria and Switzerland, ants are regarded as of bad omen. The Esthonians regard them as of good omen; and for the Huculus, red ants are lucky, black unlucky.

Not only the ant, but also the ant - hill is the object of superstitious observances. The Juangs take an oath on ant ant hill, and the Kharias use it as an altar. At Poanah a dance round an ant-hill is part of a religious ceremony. In West Africa, ant's nests are regarded by the Susus as the residence of demons. Elsewhere they are brought into connection with the souls of dead chiefs. In South Africa the bodies of dead children are buried in ant-hills that have been excavated by ant-eaters. In the Sudan it is believed that a hyaena man assumes his animal form at an ant's nest".

In Egypt ants are considered as a sign of happiness and wealth. The winged males and females especially of the yellow ant, known in Europe as the *Lasius flavus*, are much prized over other ants and nobody thinks of disturbing them. Cases are known in which people preferred to live in houses wherein winged ats abound, however unhygienic the houses might be.

The Arabs had many superstitions on ants. They used to believe that one of the great Southern nations of Yemen, named the Gurhaum  was put to an end by the ants. They also believed that the ants are nations like ourselves and that we ought not kill them; and that at the day of judgement we shall have men similar to the small red ants.

Some of the learned linealogists (those who are well-versed in the linealogy of families) was so original in his researches on ants as to find the linealogy of the ant which spoke to Solomon according to the Koran, and that Solomon heard the conversation of this ant at a distance of threee miles, and that she was a female and that she spoke to him most eloquently in ten ways of rhetoric.

There are many other supersitions^t mentioned by the Arab writers. Here are some of them:

To see ants in your dreams is considered to be a subject worthy of discussion. Some of the dream interpreters consider them to be one's own progeny, others believe them to mean the weak people; Others, again, regard them to mean the Jennies.

Moses the prophet had the wonderful power of seeing the ants in the dead of the darkest night at a distance of ten farsang (i.e. 30 miles).

If you want to drive the ants away from anything, put honey in a vessel and then say, " This is for the vice-judge; this

honey is for the Judge's servant; this is for the messenger of the judge etc".

If you throw the pupae or larvae of the ants among a group they will at once disperse. They also relate that Adil Ben Hatem used to feed the ants on the 10th day of Moharram, but owing to their religious faith, they used to refrain from eating and fast for three days, like the most pious moslem!

Having cited some of the superstitions connected with these creatures, and shown their influence on the mind of men in general, and the people of the Arab-speaking countries in particular, I shall treat, in a subsequent chapter of the history of the observations on these "little people" with special emphasis on the observations of the Jews and Arabs.

CHAPTER 11

PAST OBSERVATIONS ON ANTS.

Greeks and Romans:

Before Aristotle nothing is definitely known about Greek biologists. Aristotle was the first man on the list who made observations on at least (500) species of animals other than ants. Since Aristotle, nothing is recorded except very few observations. Biology after Aristotle declined a great deal and it was a little revived in the hands of the Greek philosopher Cleanthes who lived in Alexandria about the year (100 B.C.). His observation on ants



were handed down to us by the great Roman writer and biographer Plutarch.

Among the Roman observers on ants mention may be made of Lucretius, the poet, who revived the views of Epicurus on life, and who, according to Lange, announced the magnificent doctrine first proposed by Empedocles, that all the adaptations to be found in the universe and especially in organic life, are merely special cases of the infinite possibilities of mechanical events.

Pliny the elder is supposed to have made some observations on ants. He was a naturalist, but unfortunately, he was also a gatherer of fables and superstitions.

The decline of the Greek and Roman cultures was not favorable for investigations on any subject and especially, that of ants. So I shall trace its development in other nations especially ^{among} ~~and~~ the Jews and the Arabs.

THE JEWS.

It was only to prove certain religious aspects bearing on ants that the Jews were stimulated to make any observations. Simon ben Halaf^{ra} made experiments on ants to prove whether they have a ruler or not.

The Talmud also contains certain legislations on harvesting ants. The post-Talmudic literature on the subject is greatly influenced by the Arabic writings. Samuel ibn Hisdai, in "Ben ha Melek Weha- Nazir " (xv) a hebrew rendering from the Arabic version of "Burleam and Jossafat", holds up the ant as an example, in the sense of the passages of the Book of Proverbs,

Kalonymus, in his "Iggret Baale Hayyim", which is likewise a Hebrew version from the Arabic, describes at some length the habits of the ants, in building its abode and in gathering and preserving its food.

Mairmonides in his introduction to Seder Zerain, deduces from the fact that the ants are sometimes winged, sometimes without wings, that it is due to our minds' limitations that we cannot gauge the purpose of many things in nature. Jeshua ben Shouli says that the wisdom of ants is not from reason, but from the sparks of the Supreme soul of the active ~~from the sparks of the Supreme~~ intellect diffusing all creation. To me, this idea seems to be a slightly modified form of Averroes "Universal Thought".

Averroes held that the prime mover of the world which is eternal, and which is unity, is diffused in the particulars, i.e. in the individual things composing matter. So it is probable that this Jewish philosopher might have been influenced by that great Arab philosopher, especially, if we know that Averroes spent a great deal of his life as an exile among the Jews at a certain village near Madrid in the 13th. century A.D. and that almost all his works were translated into Hebrew.

From the purely biological point of view Gershon ben Solomon, in his work "Shaar ha-Shamayin", discusses his own experiments and observations on ants. He says that the ants gather the seeds and gnaw their points of growth, and that each ant gathers seven grains (!), although one would suffice it for life, and

that, comparatively speaking, it is the strangest of animals, since it can move both forward and backward.⁽¹⁾

Sefer ha-Berit distinguishes male, female and neuter ants: The first two on reaching maturity, acquire wings and fly, while upon the neuter devolves not only all the works, but the hatching of the eggs, of which a single female lays no less than 8,000.

From all what I have related, thus far, it seems to me, first, that all investigators above mentioned, have been concerned with the ways of the harvesting ant only.

They did not extend their observations over other species, in spite of the existence in Syria and Palestine of at least ten species.

I firmly believe that as much as the religious motive has been a stimulus to the Jews to inquire into the ways of the harvesting ant, it has also been an obstacle to more extensive observations on allied species. We shall presently see that the Arabs, whose religion is less rigid than the Jews, made more observations on these creatures.

CHAPTER III.

PAST OBSERVATIONS ON ANTS.

(CONTINUED).

THE ARABS.

It is a well known and established fact that many scientific

(1) -This I have observed myself)

books compiled by the Arabs have been lost, and the few sources that remain are not easily accessible. The growing interest of the Occidental Orientalists in the Arabic literature is still in its infancy; and inspite of the indefatigable efforts of these learned men in unearth~~ing~~^{ing} obsolete and buried branches of knowledge in the Arabic literature, they confess that they are still in the dark and that a great deal has ~~been~~ ^{has} been lost.

There are three reasons to make one believe that the Arabs have made extensive observations on ants: (1) Just as much is written in the Bible about ants, so also they are mentioned in the Keran and even more extensively. In the Keran it is related (Chap. xxvii : "Surah of Naml or ants"): that Salomon conversed with the ants who were afraid lest his enormous armies in passing through the valley of ants should crush them.

This special mention of ants in the Keran, together with their mention in the traditions and sayings of the Prophet Mohammed, must have incensed in the Arabs the faculty of investigation along that line. Indeed, one cannot read the views of the interpreters of the Keran without reaching the conclusion that they must have known a great deal about or most probably, made ^experiments on ants.

Once I was talking with one of the well-known learned Meslem Shiekhs here in Beyrouth on the subject of ants, I mentioned for him the astonishing fact that ants communicate with each other by means of a language, and that the German naturalist Wasmann has compiled an extensive book on the language

of ants. The learned and pious Shiekh at once said that the interpreters of the Koran have been divided into two schools in explaining the verses that refer to the fact that ants spoke to Solomon: (1) One school says that ants have a language and communicate with each other and that this has been vindicated by experiment. (2) The other school denied any language to the ants, and take the passage in its mystical or symbolic sense.

The second reason which makes me ^{believe} that the Arabs made extensive observations on ants, is that ^{it} is impossible to think of the extensive literature bearing on animal ~~life~~ without thinking of the ants as being scientifically treated by the Arabs. They have made close observations on even very ~~wild~~ and dangerous animals, and in their views on the origin of man and ape they have come very close to the Darwinian theory. How then, can we deny them the credit of having made experiments on ants, the small "wise people" that are mentioned in their religious book.

Unfortunately the books I have access to, are full of superstitions. The books that are purely scientific without ~~any~~ superstitions are either rare or lost. Dr. Bishara Zilzil in the first volume of his learned and interesting Arabic book, "the enlightenment of reason" (a treatise on the lives of animals and man in his different stages of civilization), mentions that he has a rare copy (manuscript) of a book on the natures of animals by the learned "Mohammad ben Ahmad El-Warak, known as the bookseller, which is very scientifically written. Among

the lost books from which the previous author has taken a great deal, is the book on "Animals" by the famous Arab Philosopher, Abd ul Latif el Baghdadi, and also mentioned by his biographer Ibn-el-Kifti.

Thirdly, from the brief account given above, about the history of the subject among the Jews, it is very clear, that many books written in Arabic on scientific subjects are not found in the original. The only thing remaining is the translation, either, in Hebrew, Syriac or Latin. From the fact that there are books on ants translated into Hebrew from the Arabic, and from other evidences mentioned in the course of these pages, it is most probable that the Arabs, must have been made extensive observations on ants.

The following observations, scattered among the scanty materials I came across, confirm my position:

The Arabs distinguished between at least four kinds of ants (1) red ants which I believe to be the harvesting ant (2) the black ant; (a) either the ordinary ~~be~~ black ant which does not bend its abdomen over its body or (b) the Aphaenogaster i.e. that which bends its abdomen over its body. They call the red ants- (and perhaps the yellow ant too which are known in Europe as the *Lasius flavus*, and which they did not distinguish from the red ant)- Fazir^{فازر} and the black ones the Okefan. ^{عقار} Some linguists apply the name Fazir to the small red ants.

The Arabs certainly knew the small ants and used to call them ^{ذر}Tharr. The same mistake that is popularly committed in considering

the pupae and larvae of ants as their eggs was also committed by them. They applied the name Beiz^{بيظ} or Mazin^{مازن} to what they supposed to be the eggs; What the ant carries in her mouth is also called by them Zibal. ^{زبال}

I could not well understand the exact denotation of the term ^{Howli}Howli-el-Hassa, owing to the fact that ^{the} term is equivocal. It may mean the small ants or it may denote the pupae or larvae. However-as I think that the latter is what is meant and so it seems to me that the Arabs knew the larvae and pupae, although without so much distinction between the two.

Regarding the habits of ants they knew plenty:

(a) They knew much about the nesting of ants. They knew about their chambers, corridors or galleries, roads and whether they nest in shaded places or in the open country, or in houses among furniture or walls.

(b) They knew also about the gathering or storing of food, and that they eat the growing part of the grain in order to prevent it from growing. Among the things mentioned in this connection and which I did not find anywhere else, is that the ants store ~~teh~~ the seeds of the coriandrum known in Arabic as the Kuzbara, of the family Umbelliferae. Instead of cutting the seed into two they cut it into four parts, since cutting it into two ~~would~~ would not prevent it from growth. They also mention that ants spread the seeds in the sun to make them dry. Gnawing the growing part of the seed takes place in winter.

(c) Another mistake which they naturally committed was the statement that when ants develop wings they are seen to die.

It is a known fact nowadays, that the winged individuals of an ant colony, are the males and females, and it is also an established fact that they take the mating flight in a hot summer afternoon, and that when they mating takes place most of the males die.

Now the Arabs in their observations thought that the ants develop wings and that they die after the first flight and that this is a sign of their annihilation. Certainly this is not true. It is only the males that die while the colonies continue to exist. This is mentioned even in their poems. Thus Abul-Atahia, one of the great Arab Poets, says " that the end of ants is near, ~~wow~~ when they develop wings for flight". وإذا استوت العنقبيذ - وقت الربيع فقد دماغض

(d) Any soil which is full of ants is not healthy for the growth of grapes. I do not know the weight of this statement, since I did not come across it in any modern book. Most probably it is true, since the ants are proverbially fond of sugar and sweet juices.

(e) They also believe that when a large ant is introduced into the nest of small ants, it will begin to eat them and that a certain man by the name of Yakteri ^{القطري} has actually seen that. On my part I believe the observation is true, while the interpretation put upon it is wrong. It seems to me that this is the truth:

The large ant which entered the nest of the small ants is a queen ant, since one of the methods of the establishment of nests as we shall see later is, that the female queen ants enter the nests of other colonies either of their own or other species.

Regarding the eating of small ants by the large one ~~as related~~
as related, it seems to me that this is the truth:

The queen either killed, or induced the workers to kill
the old, queen ant, and that she herself killed some of the
hostile workers ^{which were} carried outside the nest, and impressed this Arab
observer as being the remainss of these eaten by the female queen.

(f) Among the enemies of the ants they mention the hyena and
that it has a wonderful appetite for ants and that when they develope
wings they will be eaten by the sparrows and small birds.

(g) They also mention the wonderfull statement, which I doubt
very much that the ants can put an end to gnats and that the gnats
are turned to ants. In this, I think, I find an~~e~~ observation
worthy of consideration, although the interpretation put upon
it is not scientific:

Everything (small) which seemed to infest trees or wood in
general is called by the Arabs " gnats" or in Arabic :Arada or ^{أرادا}
Sarafa. S~~e~~ they could not knew the difference between them at
all, owing to the lackness of classificatory or descriptive works
on entomelegy. Now under the name gnats or Arada, I have no
doubt that Aphids also were included. This, being undoubtedly,
true, it follows that the Arab observers knew about the subjugation
of the Aphids by the ants.

They mention that the ant does not come in frent of the gnat
(i.e Aphid) and carries it to the nest, but it comes from behind
it and carries it to the nest.

The fact that they believe that ants exterminate gnats or

gnats ~~are~~ turned into ants, vindicates the newly observed fact that ants bring the aphids to the roots of some trees and carry them ~~there~~ back to their nests.

(h) They believed that ants can be killed~~d~~ by sulphur, (which is also now practiced in South America), tar or liquid pitch (turpentine), ~~and~~ here is a very funny thing. It is mentioned that ants can be killed also by putting a hair in the mouth ~~on~~ the mouth of the ant. Certainly this is not believed by them, but it seems that they mentioned it for the sake of fun.

(i) They believed that ants do not mate and that they grow ~~a~~ out of something ^{like} the eggs.

(j) One of the observations which I believe to be true, is that ~~ants~~ ants exposed the seeds which they gather in the moon-light; and they recognize the seeds by their power of smell, which is a modern scientific observation.

(k) Regarding the ways the ants make their nests, they say that the ants dig them up by means of their feet which are six and that they make roads zigzagging in different directions inside the nest, in fear of the rains.

(l) Here is also another observation which I did not find anywhere else; Ants attack only wounded insects.

(m) I do not know how much weight shall I give to the following statements: that the larvae or pupae if applied to a place where the hair grows, will not grow at all, that the magnet kills the ants, and that half a dirham($\frac{1}{2}$ grams) of the larvae is a strong purgative.

(n) Regarding the duration of the nest, they believe that it lives for more than a year. Thus they call that ant which lives for a year a mohwel, that is, one which lives for a year.

Now, having finished the observations of the Semetic races, the Arabs especially, I now turn to the description of ants as known to modern investigators omitting the history of the subject among other European nations since that is not new and unnecessary.

CHAPTER IV

ANTS IN GENERAL



To my mind, the subject of ants is the most interesting and the most fascinating in all the domain of biological sciences. First, because it contains instances to prove or disprove almost every biological theory or hypothesis, and secondly because it is the nearest animal to man in matters related to social and psychical evolutions. Nay, it is even more successful than men, since it solved some of the social problems which he could not solve as I shall subsequently show.

As the Cambridge Natural History is the only book in the Library treating of the families of ants in more details than any other, I shall confine myself to a summary of its classification, leaving out of account the simpler classification made by Sir John Lubbock in his book, "Ants, wasps and bees", since it is more modern than the latter. However I shall begin by mentioning the more general characters as I came across my readings

and then mention the families, reserving the detailed account of the more interesting biological problems till after that.

GENERAL APPEARANCE:

Ants are small insects, belonging to the order Hymenoptera.

Just as all insects (order: Hexapoda), their body is divided up into three parts: Head, thorax and abdomen.

HEAD.

Usually, the head of most insects (order Hexapoda) consists of five segments of fused metameres. The head of the ant bears the antennae which vary among them in the number of joints, and which differ from 11 to 13. Other than the antennae the head bears, the ocelli, which as we shall see vary, and illustrate with the compound eyes (i.e. facets) strikingly, both the problems of meristic variation and evolution.

The mouth parts consist of the upper lip or labrum, overlapping the maxillae, the mandibles and then the labium.

THORAX

The thorax is divided up into three divisions, each carrying a pair of legs: the prothorax, the mesothorax and the metathorax. Each thorax carries a pair of legs having a femur, a tibia, and several tarsi ending in a two-forked pulvillus. The wings which exist mostly in the males and females, and occur very rarely in the workers are found in the mesothorax.

THE ABDOMEN:

The abdomen is connected to the metathorax by either one, two or three constricted segments, called peduncles or propodes. The classification of ants depend upon the number of these peduncles.

The last segment of the abdomen is sometimes provided with a

sting, a cushion, or a gland full of poison. Sometimes the abdomen is bent over the anterior part of the insect, while in most cases it is on the same level with the anterior.

The shape of the abdomen differs very much. Sometimes it is elongated and cylindrical, sometimes it is a little bulking and not tapering to a point at the end. As this will be treated in the next chapter on Classification, I leave it for the present.

CHAPTER V.

CLASSIFICATION.

Many entomologists consider ants as a class by itself independent of Hymenoptera. They give to it the name, "Heterogyna". Sir John Lubbock considers them to be composed of three great families: Formicidae, Poneridae and myrmecidae. The Rev. W. Farren White in his book, "Ants and their ways" adds a fourth family under the name, "Mutillidae".

The writer of the Cambridge Natural History follows Forel in his classification, who considers them all to be of one family: ~~the~~ "Formicidae", divided up into six sub-families as follows: Camponotides, Dolichoderides, Myrmicides, Ponerides, Dorylides and Amblyoponides. I shall follow this classification although later entomologists (e.g. H. Comstock in his, "Manual for the study of Insects", and W. Harcourt Bath in his "Young collector Handbook of Ants Bees, Dragon flies, Earwigs, Crickets and Flies etc.") still keep up to Sir John Lubbock's classification.

CAMPONOTIDES

Hind body furnished with but one constriction, so that only a single ~~scale~~ scale or node exists on the pedicel. The poison-sac forms a cushion of convolutions, on which is situated the modified sting, which forms merely an ejaculatory orifice for the poison. They have 800 species and are more distributed over the face of earth than any other sub-family. We shall see presently that this type of ant is the most civilized or, technically speaking, the most highly evolved.

To my mind, since it is the most numerous of all ants, and since number is necessary for the production of varieties, it is here that we come across the most variable types in this type of animal. This I shall try to show subsequently.

SUB-FAMILY: ^{DO} 2DOLICHORIDES:

Hind body furnished with but one constriction, so that a single scale or node is formed; sting rudimentary; the poison-sac without cushion. Here again we meet with another proof of the effect of number over the number of species or varieties. There are no less than 150 species. The habits are not well known.

SUB-FAMILY 3 MYRMICIDES:

Pedicels of abdomen formed of two well marked nodes (knot - like segments). Sting present (absent in the cryptocerini and Attini). It should be noted that the workers of the genera Eciton and Aenictus of the sub-family Dorylides have, like Myrmicides, two nodes in the pedicel.

In this family we have at least 1000 species, proving the influence of number over variations. Owing to the smallness in

size of the individuals of this family, it is not well-known or even much paid attention to. Yet in this family we find intermediate forms proving the great law of Evolution as we shall see later. Suffice it here to say that Alderz found that individuals intermediate in several points between the males and workers have ^{been} discovered (group Myrmicini). To show the smallness in size and weight of this sub-family it is enough to mention that seventeen thousand individuals weigh one gramme.

SUB-FAMILY 4 : PONERIDES:

Hind body elongate, furnished with one node at the base, and having also great capacity of movement between the first and second segments, between which there is usually a slight constriction. Sting well developed. The number of species here are about four hundred. Although this type of ant is found almost everywhere in the world, a case which must favor the production of many variations and species, yet we are surprised to find that this is not the case.

The reason for this is, as it seems to me at least, is the close similarity between the individuals composing the community.. The differences between males and females and even workers are very slight. Technically speaking, secondary sexual characters are lacking. Little again is known of this type of ant. It is here also that you find a few ants in a nest, sometimes fifty in a colony.

SUB-FAMILY 5 DORYLIDES:

Clypeus extremely small, the antennae inserted very near the front margin of the head. Hind body usually elongate and sub-cylindrical, with an imperfect pedicel formed the constriction

of the back of the first segment, but occasionally there are two nodes in the workers. Distinctions between the two sexes, and between the workers and sexed forms, enormous, the queens truly wingless. The females and workers usually blind, or at any rate destitute of faceted eyes. (In Ecitoni, the antennae are not inserted quite at the front of the head, and there are two nodes in the pedicel).

The chief characteristic of the Dorylides is that the males are much less ant-like in form than they are in the other groups, and that the distinction between the females and workers are enormous. The females of the Dorylides are amongst the rarest of insects, and are also among the greatest of natural curiosities).

This family is divided up into two main groups, the Ecitons, ~~and~~ and Dorylini existing chiefly in the Eastern Hemisphere, and related closely by its workers to the Ponerides and Amblyoponides.

SUB-FAMILY 6: AMBLYOPONIDES:

The abdomen is destitute of distinct pedicel; the articulation between the first and second segments behind the true petiole being broad. This ant is considered by some to be the most primitive ant.

Having now considered briefly the classification of ants, I shall proceed in the next chapter to consider the general features applying to all of them with special emphasis on their distinctive characteristics according to the laws and methods ~~of~~ of Evolution and Biology .

CHAPTER VI

ADAPTATIONS OF ANTS TO GENERAL
CONDITIONS OF LIFE.



It is a well known fact in Biology that every individual must provide means for keeping safe and perpetuating the species; The means taken for the preservation of the individual are:

Provisions for (1) food (2) escape from enemies (3) habitat or shelter (4) means taken against sudden or gradual change of environment. Regarding the means taken for the propagation as well as for the preservation of the species I shall speak of that as I proceed.

FOOD.

Man has been once a carnivorous animal, and by gradual processes he has come to be mostly herbivorous. Mammals (e.g. pig, dog, etc.) have had the same course. So it was with the ants. We find amongst them, as we find in the human species, tribes that are still in their primitive stage in matters of food, and eating almost exclusively nitrogenous matter, i.e. eating insects or other animal bodies.

Take for example the driver ant of Africa, known as Anomma, which has a very large head armed with a formidable mandible which moves transversely and which is totally blind. Rev. Mr. White says that it has a sting like the puncture of a red-hot needle, and like the Arabs of the desert has no certain dwelling place. "These are truly the scavengers of the desert, before whom, rats, mice, lizards, cockroaches, and every kind of vermin fly in terror, but are soon overpowered and destroyed before whose deadly advance the

largest serpent is driven, and if gorged soon falls a victim to its countless hordes, in whose presence horses and mules become unmanageable.

On occasion of their visits, families have to leave their houses, only to return and find their visitors their greatest friends, being as they are the certain death of every noxious and unclean intruder within the sacred domestic precincts". Of course it is not only the large and formidable mandibles which fitted them for that kind of food, but it is also the nature of the food itself that made them possess that sort of mandible, as most naturalists hold.

So Schmucher in his book, "The meaning ~~of~~ of Evolution" says; "The modern scientist feels sure not only that the animal is fitted to his work, but that he has been so fitted by the work, that the very use he made of his organs has determined their structure. This work has decided that the structure which he has is the structure that shall survive ~~and~~ shall produce other structures like itself. Adaptation therefore does not simply express the idea that the animal is adjusted to its surroundings, but it further suggests that the animal by gradual processes has become thus adjusted. The word adaptation applies not simply to the result, but also to the process"

So in this case I am perfectly sure that both the nature of the food and the mandibles themselves have fitted the animal for such a life.

Before passing over to the consideration of the subject of food at length, we should not lose sight of the correlative variation found here. With this formidable ^{mandible} we also have an enormously large

head.

The driver is not the only species that live on insects. There are others besides, that live also on insects and especially on the larvae and pupae. Others again live eating even on the dead carcass of an ant. In Cambridge Natural History Vol. 11 on insects, the author, mentions, "Tapinoma erraticum," of the sub-family Dolichoderides and says.

" Our knowledge of it is due to Forel, who has noticed that it is very fond of attending the fights between other ants. Here it plays the part of an interested spectator, and watching its opportunity drags off the dead body of one of the combatants in order to use it as food."

I have observed several times a group of small ants dragging a part of a cricket or a beetle to their nests after killing and tearing the victim. So, it seems to me, that the habit of eating the flesh of animals is almost universal in ants except among very rare ants, as I shall presently show.

Yet since insects and nitrogenous matter are not always easy of getting, the ants have to adapt their lives to another mode of existence. This we find first expressed in some ants by their capacity of eating almost everything they find. This, to my mind, took place originally in time of scarcity of food when ants were held to attack each other by the severe call of hunger.

With this struggle came migration and the consequent divergence of type, owing to the isolation of the groups. Some of the ants were led to an omnivorous type of life, other diverged towards a certain

kind of specialized life.

As a vindication of my position, mention may be made of the fact that we find three types of ants:

- (1) Ants eating almost everything i.e. omnivorous. This is found almost among all the small kinds of ants i.e. the house ants.
- (2) Ants which feed on vegetables only. The writer of the Cambridge Natural History says that "Some species of ants appear to find both food and shelter entirely on the trees they inhabit, the food being usually sweet stuff secreted by glands of the plant"¹. *This I have found in the acacia trees in Seyroul.*

Professor Justus Weston Folsom author of the book: "Entomology with special reference to its Biological and Economic aspects", says after speaking about some of the nesting habits of *Atta Aecodoma*, "wherever they are it is impossible to grow oranges, coffee, mungo or other trees. They attack flowers, fruits and especially the leaves. Moller found that these ants grow fungus upon these leaves, and use it as food. The bits of leaves are kneaded into a plumpy, spongy mass, upon which the fungus at length appears. The food for the sake of which the ants carry on their complex operations consists of knobbed ends of fungus threads, and these bodies, rich in fluid form the most important, if not the sole food of the leaf cutting ants.

By assiduously weeding out all foreign organisms the ants obtain a pure culture of the fungus, and by pruning the fungus they keep it in the vegetative condition, and prevent its fructification; under exceptional circumstances however, the fungus develops aerial organs of fructification of the agaricine type, but this species

(*Rozites Jongylophora*) has never been found outside of ant's nests. The peculiar clubbed threads were produced by Moller in artificial cultures and are not spores, but products of cultivation".

Again the same author says that, "Other ants are known to cultivate other kinds of fungi for ~~for simpler~~ similar purposes."

Then he says, " *Atta septemioxalis* cuts the needle-like leaves of seedling pines into little pieces, which are carried to the nest".

Then ~~says~~ he says that at the end of the nest there is a chamber in which are several pulpy balls, consisting probably of masticated leaves". These leaves whether of the pine kind or not, and whether kneaded or not are used to serve as substrata on which the ants grow the fungus. Sometimes the fungus substrata is plastered to the roof so that the fungus knobs are turned upside down and look like curtains.

The writer of the article on ants in the *Encyclopaedia Britannica*, says, that the knobs of this mushroom are white and that the *Atta* weed out the mould and the bacterial growths, and that when the fungus is grown elsewhere than in ant's nests it produces conidia instead of white masses are on which the ants feed, hence it seems that these masses are indeed produced as the result of some unknown cultural process.

Again in the same article the writer says, that, " Other genera of South American ants *Apterostigma* and *Cyphomyrmex* make similar fungal cultivations, ~~as~~ but they use wood, grain, or dung as the substratum instead of leaf fragments".

Then he says, " that such kinds of ants do not eat any other food or the fungus of other species of ants even if they die of starvation.

CHAPTER VII.

A D A P T A T I O N S O F A N T S T O T H E G E N E R A L
C O N D I T I O N S O F L I F E

(C O N T I N U E D)

FOOD (Continued)

Now, this kind of life, certainly has been reached through modification of mouth parts, and scarcity of food, as I shall presently prove after discussing the mode of food-finding or storing of the harvesting ants which abound here in this country.

I have observed several nests of the harvesting ant in this country, at least 30 nests of different species differing in colour and shape. I have observed the mouth parts very carefully. I have found that the mouth parts of the members of the community differ, not so much in structure as in size.

The mandibles are powerful, yet they do not so much converge to a point and they are flattened at the end like the edge of an axe, dentate a little at the inside. Now such mouth structures does not fit the animal for life of exclusively nitrogenous matter, because of the inability of the jaws to tear as I here experimented with them:

I let an ant bite me, which she did very pugnaciously, yey she was not able to tear a part of my skin.

I brought an ant from another nest and put it in, at the entrance of another nest near by; at once the stranger ant was attacked and the attacker took hold of one foot of the intruder, yet she was unable

to extract it, although I had the patience to observe ^{them} for more than 20 minutes, and then I left them, because I happened to be busy that time.

Now had the mouth parts of this harvesting ant ^{been} fitted for tearing bodies of insects, it would have been very easy for her to tear the leg of her enemy. This is why the harvesting ant and others which I shall duly mention have led a vegetative ^{to} life.

The harvesting ants, gather the seeds of the grass family especially, and strip off the husk of the green seeds and pile them in heaps near the nests. This I have observed myself. These seeds are brought out of the nest to dry up and the growing place is gnawed to prevent its germination. Yet there is a special kind of plant of the grass family called the ant rice of *Aristida Oligantha* on which the harvesting ant almost exclusively lives. Here opinion differs very much. Some hold that the ants themselves sow the seeds of this kind of plant and prevent the growth of any foreign plant near it. Others including Dr. Wheeler and the writer of the article on ants in the *Encyclopaedia Britannica* hold that it is not true that the ants sow the seeds, and ^{that} this is a misobservation.

FOOD CONSERVATION:

Dr. Wheeler in an article in the *National Geographical Magazine* (Vol. XXIII, No. 3 August 1912, Washington) says: "If the food is solid, minute particles of it are rasped off by means of the tongue and pressed into a small pocket in the ~~top~~ floor of the mouth. The juices expressed from the mass are then sucked back thru the gullet into the dilated portion of the alimentary tract, the crop; and the useless, pellet is spit out. The crop is very distensible, but thin walled and lined with a

layer of chitin, which is impenetrable to the liquid contents, so that none of the ~~contents~~ food, so long as it is stored in this receptacle, can be absorbed or digested. The crop is closed behind by a complicated valve, which separates it from a short, bag-like stomach,. The walls of which have a permeable lining, so that it and the succeeding portions of the alimentary tract, the intestine are able to digest and absorb any food which may be permitted to enter them through the valve. " This, of course, applies to almost every ant, the harvesting ant included.

Dr. Wheeler states that it is the lack of insects that led the harvesting ant to live on plant. Yet, to my mind, it is very strange that these ants, aware of the benefits they would get out of the aphids, should keep them and avail themselves of them, breed them and take the utmost care of them, and how is it that they should neglect the breeding of insects for their food,. So it seems to me, that it is not probable that ants were led to the ~~best~~ ~~vegetation~~ vegetative life owing to the scarcity of insect food or nitrogenous matter only. There must be some other reason for that. I mention this by the way, since I shall treat of it at length at the end of this heading on food.

It remained for me here to mention as a case of divergence in the matter of food, from common ant-type, the honey-ant. In the Cambridge Natural History, the writer on the article on ants says, " The honey ant of the United States and Mexico has been investigated by M'Cook and others, the chief peculiarity of the species is that certain individuals are charged with a sort of honey till they become

enormously distended, and in fact serve as leather bottles for the storage of the fluid.

The species *Myrmecocystus hortideorum* and *M. melliger*, are moderate sized insects of subterranean habits, the entrance to the nest of the *M. hortideorum* being placed in small raised mound. The honey is the product of a small gull found on oak leaves and is obtained by the worker-ants during nocturnal expeditions, from which they return much distended; they feed such workers left at home as may be hungry; and then apparently communicate the remainder of the sweet stuff they brought back to already partly charged "honey-bearers" left in the nest. The details of the process have not been observed, but the result is that the abdomens of the bearers become distended to an enormous extent, and the creatures move but little, and remain suspended from the roof of a special chamber. It is considered by M. Cook that these living honey tubs preserve the food till a time when it is required for the purposes of feeding the community. The distension is produced entirely by the overcharging of the honey crop, the other contents of the abdomen being forced by the distension to the posterior part of the body.

Others beside this ant, live on juices of special trees and guard it against the attacks of any enemy. Now to make the problem brief and clear:

The matter of the choice of food by ants is exactly similar to that of man. Man in his primitive state has been a flesh-eater, so ants were. We can still see human tribes lead a wild life, eating flesh of animals and even the bodies of each other. So it is among ants. Dr. Wheeler in his article on ants in the National Geographical Magazine says, "Most of the species of the oldest, most primitive;

and most conservative sub-family. Poneridae, have not been able to relinquish their carnivorous habits, and have therefore been prevented from forming large colonies".

The driver ant still lives on insects. Just like man also, ants still eat-riish meats. Again, just as the local distribution of man led him to consume a particular kind of food, for examples rice in Japan and China, vegetables in the Tropical countries, meats in the Northern and cold countries, so it is with ants. Buckle in his "History of Civilization" in England points out that it is the physical aspects of nature coupled with its available food produce that led to this divergence in the constitutions and ways of living of man. The same thing holds true among ants.

I believe that ants have once been confined to a locality, without any bond, leading solitary lives, yet in hordes, just as we find in the primitive society of men, some of the present wild tribes, and also among some mammals (e.g. the Zebra tribe, and also the bison in America, birds everywhere etc). Scarcity of food coupled with some local accidents, like the abundance of enemies of the like, led them to disperse in groups for search of food, and to migrate to more or less distant parts.

This instinct of migration is still flourishing among some of species, e.g. the Driver-ant of Africa. This led them to choose their food. Some were able to reside in an agricultural state, some still kept on leading a nomadic life. The length of the individual life coupled with the long life of the colony led them to learn by experience the use of some food. Others led a subterranean life and by accident fell

upon fungus and learnt by experience again to cultivate it and gradually learnt to improve it.

Yet to this theory, it might be objected that the present distribution of ants on the face of the Earth explode the hypothesis in consideration, since it indicates that there has never been any such a thing as a place gathering all the communities of ants.

To this I may answer that the primitive ants have been all winged and probably they have evolved from the allied hymenopterous bees as mut ants, and they have met the same fate everywhere. That is to say, each group in each locality met the same processes that tended to make them all similar to each other. Some of them have been more evolved than the others. This is glaringly apparent in the case of the polymorphism which is mostly met in ants and aphids.

LinVelle and Kelley in their book, "General Zoology" say "Variation in form, size, and color between individuals of the same species is spoken of as dimorphism, if the variation shows two well marked types; and polymorphism, if there are several different variations". Now in almost every Colony of ants we meet with at least three kinds of individuals; males, and females, which are sterile females with undeveloped ovaries. In some species there are more than one kind of workers. In others there is a type whose exclusive function is military i.e. soldiers. The reasons for this differentiation I shall discuss in another chapter.

Other than the probability that ants have been diverged thru

scarcity of food, the development of wings, it is also probable that this divergence might have come thru the strong winds. By this I mean that, strong winds might have carried, eggs, larvae, pupae or even ~~in~~ ^{mag}agoes to more or less distant regions, and that this divergence in type might have partly come thru that,. The lightness of the body of the ant strengthens this view. I have observed, myself, ants carried by winds from one place to another .

CHAPTER VIII.

ADAPTATIONS OF ANTS TO THE GENERAL
CONDITIONS OF LIFE
(CONTINUED)

HABITAT OR NESTS:

What has been said regarding the origin of the ^b habits of ants in devoting their lives to one kind of food apply as well here in the case of their habits with regard to nests.

Nests are generally speaking. of three kinds. (1) nests built in earth ^{(2) nests built on trees} (3) Nests built on other materials such as crevices in walls, wood of a closet, ect.

(1) Regarding the nests built in earth they are of two kinds with modification of each: (a) ant-hills, (b) nests built under the ground with no hills over it. What applies to all of these is that each nest consists of chambers connected with each other by corridors and having ^{rooms} stones, two or three connected with each other by corridors. The upper chambers serve for the newly hatched ^t

larvae, the lower for the pupae . There are chambers for the storage of eggs, others for the storage of food.

The chambers are arranged in such a way as to receive the greatest heat. So, the workers are continually active in transferring the young from a lower chamber to a higher one in the winter mornings to make them receive the greatest available amount of heat of the sun, and at night they are again taken to the innermost chambers to make them warm. The extension of these kinds of nests ^{is} sometimes enormous, reaching the incredible length of tens of feet and depth of ten to fifteen feet below the ground, the object of this as the writer of the Cambridge Natural History says, is, " to have access to sufficiently moist ground earth, for ants are most sensitive to variation in the amount of moisture; a quite dry atmosphere is in the case of many species very speedily fatal."

This system of underground labyrinths is sometimes accompanied by above ground buildings consisting of earth more or less firmly cemented together by the ants; this sort of dwelling is most frequently adopted when the soil in which the nests are placed is sandy; it is probable that the earth is in such cases fastened together by means of a cement produced by the salivary glands of the ants, but this has not been determined with certainty".

I have personally observed this cemented ground of the ants nest of the red kind of the harvesting ant here in Beyrouth near the fields of the pigeon Rocks. The area around the entrance of the nest is so firm and clean that I could not crush it with repeated heavy ^{beats} ~~blows~~. Indeed, it is very strong, and I think that the ants themselves must have applied a kind of cement to that.

I have also observed the black kind which bends its abdomen over its anterior part. It was constructed in a rocky road near the Municipal Hospital near the sand. I unearthed the nest, and found to my surprise, many radiating chambers. I could not dig all the nest, since it was in the rock and it was with great difficulty that I could see few larvae and pupae, after I exposed myself to the jests of the passers-by.

The robber ant, owing to its small size lives in small chambers inside the nests of *Formica Fusca* and tries to rob the larvae of the host. On the authority of the Cambridge Natural History, "The Samba or Saura ants of South America (the genus *Atta* of some, *Aecodema* of others) appear to be most proficient in the art of subterranean mining. Their ~~symptoms~~ systems of tunnels and nests are known to extend thru many square yards of earth, and it is said on the authority of Hamlet Clark that one species tunnelled under the bed of the river Parabyia at a spot where it was as broad as the Thames at London Bridge".

Some species have one entrance to their nests, other have more than one. Here in Beirut we have examples of ants which have more than one nest. In the college ground near the Presidents' office opposite the book store I observed, ~~threeweek~~ three weeks ago a nest of ants, ~~inspite-of-the-fact-that-the-nest-stial-exists~~. After one week I could not find a single ant in the nest, inspite of the fact that the nest still exists. The same thing I have observed in other nests, in three ~~at~~ others at least, one at the pine-grove near Fourn-el-Shibback, the other two near the fields of the pigeon rocks near the Bayyehom quarter.

That such kinds of nests exist, is vindicated by the following statement of Sir John Lubbock in his book "Ants, Wasps and Bees"; - - - - -

" Very often indeed a community has only one dwelling, and in most species more than three or four. Some however form numerous colonies. M. Forrel even found a case in which one nest of *F-ensecta* had no less than two hundred colonies, and occupied a circular space with a radius of nearly two hundred yards."

(2) As to the ants that build their nests on trees, there are some that build them inside the hollow thorns that project from the tree and make very small holes through which they either enter or leave. Others again live inside a nest made of plastered leaves. Here an ant takes two leaves together, while another carrying a pupa, applies it to the edges of the two leaves and thus plasters them together.

In the Cambridge Natural History the author says, " Forrel has observed that in the tropics of America a large number of species of ants live in the stems of grass". Then after that he says, " The tropics also furnish a number of species that make nest of delicate paper, or that again spin together by means of silk the leaves of trees. One eastern species - *Polyrhachis spiniger* - fabricates a gauze-like web of silk, with which it lives in a subterranean chamber after the manner of a trap-door spider".

I have observed while I was in Egypt some species of ~~man~~ small ants make their nests in pots in which some plants were planted. Some of the plants died, other flourished, In unearthing some nest, I have been able to notice the nest and the way they have eaten up the root of the plant of which they kept a small part, evidently to furnish them with moisture, in spite of the fact that I was watering the plant, all the time. Here, I believe that the nest was made in such a way as to make the water ineffective in destroying their nests.

(5)

(3) Regarding the other kinds of nests, I have observed them make their nests in walls, in drawers, in closets, in boxes, ceilings etc

CHAPTER IX

NESTS (CONTINUED)

HOW THE NEST IS ORIGINATED OR BUILT

Usually the female queen is the first to originate or build the nest. Yet there are three ways for the queen to build a nest, or in other words, to start a colony.

(1) The queen may strip her own wings after the mating season and then seek a crevice and hide herself in it, and there lays her eggs. She keeps on with the eggs till the first brood hatches. During that time which may extend over four months or more the female queen does not eat anything except that she avails herself of the fat in her body and the muscles attached to her wings.

The first brood is naturally small in size. With the first brood the queen proceeds to enlarge the nest, making new chambers and galleries as usual. Yet after the workers have developed their bodies, all the feeding of the younger ants, the queen, taking care of the larvae, and pupae, fall upon their shoulders. It is the workers who take the function of keeping the nest in order, enlarge it and defend it.

(2) Again the queen may not be able to build a nest, and in this case she may enter a nest of a foreign species or a nest of a colony of her own kind. In this case one of two things are probable to take place. Either the queen kills the old queen-host or probably set her

to flight and kills or threatens any worker ant which might attack her. . . it is probable also that the workers themselves may kill their own queen.

In an article on the " Origin of Slavery" Among ants, published in the Popular Science Monthly (Vol.71 Dec. 1907) by Dr. Wieber Morton Wheeler of the American Museum of Natural History, says, that, " in *Formica difficinalis*, Variety Corscians, the fertilized female of the ant quite unable to find a colony unaided, enters a colony of *Formica Schaufssi* var. *incerta*, and is adopted with surprising facility. The old queen disappears with an unknown method.

In this case the queen of the host species is probably put to flight at the time the Sanguineous queen enters the nest". The new queen lays eggs which are taken care of by the old workers, who, after dying, the whole community gradually becomes of one exclusive species." The writer quoted above again says, " Sautschi has recently made the illuminating discovery that the queen *Bothriomyomen*, after entering the nest of *Tapinoma*,

actually decapitates the queen of the host species and is adopted in her stead.

"The *Formica Sanguinea* female queen enters a *Formica* colony belonging to some variety of the *F. Fusca* or *Schaufssi* group, kills or puts to flight the workers that attack her and hastily appropriates a number of worker larvae or cocoons." In these cases the workers and queen live in an already made colony.

(3) The third method of originating a colony or nest is by means of the workers taking a queen by force after the mating season and strip her of her wings and oblige her to live among them for the benefit of the community.

In all these three kinds of originating a nest, the queen may live with her own species or may live, as we have seen with another species. Having now discussed the originating of nests I shall now proceed to speak of the special adaptations provided for defending them against, and attacking their enemies.

CHAPTER X

ADAPTATION OF ANTS TO THE GENERAL
CONDITIONS OF LIFE (CONTINUED)



ADAPTATIONS FOR OFFENCE AND DEFENSE

Before proceeding to discuss this subject I must confess that I find it very difficult to alienate the life of the individual from the life of the species. The individual here is so bound with the community that it is impossible to consider him alone, without at the same time, taking concern of the community.

Now, it is the small body of the ant that made the individual ant act in concert with the whole community. So, to my mind, the gregariousness of ants is one of the first means of defending themselves against enemies.

In fact, it is the most numerous ants that are more flourishing than others. Some of them, for the same reason perhaps have taken to a community life with other communities. M'Cook has observed in the Alleghanies that *Formica exsectoides* forms colonies of enormous extent, and including an almost incredible number of individuals. In one district of about fifty acres there was an ant-city containing no less than 1700 of these large ant hills, each one teeming with life" It was found by transferring ants from one hill to another, that no hostility whatever

existed between the ~~different~~ denizens of different hills; the specimens placed on a strange hill entered it without the least hesitation.

The second method is by differentiating the individuals of the community into workers and then later on into soldiers and even officers. Rev. Farren White after discussing the relative size of the heads of several ants says, " Though in the colonies of the British species we do not find any of these large-headed individuals, yet, as a rule, the size of the workers varies considerably, and in some it is much more marked than in others. As an instance I would call attention to *Formica Sanguinea*

In the nest of this ant we find some very large workers, who make their appearance and stand in a threatening attitude at the entrances and in the environs of their dwellings, prepared to resent most determinedly all intrusion upon their privacy." In Cambridge Natural History the author says, " In addition to the male and female individuals of which the species of insects usually consist, there are in ants workers of various kinds, and soldiers, all of which are modified infertile females.

In another type of ants, there are some types that do not do anything except to keep order among the ants that are making the raids. To me, this ~~same~~ seems to be a cause of polymorphism.

The third method of defending or setting themselves against enemies is by means of the sting and the poison and the mandible. Some species have their sting as the red-hot needle, others have stings even dangerous to man. Regarding the poison they have, it is said that some species kill each other by means of throwing that poison ~~at~~ a distance. Another kind of ant has a peculiar method of attacking an enemy: The author of Cambridge Natural History says that *Tapinoma Erraticum*, although destitute of all power of stinging, this insect has ~~acquired~~ a very useful means of defense in the oval glands with which it is provided; these

secrete a fluid having a strong characteristic odour, and possessing apparently very noxious qualities when applied to other ants.

The *Tapinoma* has no power of ejecting the fluid to a distance, but it is very skilful in placing this odorous matter on the body of an opponent by touching the latter with the tip of the abdomen; on this, being done, its adversary is usually discomfited.

As to the mandibles it is among the workers and especially the soldiers that we find the most formidable mandibles. Some are used for tearing the bodies of enemies, others are used for crushing the heads of enemies. Some mandibles are dentate or having spires from the inside as in the *Myrmica pyriformis* which is the most formidable of all ants, owing, as I said before., to its dangerous sting, which, when used on the human body, is said to give rise in some cases to serious consequences.

The fourth method of defending themselves against and attacking enemies is by means of waging wars. As this subject is connected with another feature of the ant life viz:- Parasitism- I shall treat of both together, since parasitism and slavery are as I believe- features in the ant-life intended for defense, as well as offense, although there are evidences in favor of the view that they are for taking care of the life of the community as a whole and not for the individual.

However, granting this latter view, I have already intimated in a previous chapter, that the life of the individual is inseparable from the life of the species.

As the views on the subject of parasitism and slavery differ very widely, and as the literature bearing on the subject here is very scanty,

I shall rely upon the views entertained by Dr. Wheeler in his article upon, "Origin of slavery and Parasitism among Ants", in the Popular Science monthly of 1907, after & of course considering their behaviour in war .

CHAPTER XI

A D A P T A T I O N S F O R O F F E N S E A N D D E F E N S E

(CONTINUED)

WAR AMONG ANTS:

Wars among ants, are conducted in different ways. The Driver-ant of West Africa, for example as described by Savage, on the authority of Romanes, "keep down the more rapid increase of noxious insects and smaller reptiles; consume much dead animal matter, which is constantly occurring, decaying, becoming offensive, and thus vitiating the atmosphere, and what is by no means the least important in the Red Terrid Zone, often compelling the inhabitants to keep their dwellings, towns, and their vicinity in a state of comparative cleanliness. The dread of them is upon the living them. Their entrance into a house is soon known by the simultaneous and universal movement of rats, mice, lizards, Blapidae, Blattidae, and of numerous vermin that infest our dwellings. Not being agreed, they cannot dwell together, which modifies in a good measure the severity of the Driver's habits, and renders their visits sometimes desirable.

They move over the house with a good degree of order, unless disturbed, occasionally spreading abroad, ransacking one point after another, till either having found something desirable, they collect upon it, when they may be destroyed en masse by hot water. When they are fairly in the narrow limits of our beds or chairs."

Sir John Lubbock says, " These ants will ~~soon~~ destroy even the largest animal if it is confined. In one case Savage saw them kill near his house a snake four feet long. Indeed, it is said that they have been known to destroy the great python, when gorged with food and powerless. The natives even believe that the python, when after crushing its victim does not venture to swallow it, until he has made a search, and is satisfied that there are no Drivers in the vicinity.

It is very remarkable that these hunting ants are blind. They emerge, however, principally by night, and like some of the blind hunting ants of Brazil (Eciton vastator and E. erraticum), well described by Bates, prefer to move under covered galleries, which they construct rapidly as they advance. " The column of foragers, pushes forward step by step, under the protection of these covered passages, thru the thickets, and on reaching a rotting log, or other promising hunting ground, pour into the crevices in search of booty".

Rev. Mr. White says that from his personal experience the military instinct is not confined to the Eciton species we ^{first} have been observed to send out spies, or rather a small party, detailed for the service. Then he says that if the intelligence gathered by the scouts is favorable, the march commences in regular order, communications are maintained between rear and van. During a contest, should occasion demand it, carriers are despatched for reinforcements, that the officers, who are distributed at regular intervals along the line of march, are distinguished by very large heads. They are never found carrying either the young or the spoil of war, which consist of all kinds of soft bodied insects, etc.

Romanes in his book, "Animal Intelligence" after giving a statement

similar to that, says, " Forrel saw several of these scouts, (of *Polyergus* or *F. rufescens* of the Amazon) carefully inspecting a nest of *F. Fusca* which they have found, investigating specially the entrances. These are purposely made difficult to find by their architects, and it not unfrequently happened that after all precautions and inspections on the part of the invaders, an expedition fails on account of not finding the city gates. "

Romanes again, quotes Buchs^{er}'s excellent epitome of Forrel's observations in this connection, " The most terrible enemy of the Amazons is the Sanguine ant (*F. Sanguinea*), which also keeps slaves and thereby often comes into collision with the Amazons on their marauding excursions. It is not equal to it in bodily strength or fighting capacity, but surpasses it in intelligence; according to Forrel it is the most intelligent of all the species of ants. If Forrel for instance poured out the contents of a sack filled with a nest of slave species near an Amazon nest, the Amazons apparently generally regarded the tumbled together heap of ants, larvae, pupae, earth building materials etc., as the dome of a hostile nest, and took all imaginable but useless pains to find out the entrances therein, leaving on one side for this investigation their only object, the carrying of the pupae; but the Sanguine ants under similar circumstances did not allow themselves to be deceived, but at once ransacked the whole heap. "

Another experiment which Forrel made was to pour out a sack full of Sanguine ants near the nest of the Slave ant *Formica Fusca*, while a marauding expedition of the Amazon ant was approaching, and a desperate fight took place in which the Amazons were victorious.

Sometimes the Amazon ants divide themselves up into divisions for economy both of time and activity. Ferrel, according to a passage quoted by Romanes tried to establish the normal frequency of expeditions, and found that a colony watched by himself for a space of thirty days sent out no less than forty-four marauding excursions. Of these about eight and twenty were completely, nine partially, and the remainder not at all successful.

Regarding Civil Wars among ants they are also said to take place. The Amazons according to Ferrel on the authority of Romanes tear each other with incredible fury, and knots of five or six individuals which have pierced each other may be seen rolling over each other on the ground, it being impossible to distinguish between friend and foe.

As to the method used by the Sanguine ants in their marauding excursions, it is most wonderful. The Sanguine ants divide their army up into small detachments. They keep communicating with each other by means of scouts, going and coming. When they reach their destination, each troop keeps or guards an entrance of the nest which is going to be plundered. They wait till reinforcements come. Then they make a blockade or a siege around all the entrances of the nest, not permitting any member of the besieged community to come out with a pupa or larva. They do not attack the enemy as do the impetuous Amazons, but wait till all the inhabitants of the nest come out, carrying nothing, then they enter the nest, carry all what they can without shedding a single drop of blood! Some detachments are appointed to follow the vanquished who may chance to take any larva or pupa. When they empty the plundered nest of its contents they return in order, without hastening, since they are afraid of nothing.

Büchner, on the authority of Romanes, relates wonderful things about ants in connection with their wars, and says that they sometimes came to a lasting alliance! He says that battles between ants of the same species often end with a lasting alliance, especially when the number of the workers on both sides is comparatively small. The wise little animals discover much more quickly and better than men, that they can only destroy each other by fighting, while union would benefit both parties. Sometimes they ~~drive~~ each other out of their nests in a quiet friendly way. Forel laid on a table a piece of bark with a nest of the gently *Leptochoran Acervorum*, and then put on it the contents of another nest of the ^{of the} same species. The last ~~carriers~~ carriers were by far the more numerous, and soon possessed themselves of the nest, driving out the inmates. But the latter did not know where to go, and turned back again. They were then seized by their opponents one after the other, carried away as far as possible from the nest, and there put down. The oftener they came back the further were they carried away. One of the carriers arrived in this fashion at the edge of the table, and often it had by means of its feelers convinced itself that it reached the end of the world, mercilessly let its burden drop into the fathomless abyss. It waited a little to see, if it had attained its object, and then turned back to the nest.

Forel picked up the ant which had fallen off the floor, and put it down right in front of the returning ant. The latter repeated the same manoeuvre as at first, only stretching its neck further over the edge of the table. He several times, reiterated his experiment, and

always with the same result. Later the two colonies were shut up together in a glass case, and gradually learned to agree".

The cruelty of ants towards each other is extremely awful. They render their victims defenseless by wounds, then tear them to pieces, first antennae, then legs, body etc.

Other ants have sentries to watch at their doors so that no enemy would approach without at once, being attacked. Lapsams according to Forel has a regular barricade flight. " Passage after passage is stopped and defended to the utmost, so that the assailant can only advance step by step. Unless the latter are in an enormous majority, the struggle may last a very long time with these tactics. During these times, other workers are busy preparing subterranean passages backwards for eventful flight. Generally such passages are already made, and during a fight a new dome of the Lapsams may be seen rising at a distance, it not being difficult for them to make this with the help of their extended subterranean passages and communications."

Other ants avoid single combats owing to their small bodies and fight as Forel says " in closed ranks". several of them gathering around an enemy.

On the authority of Romanes, again, Agricultural ants (i.e. harvesting ant) at times carry fierce wars with each other, especially in times of scarcity. Romanes quoted Megridge who says " By far the most savage and prolonged contests which I have witnessed were those in which ~~the combatants~~ the combatants belong to two different colonies of the same species... The most singular contests are those which are waged for seeds by A. barbara (i.e. harvesting ant), when one colony plunders the stores of an adjacent nest belonging to the

same species, the weaker nest making prolonged though, for the most part, ineffecient attempts to recover their property. In the case of the other species of ants which I have watched fighting, the strife would last but a short time a few hours or aday - but *A. barbara* will carry on the battle, day after day and week after week. I was able to devote a good deal of time to watching the progress of a predatory war of this kind, waged by one nest of *A. barbara* against another and which lasted for forty-six days from January 18 to March 14".

On the authority of Mc Cook whom Romanes quotes, " The erratic ants do not appear to ~~be~~ be held as common enemies by the agriculturalists, and they are even permitted to establish their formicaries within the limits of the open disk. Sometimes however, the diminutive hillocks which mark the entrance to an erratic ant-nest multiplying beyond the limit of the agriculturalist forbearance. But they do not decline war, now resort to any personal violence.

Nevertheless, they get rid of them ~~only~~ enough, by a regular system of vexatious obstructions. They suddenly conclude that there is urgent demand for improving their public domain. Forthwith they sally forth in large numbers, fall eagerly to work gathering the little black balls which are thrown up by the earth worms in great quantities everywhere in the prairie soil, which they bring and heap upon the paved disk until all the erratic ~~and~~ nests are covered. The entire pavement is thus raised an inch or so, and pains are taken to deposit more balls upon and around the domiciles of their tiny neighbours than elsewhere. The erratics struggle vigorously against this Pompeian treatment;

they bore thru the avalanches of balls only to find barriers laid in their way. The obstructions at length become so serious that it is impossible to keep the galleries open. The dwarfs cease to contend against destiny, and, gathering, together their household store, quietly evacuate the premises of the inhospitable giants. It is the triumph of the policy of obstruction, a bloodless but effectual apposition".

CHAPTER XII

ADAPTATIONS FOR OFFENSE AND DEFENSE.

(CONTINUED)

SLAVERY, PARASITISM, MYRMECOPHILISM:

Since these three subjects are intimately connected together and since they arose out of the necessity, for the life of the species as a whole, I shall treat of them in that connection. It is here and in their wars that we find the life of the individual ant inseparable from the life of the species. These methods of slavery, parasitism, etc. are subsidiary to the more urgent need of propagating the species. Therefore I shall ~~not~~ proceed at once to speak about the life of the species, reserving till the end of the chapter the discussion of the others.

I have already said that it is the female-queen that originate the nest. She, also, is the only fertile female in the nest that lays eggs. Since the male, after the mating season ceases to be of any value to the community he dies immediately. The mother sacrifices her pleasure

of flight , in stripping herself of her own wings and even remains for months without food for the sake of her young . Nay, she even sacrifices the future of her young in bringing up the first brood smaller in size than the latter ones who are destined to be tended by this first brood . Yet, as I said before, this is not the only method of building a nest. It is out of the other methods of making a nest, i.e. of leading a parasitic life upon others, of intrusism; ~~that~~ that the habit of slavery grew to be so strong in the lives of ants.

The female queen ant, in order, to preserve the life of the species lead a parasitic life. Dr. Wheeler in the very interesting article on the origin of slavery among ants discusses that point, and points out that , up till now, no specialist on this subject has been able to account for the origin of slavery among ants, since all researches, from Darwin till Wasmann, who is now considered to be ^{the} greatest authority on the subject, paid attention to the fact that, it is the queen that teaches the workers of the community this habit of slave making.

"Males and virgin queens are produced after the expiration of several years, when the colony may be said to have completed its ontogenic development." Then the writer of the above mentioned article goes on to discuss the different phases of parasitism among ants, and points out that the reliance of the queen on the workers, for taking care of her brood and herself, is the first step towards a dependent life . This led to two things:

Excessive or redundant type of parasitism known to occur only among the Attune ants of tropical America. The queen may choose a mate of another species and depend on the workers of this chosen male to take care of her. Briefly speaking according to Wheeler in this article the

way the queen establishes a community led to three kinds of social parasitism:

(1) Temporary social parasitism. In this kind of parasitism, the fertilized female of *Formica difficinalis* var. *consciens*, quite unable to found a colony unaided, enters a colony of *Formica Schaufussi* var. *incerta*, and is adopted with surprising facility. From this kind of parasitism the workers or the progeny of this new queen, who are destined to supersede, as I have previously shown, the old workers, learn from the queen the life of dependence on others. Little by little this develops in them a tendency to subdue other species and make slaves of them.

(2) The second type mentioned by Dr. Wheeler is what he calls "Slavery or Dulosis", where the queen (usually a *Sanguine*) enters a nest belonging to *Formica fusca* and sets to flight all those who offend or attack her and adopts the larvae or pupae and tender them till they grow to take care of her. It is this *Sanguine* which is famous for its attacks on the *F. fusca* and others, to make slaves of them.

Sir John Lubbock in his book, "Ants, Wasps and Bees", after mentioning the species enslaved by *Formica Sanguinea* and that they enslave *F. fusca* and *F. rufibarbis* quotes Huber to whom, as the author says, we are indebted for the existence of slavery among ants, who says of the *Polyergus rufescens*,

"On June 17, 1804, while walking in the environs of Geneva, between four and five in the evening, I observed close at my feet, traversing the road, a legion of Rufescent ants.

"They moved in a body with considerable rapidity, and occupied a space of from eight to 10 inches in length, by three or four in breadth. In a few minutes they quitted the road, passed a thick hedge

and entered a pasture ground where I followed them. They wound along the grass without struggling and their column remained unbroken, notwithstanding the obstacles they had to surmount. At length they approached a nest, inhabited by dark ash coloured ants, the dome of which rose above the grass, at a distance of twenty feet from the hedge. Some of its inhabitants were guarding the entrance; but on the discovery of an approaching army, darted forth upon the advanced guard. The alarm spread at the same moment in the interior, and their companions came forth in numbers from their underground residence.

"The rufescent ants, the bulk of whose army lay only at the distance of two paces, quickened their march to arrive at the foot of the ant hill the whole batallion, in an instant, fell upon and overthrew the ash - coloured ants, who, after a short but obstinate conflict, retired to the bottom of their nest. The Rufescent ants now ascended the hillock, collected on crowds on the summit, and took possession of the principal avenues, leaving some of thier companions to work an opening in the side of the ant hill with their teeth. Success crowned their enterprize, and by the newly made breach the remainder of the army entered. Their sojourn was, however, of short duration for in three of four minutes they returned by the same apertures which gave them entrance, each bearing off in its mouth a larva or a pupa."

Forel, on the authority of Romanes, on his ~~1875~~ book, "Animal Intelligence" says, "On an average a successful expedition would bring back to the colony a thousand pupae or larvae. On the whole, the number of future slaves stolen by a strong colony during a favorable summer may be reckoned at forty thousand!".

Sir John Lubbock says, "*Polyergus rufescens* present a striking lesson of the degrading tendency of slavery, for these ants have become entirely dependent on their slaves." Even they have lost the power of feeding themselves. Experiments were made by Lubbock and others to the effect that these ants die even in the midst of plenty, indicating that they have lost their power of independence.

(3) The third type according to the views of Dr. Wheeler in the above mentioned article, is what he calls, "Permanent Social Parasitism." He says, "The European *Anergates atrantulas*, parasitic on *Tetramorium caespitum* lacks the worker caste". In this case the queen enters another nest the workers of which kill their own queen ~~enters another nest/the~~ and adopt the new intruder as their queen. "It is not improbable" he says, "that all three of these derivative types, namely temporary, permanent and dulotic parasitism, have developed independently out of the primitive adoptive type of colony formation."

So, from this discussion, he conceives of the origin of slavery and parasitism among ants to be wholly due to the queen. He says, "The worker here inherits from the queen the instinct of entering the nests of the *host* species, and appropriate the young." He considers the failures of Darwin and Wasmann to account for the origin of slavery among ants to be mainly due to the fact that they attended to, and studied the workers only. It is the queen that always, plays the greatest part in the characters of ants, since the workers are sterile and cannot transmit such an instinct to the future generations.

MICOPHILISM:

Ants do preserve their lives also thru other insects dependent on them. Yet, unfortunately, besides the insects useful to them, there

have grown others apparently useless, and even injurious, to ants. Wasman has counted no less than 1500 species of these dependent insects. This whole subject, technically called, "Myrcophilism," has been thoroughly studied by him. I shall follow his classification as given by John Henry Comstock, and Anna Botsford Comstock in their book, "Manual for the study of Insects."

According to Wasmann, mycophiles are about 1200 species (although others relate of the same Wasmann, that he counts 1500 species), but not a few are spiders, mites, crustaceans etc. Wasmann divides them into five divisions:

(1) CAPTIVES:

This includes aphids, coccids which give the ants a kind of honey; The insect on being tapped by the antennae of an ant, produces from her alimentary canal a drop of honey which is licked by the ant. Aphids have a special season of migration. Ants perceiving that, wait till the whole aphid community moves and then carry them to roots of other trees near by and then take them to their nests and keep them, feed them and take care of their eggs till they hatch. They keep hedges around them to keep them from fleeing. Sometimes they let them go thru an underground secret road to a tree near by to graze on pasture.

"The honey", says the author of this book on entomology, "contrary to the prevalent accounts, is not furnished by the so called honey tubes of the aphids, but comes from the alimentary canal: The honey tubes are glandular indeed, but probably repellent in function".

It is most astonishing that the experiments made by some biologists in persuading the aphids to emit honey by gently tapping them proved utter failure. In the aforesaid book on Entomology, the author says, "In spring the ants tunnel to the roots of pigeon grass and smartweed

seize the aphids and carry them to these roots and later to the roots of Indian Corn". Wings of aphids are usually gnawed by the ants. With the aphids we find also in the nests of ants different kinds of scale insects.

GUESTS: (2)

INSECTS NEVER FOUND OUTSIDE THE NESTS OF ANTS:

Beetles notably Staphylinidae and Pselephidae. The rove-beetles make themselves useful by devouring refuse organic matter. Ants do not take care of these guests. *Locechusa* is one of these favored beetles, as it has abdominal tufts of hairs from which the ants secure a secreted fluid". *Atemeles* is another kind which feeds from the mouth of an ant just like an ant. I have myself observed these *atemeles* in two nests which I unearthed. Some of them ran outside the nests as I dug them, but could not go anywhere so they came back, but to find the entrances to the nests shut. The ants, to me at least, did not seem to pay attention to them, perhaps owing to the unexpected calamity which I caused to befall them.

Some beetles are blind (e.g. *clariger*), and seem to depend exclusively on the care of the ants, since they cannot feed themselves and even be in the midst of plenty. In Cambridge Natural History, the author says, "The greater number of these guests belong to the order ^U-elep Coleoptera, and of these there are many hundreds- probably many thousands of species that depend on ants for their existence. Again he says, "The most curious of all the ants' nest beetles are the *Panissidae*, a family exclusively dependent on ants, and having the curious faculty, when disturbed, of bombarding - that is, of

a small quantity of vapour of liquid in a state of minute subdivision accompanied by a detonation. "

VISITORS (3)

Some insects enter the ants' nests without being attended to, whether they stay or leave. Among these mention is to be made of Staphilinidae.

(4) Intruders:

"Staphilinidae and Histeridae which steal food from the ants, kill them or devour their larvae or pupae at any opportunity. *Quedius brevis* and *Myrmedonia*, as Schwarz observes, are soft-bodied forms which remain beside the walls of the galleries or near the entrance of a nest and attack solitary ants; while *Hetaerius*, which mixes with the ants, is protected by its hard and smooth covering covering, under which the legs and antennae can be withdrawn.

Ateleura has been described by Janet. It steals the food of the ants, while they are engaged in the operation of feeding each other". This kind of insect, Wasmann, on the authority of the author of the article in the Cambridge Natural History, calls *Synecethry*, including these insects etc. to which the ants are hostile, but which nevertheless maintain themselves in the midst of their foes.

(5) PARASITES.

"Nematode worms occupying the pharyngeal glands of ants, larvae of stylops inhabit their bodies, more than thirty kinds of mites attack themselves to the heads or feet of ants while Chalcididae and Procterypidae parasitize ants' eggs".

Wasmann calls the first type of myrcophilism: *Symphily* or true guests which are living in a symbiotic kind of life, Romanes says in

his book, "Animal Intelligence" quoting Petry in his "Intellectual Life of Animals".

According to Andebe, certain leaf-bugs are used as slaves by the ants in the Brazilian forests. When these ants want to bring home the leaves which they have bitten off the trees, they do it by means of a column of these bugs, which go in pairs, kept in order on either side by accompanying ants. They compel stragglers to re-enter the ranks, and laggards to keep up by biting them. After the work is done, the bugs are shut up within the colony and scantily fed".

The second kind of myrcophilism, Wasmann calls metochy: i.e. guests which are neither useful nor injurious.

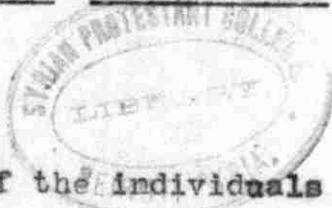
Having finished the general habits of life, among ant, let us turn to the more particular phases, which, as I believe are no more than adaptations to the needs of life.

CHAPTER XIII.

ADAPTATION OF ANTS TO GENERAL CONDITIONS OF LIFE. (CONTINUED)

CLEANLINESS:

As a means of keeping and preserving the lives of the individuals and species, ants are most scrupulous about cleanliness. The experiments of Sir John Lubbeck indicates that a stined ant would not stay a long time in the nest before it is well cleaned by its confrères in the nest. Pupae and larvae are all the time lickd and cleaned, clearly, as some suggests, for the main object of killing the microbes and keeping off the parasites. Rev. Farren Whites in his usual joking manner calls that, "The toilet of the Ant".



BURYING THE DEAD:

Ants do not tolerate seeing the dead in their own community, but try to bury them away from the nest, perhaps ^{for} fear of bad smell. Lubbock has proved that in his experiments. According to Romanes, Mrs. ^Hilton having killed a number of soldier ants, and returning half an hour afterwards to the place where the dead bodies were lying, she says, "I saw a large number of ants surrounding the dead ones. I determined to watch their proceedings closely. I followed four, or five, that started off from the nest towards a hillock a short distance off, in which was an ants' nest. This they entered, and in about five minutes they reappeared, followed by others. All fell into rank, walking regularly, and slowly, two by two, until they arrived at the spot where lay the dead bodies of the soldier ants.

In a few minutes two of the ants advanced and took up the dead body of one of their comrades; then two of hers, and so on, until all were ready to march. First walked two ants bearing a body, then two others with another dead ant, and so on until the line was extended to about forty pairs, and the procession now moved slowly onwards, followed by an irregular body of about two hundred ants. Occasionally the two laden ants stopped, and laying down the dead ant it was taken up by the two walking unburdened behind them, and thus, by occasionally relieving each other they arrived at a sandy spot near the sea.

The body of ants now commenced digging with their jaws a number of holes in the ground into each of which a dead ant was laid, where they now labored on until they had filled up the ants graves. This did not quite finish the remarkable circumstances attending this funeral of the ants. Some six or seven of the ants had attempted to run off without performing their share of the task of the digging, these were

caught and brought back, where they were at once attacked by the body of the ants and killed upon the spot. A single grave was quickly dug, and they were all dropped into it". Similar instances are related by Sir John Lubbock and Rev. Farsen White.

RESPONSE TO PARTICULAR STIMULI:

The white sunbeam when made to pass through a prism is analyzed into: violet, indigo, blue, green, yellow, orange, red. It has been found by experiments chiefly conducted by Sir John Lubbock that ants respond exclusively to some of these colors and try to avoid, for example the violet. This seems to me a case of adaptation of the species resulting either from its mode of living or from its bodily structure. Yet it has been proved by Sir John Lubbock that they do not avoid the violet for its chemical or actinic rays, but rather, for the light or perhaps the heat itself, since he tried experiments with carbon bisulphide and other chemicals effective in their chemical actions. The ants did not show any tendency to avoid the rearsness to the chemical compound, evidently proving that it is not a case of actinic rays.

Not only do they avoid violet, but also ultra-violet. Yet they have been, by experiments, haituated to stay under this color of the spectrum. In her book entitled, "Animal Mind" (a text book of comparative Psychology,) Miss Margaret Floy Washburn, Ph. D. says " The chemical sense in the animals lower than insects, has functioned chiefly as a food sense. There has been but little evidence of the development of qualitative discrimination within the sense itself." Then she says, " There is evidence that taste and smell are distinct in many insects". " Ants fed honey mixed with strychnine will taste it and then stop, and then stop, and will do this even when the antennae and mouth palpi are

removed , indicating that the taste organs are in the mouth itself".

This, of course, is a kind of differentiated response to a stimulus. It is thru chemical stimuli that ants find their food, and larvae. Even it has been suggested, ~~may~~ proved, that they find home and way-by means of smell, and not by means of sight. Bethe on the authority of the aforesaid Miss Margaret, tried to show that all ant behaviour is a series of unconscious reflexes to chemical stimuli; This has not been established, since Wasmann says, the reverse.

"Bethe points out that this chemical stimulus deposited by the feet of the ants is volatile. If a strip of paper be placed across an ant's path, the ants on crossing ~~it~~, it stop quest-about, and are delayed until one accidentally runs across an-ant's-path,- the ants the strip and others follow, (Why asks Wasmann, if they are being reflexly drawn along, do they not merely stop short when the stimulus fails, instead of hunting for it?) The piece of paper is thus gradually adopted into the ant road; if it is subsequently removed, the ants stop and are bewildered, at the place where it was, showing that the earlier traces of their foot under the paper , have evaporated.

Again Bethe thinks he has evidence that the chemical stimulus left by the feet of ants going from the nest is different from that deposited by those going to the nest, and that ants on the way home, will not follow a track made by the feet of other ants on the outward journey , and vice versa. Bethe found that when the usual road to an ant nest had been interrupted by the removal of a heap of sand, and the road across the breach had been established solely by incoming ants, the outgoing ants refused to follow it, and made a new road for themselves. Wasmann thinks this may have been done merely on account of the faintness of the recently established path as compared with the old one.

Bethe observed also that if a strip of paper had been adopted into an ant-road, and was then while an ant was on it rotated thru 180 degrees, the ant stopped and was disturbed on coming to the end of it".

"Ants of certain families (*Lasius*) which habitually make regular and frequent roads, can if they come upon one of these roads. In wandering, at once take the proper direction, either to or from the nest. Evidently the mere presence of two smells would not enable them to do this. Bethe suggests that the particles of the two chemical substances are also differently polarized, so that one of them can be followed only in one direction, the other in the opposite direction. Wasmann objects to this that an ant returning to its own traces would destroy them, as the opposite polarization would cancel; and that similar confusion would occur in a narrow and much frequented road. He and Forel both think that, granting the distinction between the outward and inward paths, which is made by only a few families of ants, the direction is most probably given by a perception of "smell or form" of the footsteps obtained thru the antennae".

CHAPTER XLV

INTELLIGENCE AMONG ANTS.

Professor Lloyd Morgan in discussing the subject of instinct in his book, "Animal Intelligence" points out that if ants observe the routine action of man and how he is acting according to order and system, they would attribute that to instinct. Therefore, he says, we should be on our great-deal guard in the discussion of the subject of instinct or intelligence among animals lower in the scale of life than ourselves.

Regarding the intelligence of ants there is a great deal to say on

both sides. I have already intimated in the previous chapter that opinions vary, and gave the extreme views of Bethe and Weismann. Lubbock's experiments tend to discredit them with intelligence and to show that their actions are mostly instinctive. Bergson the great French Philosopher of the day, discredits all insects with any intelligence, and considers the ant's behaviour, according to H. Wildon Carr in the summary of his views in the book "Henry Bergson, the Philosophy of Change," as purely instinctive. After discussing the mode of the perception of life in man and saying that this is mostly accomplished by intelligence he considers instinct an essentially different mode of perceiving life from intellect not only in function, but also in the kind of knowledge given.

He says, "when we study the behaviour of insects we find instinct brought to a perfection that rivals, or even surpasses, the intelligence of man. Especially is this so in the ants and the bees. These creatures represent the culminating point of progressive evolution of instinct. Their marvellous actions can only be explained by supposing that instinct is a quite different and, in a certain manner, opposite mode of mental activity to that by which we approach reality". The philosopher considers instinct and intelligence opposite and contrary to each other, since the one blocks the other. Intelligence is hesitation, delineation, representation of a picture in the mind before the action, while instinct is a stimulus followed immediately by the act, without perceiving the end in view. This is confirmed by Professor William James in his brief Text on Psychology, where he defines instinct as: "The faculty of acting in such a way as to produce certain ends, and without previous education in the performance. Instincts are the functional correlatives

of structures. With the presence of a certain organ, goes, one may say, almost always a native aptitude for its use."

Prof. Lloyd Morgan in his book "Animals: Life and Intelligence," differentiates between what he calls innate capacity and instinct, and says that "what is handed on thru inheritance is an innate, and not an individually acquired character." Then says he, "that the mental actions are not racial but individual and therefore do not come down to the progeny, since they are dependant on the circumstances of the individual which, undoubtedly differ from those entouring his progeny."

"Speaking of ants and bees Darwin pointed out that their instincts could not possibly have been acquired by inherited habit, since they are performed by neuter insects, by undeveloped females incapable of laying eggs and continuing their race. For a habit to pass into an instinct by inheritance it is obviously necessary that the organism which performs the habitual actions should be capable of producing offspring by which these actions might be inherited. But in this case the parental forms do not perform these instincts, while the neuter insects which do possess them are sterile." Then Darwin says, "The modification of structure or of instinct, correlated with the sterile condition of certain members of the community, have proved advantageous consequently the fertile males and females have flourished and transmitted to their fertile offspring a tendency to produce sterile members with the same modification. This process must have been repeated many times, that the prodigious amount of difference between the fertile and sterile females of the same species had been produced which we see in many social insects."

The aim of Darwin in that statement, is to apply his theory of Natural Selection in this case of instinct to the individual as

well as to the group. In discussing the views of Darwin of instinct in his book "Method of Evolution". H. W. Conn adds another factor to those of Darwin. Darwin here speaks of the factor of Natural Selection. Conn on behalf of Darwin and Romanes adds the factor of the "Lapsing Intelligence," by which is meant, that ~~will~~ⁱⁿ every instinct there is a little amount of intelligence. Conn on their behalf says:

Now if reason can thus modify the instinct of an animal may it not be that we have in this factor the needed agency to guide the development of instinct? In time the modification in turn becomes a part of inheritance and when this occurs the reasoning faculty no longer plays a part at this point, and the new modification of the habit of life becomes part of the instinct, the intellectual factor has "lapsed."

To make the long story short we must then inquire according to these discussions, whether ants' behaviour is surely instinctive or intelligent. Before giving a definite answer let us see what are the elements of pure intelligence and those of pure instinct in animals and see how much applies to ants:

Both instinct and intelligence have their sources in the senses. Let us then have a glance at the senses of ants:

CHAPTER XV

SENSES OF ANTS:

SIGHT:

Ants have two kinds of sight or eyes: ocelli; three in number, and two compound eyes having facets, the number of which differs in different species, thus offering cases of evolution and meristic variation which is according to Davenport in his book "Principles of Breeding"; that variation, which, "has reference to a deviation in the number or

arrangement of repeated parts involved in the plan or pattern upon which any particular organism is built". Thru these kinds of sight they can see to a distance of few inches.

TASTE:

Professor Morgan in his book, "Animal Intelligence" says, "the organs of taste in insects are probably certain minute pits, in ~~some cases~~ in each of which is a delicate taste-hair, which, in some cases, is perforated at the free end. They occur in the maxillae and tongue, in ants and bees, and on the proboscis of the fly etc." I have also shown in the chapter on ~~Responses to Stimuli~~ "Responses to Stimuli" something related to this heading.

SMELL AND TOUCH:

In the articles on ants in the Encyclopaedia Britannica, the writer says "Recent experiments by A. M. Field show that an ant follows her own old track by a scent exercised by the 10th segment, is guided to the eggs, maggots and pupae, which she has to tend, by sensation thru the 8th and 9th segments and appreciates the general smell of the nest itself by means of organs in the 12th segment."

HEARING:

Sir John Lubbock has tried all kinds of musical sounds with the ants, but he was unable to make the slightest appeal to them. He inferred that they do not have the sense of hearing and perhaps no ear. Yet the existence of ants that emit sounds throw some doubts upon Lubbock's ^{experiments} which certainly have been limited to few species.

"Certain East Indian ants are reported to make a loud hissing noise when disturbed, and some American species are said to chirp." Field and Parker's experiments tended to confirm the following:

The only vibrations responded to were those which were communicated thru the legs." This is a primitive sort of ear. However it indicates

the existence of an auditory organ of perception." The chirp of the ant is considered to be a call for one of the sexes. In this case some ants at least possess auditory organs.

Now, all these senses exist also in higher animals, although differ in degrees, but what do we see? In spite of the apparently deficient ~~in~~ *ants we see that they have perfected* instruments of leading a very highly efficient life. Therefore this highly efficient order and system of life among ants cannot be attributed to such factors of intelligence, and we must seek for others. I have, thus far, considered every thing pertaining to these insects as intended in the first place for the benefit of the race. Let us see whether there is any mental content which usually forms the bulk of an intellectual life.

CHAPTER XVI

FACTORS OF THE INTELLECTUAL *Life* (CONTINUED)

The factors that indicate an intellectual life are : memory, communication, emotion, education, sociability and judgement. Are these existent in ants and how far? Yes, and to a large degree. Let us see.

Memory.

Ants know their way to and from the nest, even if we efface their foot-points. They recognize each other after the lapse of even months. They learn by repetition as has been proven by Sir John Lubbock. Romanes on the authority of Karl Vogt relates in his book, "Intelligence" that "Ants from a certain nest used to go thru certain inhabited streets to a chemist's shop 600 metres distant, in order to obtain access to a vessel filled with syrup. As it cannot be supposed that this vessel was found in successive working seasons by as many successive accidents, it can only be concluded that the ants remembered the syrup stove from season to season!"

Communication.

Ants communicate with each other thru the antennae. Lubbock, Rev. Farren White, Huber, Forel, and almost all experimenters have *credited* ants with a sort of communication power. An ant for example, finding a heap of larvae, would go and tell her comrades who come following her in groups. The same thing takes place when food is found, and when enemy is encountered, and a dead is found etc.

Romanes considers that such communication is, "not detailed, and probably is no more than "come." S. J. Holmes ph.D. in his interesting book "Evolution of Animal Intelligence" says, "Some power of communication has been abundantly shown, but for the most part, it consists of signs instinctively made under certain conditions and which are instinctively responded to by other ants."

"Wasman has compiled a sort of vocabulary of signs made by the antennas in a "Worterbuch der Fuhlsprache," according to the vigour and frequency of the strokes of the antennas, and the part of the body stroked, the ant which is addressed may be importuned for food, warned of danger, or induced to cooperate with the communicant in various activities."

TRAINING OR EDUCATION:

Ants have sports which they teach each other. The faculty of imitation is highly developed in them. Holmes says, "According to Wasmann, not infrequently ants imitate one another's acts, and other observers have remarked upon the same proclivities in bees and termites." I have already said that ants learn to be used to ultra violet rays. Wasmann taught them to discard their fighting attitude in an artificial formicarium.

EMOTION

It is very difficult to speak of this subject. Moggridge, on the authority of Romanes, is of opinion that the habit of throwing a sick and apparently dead ants into the water, is, in part to be rid of them, and partly, perhaps, with a view to effecting a possible cure, for I have seen one ant carry another down the twig which formed their path to the surface of the water, and, after dipping it in for a minute, carry it laboriously up again and lay it in the sun to dry and recover it!

Mr. Belt made some experiments by placing a stone on certain ants. When ants of the same nest saw this they soon came in numbers enough for the occasion after certainly communicating with each other, and rescued the unfortunate.

JUDGEMENT:

Certainly they have that faculty. It is enough for me here to mention the remarkable cases of building bridges. Sometimes they form chains held-a-branch and by the gentle ~~branch~~ breeze of the air make the end of the chain hold a branch of a tree on the other side and let the others pass, or again bring small pieces of wood and mount them and use their feet as oars.

CIVILIZATION AND SOCIETY:

Ants, as I have previously said, are the most intelligent animals after man. There are gradations in the civilized states of man illustrated by different tribes. The same thing is found among ants. We have seen that they have carnivorous species, herbivorous and also omnivorous species as we find among man. One of the most difficult problems of man, and which, had not been solved, and perhaps will never be solved by him, is the matter of the distribution of food. Every body is still suffering

from the injustice and inequality consequent~~y~~ on the unjust distribution of wealth.

Among ants, there is no such a difficulty. Everybody is receiving his share. Everybody is sharing the same position, the same property, the same position, the same property, the same ideals. Everybody is equally patriotic as every other member of the same community. There is no need for a "super ant" as we speak of "supermen." They have solved the problem of the increase of numbers by means of rendering the greater part of the community infertile. From the primitive state of flesh-eating to the cultivation of one plant with the multip~~l~~ifarious actions, one sees no equal process in the animal evolution of life except in man.

To come to our main point, are the ants endowed with intelligence. ? I have brought arguments in favour of both views, and have shown that it is difficult to give more weight to either one without extending the investigations and researches more deeply.

On my part, I believe that ants are endowed with a remarkable degree of intelligence and that they differ from all other animals in the many activities and fields to which they apply their endowments.

Ber^son believes that instincts are wholly devoted to small^o field of action. That is true so far as other animals than ants are concerned. We have seen that they show a remarkable differentiation of action under different circumstances, which agrees remarkably with the mental behaviour of man. The eye of the squid which is a crustacean, is exactly similar to that of a vertebral animal. This is a case of what biologists call "convergence". So it is with ants. Perhaps they are endowed with a kind of intelligence similar to that of man. Indeed, I believe that they are even endowed with a racial mind. This I shall show in the subsequent chapter on causes of Polymorphism.

CHAPTER XVII

CAUSES OF POLYMORPHISM:



It is not the tendency towards individualization in man, that led to his enormous knowledge of racial experience. Rather, it is the experience of the individual, as a member of a group that made him gain racial experience. So it is not individual intelligence that gives insight into the nature of society, but it is the social experience among the group that modified ones conception of society.

We do not speak of social or racial experience among wild animals that live individually and singly. Even among the savage tribes we hardly speak of such experience unless there be a group bound by certain tribal ties. It is only among the most highly evolved types of societies that we speak of racial experience.

Man is one of these social animals that learn by experience. So it is with ants. Even if we admit that ants' actions are mostly instinctive we cannot, with facility, deny that they have group experience, since social or group actions even among man are mostly instinctive and at least sub-conscious.

Dr. Gustave Le Bon in his book, "The crowd" has remarkably shown that, and that the intellect plays a very little part in man's social actions. So we cannot deny *social* or racial experience to ants, especially when we know, as we have seen, that they are endowed with all the necessary elements of the intellectual life.

Now, to my mind, all this differentiation of the ants into a third and fourth type of individuals was necessitated by the need of the community for food. It is food that led the community to devote some of its members to its procuring. But how did this come to be so. There are three possibilities:

(1) That by racial experience ants found that individuals devoted for the gathering of food should be stripped of their wings and ovaries in

order to make the individuals in the community live, and therefore they kept on producing workers. As to the existence of the workers it is still doubted whether they are newly evolved or not. I have no doubt that they are, since it is now an established fact that soldiers, which, are modified workers are recent in the process of evolution, and it is probable that through a process of which we are ignorant, the workers turn the pupae into workers by growing some pupal or larval organs which atrophy and therefore we get workers. In this case it would be that undeveloped ovaries and the absence of wings serve as a case of correlative variations.

(2) It might be, by food, that ants produce these workers just as the bees produce their queens. Yet that is not yet established and we cannot say that these are due to inheritance. Professor G. Lloyd Morgan F.G. S. in his book, "Animal Life and Intelligence." says, " Still we should remember should that among neuter-ants- for example, the Sariba ant of South America (Oecodoma Cephalotes) there are certain so called soldiers with relatively enormous heads and mandibles. The position of these parts so inordinately developed must necessitate many correlated changes. But these cannot be due to inherited use since such soldiers are sterile.

(3) The third possibility involves one of two things (1) either, according to the Weismannian theory, the germ is infected and therefore the worker, which is an undeveloped female, becomes deficient in ovaries which requires the absence of wings as a case of correlative variation or (2) It is a Mendelian character with the elimination of a Mendelian factor. I am more in favor of this third view of possibility, especially the last part, i.e. the Mendelian possibility, and that the workers in the community are dominant while the males and females are recessive. This ought to be ^{proved} ~~power~~ by experiment. It is only a mere suggestion, and it shares as far as I know, the same value as any other hypothesis accounting for polymorphism among ants.

CHAPTER XVIII

C O N S C L U S I O N

I have, thus far, related enough about ants: I have shown how they have occupied the mind of man through the duration of ages, and how they have been so much pondered over, wondered at, respected and even worshipped.

Every eccentricity in nature, especially that which approaches the highest endowments of man, strikes him with wonder and surprise, and stimulates to a very remarkable degree, his inquisitive powers. Ants are the most wonderful creatures in the animal kingdom. We have seen how they played a great part in religion, and how laws were formulated for their sake.

Not only have they been pondered over, contemplated on, observed, but even experimented with. We have seen how these experiments were conducted to profit and to throw light on certain facts, how they respond to particular colors of the spectrum, to certain chemicals under certain conditions.

We have also seen how they build their nests and make them well ventilated, clean, and capacious, fitted for all kinds of ants at the different stages of their lives.

In a series of chapters on food I have shown how they gather food, seeds, vegetables, and nitrogenous matter, and how they store the food for the times of need and how food has been a great cause of their polymorphism and their differences in the modes of life.

Throughout the whole book I have pointed out that all their endowments and activities grew out of necessity and that they all have been evolved through adaptation. Not only are they gifted with the necessary means of living in seclusion away from the struggle of others, but, as

I have shown, they are possessed of capacities not inferior to any animal destined to struggle with any living organism for life.

I have shown, at least, according to my opinion, that their ~~instinctive~~ habits of life are not ~~all~~ only due to the mere caprice of instinct, but the intelligence plays a great part in their life. Even, I have gone a further step, and endowed them with a racial mind, and have shown that they present admirable resemblances to man's actions, and that this is called by biologists "Convergence".

Why, then, should man pride himself over all other animals, that he is the supreme being in the universe. Had ants, with their systems of life, been possessed of a body, ^{as} bulky as that of a vertebral animal, man, would have no place in nature, but would be, at most, ^{to} seen employed in performing whatever ants would ask of him. If man wants to keep his superiority in the animal kingdom, let him try to make his evolution run through a process of its own different to that operating in the life on any other species of animals, or else, he would lose that suzerainty.

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