1932

Comparative sociology of the hexapods

Campbell, Nellie Mae

Boston University

http://hdl.handle.net/2144/8189

Boston University
Comparative Sociology of the Hexapods

by

Nellie Mae Campbell

(A. B. Dalhousie, 1925)

submitted in partial fulfilment of the
requirements for the degree of Master of Arts

1932
Comparative Sociology of the Hexapods

Introduction

I. Social Life among the Coleoptera
   1. Silvanidae
   2. Tenebrionidae
   3. Ipiidae
   4. Platypodidae

II. Social life among the Termites
   1. Nasotermitidae
   2. Calotermitidae
   3. Hodotermitidae
   4. Termitidae

III. Social life among the Hymenoptera
   A. Wasps
      1. Scleroderma
      2. Stenogaster
      3. Belongaster
      4. Ropalidinæ
      5. Polistinae
      6. Vespa
B. Bees

1. Ceratinidae
2. Andrenidae
3. Bombidae
4. Apidae
5. Apinae

C. Ants

1. Ponereinae
2. Dorylinae
3. Myrmicinae
4. Dolichoderinae
5. Camponotinae

Summary

Bibliography
Comparative Sociology of the Hexapods

Introduction

Until very recent years the science of comparative sociology has remained undeveloped. Sociologists have left this study to the biologists, and the biologists have been less interested in societies, as such, than in the structure of the members comprising the group or the individual activities of a single member.

Animals are considered social when several members live together for the mutual benefit of all, as exhibited in the communal life of termites, social wasps, bees and ants. Permanent social life is usually only possible for animals that have access to an abundant food supply. Therefore we find it more fully developed among herbivorous than among carnivorous animals.

Solitary species are sometimes brought together by accident, as in feeding; such a grouping is an association and is to be distinguished from a society. Societies may have been built up by the periods of association between parents becoming lengthened in order to rear their progeny. Wheeler advances the theory of trophallaxis, or reciprocal feeding, as the family origin of flocks and herds. It is possible, however, that they were brought about by the instinct for companionship. Migratory grasshoppers and dragon flies, although they are solitary insects, unite into swarms when they are migrating. Some animals are social only during a certain period of the season. In spring, during the mating period, we often see groups of mayflies dancing
about in the air. Female wasps of certain species spend the winter together in some sheltered corner. In societies, where the majority is sterile, we find various castes where each is adapted to fulfill a special function. In the case of the social insects we find the queen adapted to egg-laying; sterile workers take care of the colony and act as nursemaids to the young; another caste, the soldiers, protects the colony; usually the only function of the male is to fecundate the queen. There is no actual leader; the queen is queen in name only, yet peace and order prevail. All seem to be physically attuned to one another without command or any other intellectual operation. The fact that these highly organized societies lack the impetus received from tradition and social heredity accounts for the few changes that have taken place in the social life of insects during the past fifty million years.

Social life has benefited individuals as a group yet, it is detrimental to the development of the single individual of that group. Holmgren has shown that the brains of the termite kings and queens have shrunk to one third their natural size, while their sympathetic ganglia have increased to three times their original size. Structures and traits, which formerly were common to each individual, are now divided among various social individuals where they have become more highly specialized - the individual is sacrificed to the group.

Insects are the only other animals besides man which form organized societies. There are over five hundred thousand species of known insects but only about six thousand are social. According to Wheeler, they represent nature's most startling efforts in
5. communal organizations and, since the time of Solomon, have been held up to man as worthy of imitation.

Wheeler classifies the social and sub-social insects as follows:

1. Silvanidae (Coccidotrophus, Eumausibius)
2. Scarabaeidae (Copris, Minotaurus)
3. Passalidae (Passalus)
4. Tenebrionidae (Phrenapates)
5. Ipidae (Xyleborus)
6. Platypodidae (Platypus)

Hymenoptera (Aculeata)
7. Bethylidae (Scleroderma)
8. Masaridinae (Ceramius)
9. Eumeninæ (Synagris, Odynerus)
10. Zethinæ (Zethus)

*11. Stenogastrinæ (Stenogaster)
*12. Epiponinæ (Belonogaster, Chartergus)
*13. Ropalidiinæ (Ropalidia)
*14. Polistinæ (Polistes)
*15. Vespinæ (Vespa)
16. Sphecinæ (Ammophila)
17. Trypoxyloninæ (Trypoxylon)
18. Bembicinæ (Bembex)
*19. Halictinæ (Halictus)
*20. Ceratininæ (Allodape)

"Social Insects" pp. 16-17
*21. Bombinae (Bombus)
*22. Meliponinae (Melipona, Trigona)
*23. Apinae (Apis)
*24. Formicidae (Formica)

Other orders
25. Blattoidea (Dasypoma)
26. Dermaptera (Forficulidae)
27. Orthopera (Gryllotalpa)
28. Embidaria (Embiidae)
29. Zoraptera (Zorotypus)
*30. Isoptera (Termitidae)

Twelve of these groups, marked by the asterisks are social, the others may be termed sub-social - they have not progressed beyond the rudimentary beginnings of social life.
Goleoptera - Social Beetles

Social beetles such as the Silvanidae, Tenebrionidae, Ipidae and Flatypodidae owe their classification in the social insects to the fact that although they are not far enough advanced in the social scale to develop castes in their societies, yet the mother and father co-operate in the work of building the nest and caring for the young in a marked degree higher than that of the spider, where the colony is merely a mother society. The procuring and storing of abundant food supplies make it possible for these beetles to live a longer life so that they survive the rearing of their progeny.

The sacred scarabs, dung or tumbling beetles are often found in the open, rolling balls of dung to an elliptical chamber which serves as nest. The eggs are laid in a pellet of sheep-dung. Some of these beetles could not even be termed sub-social - two partners may be seen industriously trundling a pellet, but one of them may be an aggressor which has offered his help after the pellet was formed, and he is watching his chance to rob the owner of his rightful spoil.

Sisyphus schoefferi is truly social, the male helps the female in trundling the pellet to the nest. The female guards the eggs for four months. When the young emerge, she takes them to the surface and family life is ended. In Lunaris, both male and female tend the eggs and watch over the young until the family disperses.

Geotrupes (meaning earth-piercers) digs deep tunnels into the soil, often five feet in depth. Male and female co-operate in
the work; as the male lowers the pellets of dung into the chamber, the female is working below. After the nest is completed, she lays an egg at the bottom of the burrow and provisions it with food by tearing the pellet apart and packing it down. Side branches are tunnelled out, an egg is laid in each and provisioned in the same way.

The Spanish Copris, because of her short legs and ponderous gait, is not adapted to trundling her pellet to a distant nest, so she burrows under the dung heap and soon carries it into her underground nest, where it is consumed. When egg-laying time arrives, she searches around for sheep dung. The pellets in which the eggs are placed have no definite shape, but the surface is always nicely curved and smooth. As she does not roll them, this smoothness can only be obtained by pressure exerted upon them by the body of the beetle. The mother mounts guard over the eggs from the last of May to the first of September, seeing that they do not crack nor are overgrown with fungi. Just as the pigeon softens the grain in her crop before she disgorges it to her young, so the dung beetles masticate the dung into an easily digested food for their larvae before they line the cavity of the egg chamber with it. The next layer consists of a harder material made up of vegetable fibers and the outside is a hard-packed layer. This affords a progressive change of diet for the young as they emerge. The mother beetle remains in the nest until the young are developed; when mature, she brings them to the surface and the family disperses.
Passalidae (Passalus cornutus) colonies are made up of large black beetles consisting of male, female and offspring. They may be found in decayed wood as far north as Massachusetts. The parents guard the larvae until they mature into adults, the colony being kept together by peculiar signals made by the beetles.

Tenebrionidae (Phrenapates). These beetles are unlike the Passalidae in that they live in smooth galleries extending as far as one and a half feet into the silk cotton tree (Bombax). The fine shavings of the wood are fed to the larvae by the parents which guard the offspring and hold them together by means of a strong characteristic odor.

The Tachigalea beetles are very small, measuring less than one quarter of an inch in length, occurring only in the hollow petiole of the leaf of the young Tachigalea tree in the tropics. They are more advanced in their social life than the preceding beetles. Small mealy bugs make their way into these petioles, and the whole colony of beetles soon learn to stroke them with their antennae to get the sweet droplets of excreta. The larvae feed upon these excreta and the tissues of the petioles. They soon hatch into adult beetles. Thus the colony is increased by the addition of succeeding generations. When the colony becomes too crowded, some leave and seek new petioles, but, as the tree grows older, ants take possession of it and the mealy bugs, driving the beetles away.

The Ipidae comprise a large group of nearly four hundred species. Some species of this family cultivate a certain kind of fungus as food, hence they are called ambrosia beetles. The male
assists the female in caring for the young which are raised in separate cradles. Each cradle is supplied with fungus and all excreta are carefully thrown out.

The highest form of social development in beetles is that of the Platypodidae. These wood-boring beetles live in societies feeding upon the fungi they cultivate in their burrows. Schneider-Orelli has proved that the female sometimes carries the fungi in her stomach to a new burrow to start a new "garden". Strohmeyer tells us these beetles carry the spore from one nest to another by means of a basket-like structure on their heads. Because of this transportation of fungi from one nest to another we may compare these beetles to the more highly socialized insects - the ants.
Isoptera: Termites

Although termites are frequently called "white ants" they are quite unrelated to the true ants, but like the Formicidae, all termites are social and show great polymorphism among their members. There are over fifteen thousand species, widely distributed in temperate and tropical countries, but reaching their highest form of social development in the tropics. Holmgren, Banks, Snyder and Sjöstedt have classified them according to the following families:

1. Masotermitidae
2. Galotermitidae
3. Hodotermitidae
4. Termitidae

As we pass from the lowest family Masotermitidae to the highest, the Termitidae, an increase in size, complexity of behavior and polymorphism of the colony will be apparent. Unlike the ants and bees, the termites are not a "feminist" society. There are male representatives in each caste as well as female.

The masotermitidae consist of a single living species *Mastotermes darwiniensis*. Its close resemblance to the cockroaches shows the possibility of the Blattoidea and the Isoptera having a common ancestor thus proving the termites to be the oldest of all the social insects. This species *Mastotermidae darwiniensis* does not build a true nest but lives in timber. Although a soldier caste has been developed, there are no workers. Like all the lower groups, these termites contain ciliated protozoa in their hind gut which enables them to feed upon cellulose. The
Calotermitidae are more highly specialized; although they do not build nests, their castes include the royal couple, young winged males and females, soldiers and worker-like forms. Grassi's observations seem to prove that the soldiers may be occasionally fertile. A true worker caste is found in the Hodotermitidae. The Termitidae are the most highly specialized of all the termites. In the highest form of their development the caste system is made up of five different forms, three fertile and two sterile, represented by males as well as by females. The three fertile forms comprise the reproductive group - the highest is called the macropterous form - the true winged kings and queens; the second is the brachypterous form, the substitute kings and queens which are not as fully developed as the first; the third is the apterous form, worker-like substitute kings and queens. Both worker and soldier castes are sterile; their differentiation into sub-castes depends upon the size of the colony.

Although some termites nest on trees and in the ground, the majority of the higher forms build their nests on the ground where their mounds are often congregated into so-called termite "villages" or "cities". These termitaria, in the grasslands of Africa, may reach a height of twenty feet or more with a basal diameter of twelve feet. They are built so strongly of soil, mixed with glandular secretions, as to be almost indestructible. Tree nests are built of pellets of chewed wood glued together with saliva and fastened to the trunk of the tree. Owing to the light-shunning habit of their inhabitants, these nests, unlike those of the ants,
have no visible entrance. The true king and queen are usually the only termites that are pigmented and can stand the sunlight, but social life, through the impulse of hunger, has forced one species known as "harvesting" termites to the surface in search of food. Their "shelter tubes" are often found running up the trunks of trees to a great height; unlike the other species they are dark colored and possess eyes.

New colonies result from the annual colonizing flight of the winged kings and queens. This flight occurs in the early spring or in the autumn; great excitement pervades in the nest before the flight, but the workers restrain the kings and queens until the weather conditions are favorable. After a rainstorm, holes are made by the workers in the surface of the mound and the kings and queens, joined by others from the neighboring mounds, fly swiftly into the air. Their large numbers insure cross-fertilization, but mating does not take place in the air. They pair off into "royal couples" on their return to the ground. Sometimes they may return to the old colony where the young queen, after fecundation, shares in the egg-laying, but usually a new site is chosen, and after shedding their wings each royal couple begins to build its new home. Most of the work, however, is done by the queen. After the nest is large enough to contain both of them, the outside entrance is sealed up and the "royal couple" are ready to mate. Unlike the ants and wasps, the life of the male is not sacrificed by mating, and he remains with the queen throughout life, coition frequently taking place. Fuller gives the following description of the king (Termes natalensis):
"This creature displays an extraordinary devotion to his mate. He seldom wanders more than an inch away from her; constantly approaching her head and paying apparent court; then inspecting her flanks and eggs with pre-occupied attention; behaving, in short, as most male termites seem in the habit of doing, but never revealing the purpose of his existence."

Under favorable conditions the royal pair may remain together for a year before any eggs are laid. Normally the queen lays from one to six eggs daily until fifteen to thirty are laid, then the laying ceases and the parents spend their time in enlarging the nest and caring for the eggs which are frequently moved from one part of the nest to the other, according to conditions of temperature and moisture. Unlike all other social insects, termites have incomplete metamorphosis, with resting stages between the moults. Although the workers feed the young and help them in moulting, yet there is less contact between the young and the adult forms than in the bees and ants. The young may develop into five different castes; there always seems to be a proper numerical proportion between the number of individuals in the various castes; just how this is brought about is still a matter of conjecture among entomologists. "Histological studies conducted by Miss Thompson have proved that the ontogenetic origin of the termite castes is due to intrinsic causes of germinal origin and not to extrinsic stimuli."

1 Biology of Termite Castes. P. 525.
Wheeler (1907) makes the following statement: "While experiments on many organisms have shown that the quality of associative food may produce great changes in size of stature there is practically nothing to show that even very great difference in the quality of food can bring about morphological differences of such magnitude as those which separate the queens and workers of many ants . . . it must be admitted that a direct causal connection between underfeeding on the one hand and the ontogenetic loss or development of characters on the other has not been satisfactorily established. The conditions in the termite, which are often cited as furnishing proof of this connection, are even more complicated and obscure than those of Social Hymenoptera."

A natural explanation seems to be that these castes have originated by segregation from a heterozygous parent form, and in the gradual development of the nymphs the arrest of growth may affect both the soma and the gonads, resulting in the sterile soldiers and workers, or it may affect the soma only, giving rise to the substitute reproductive forms. If the queen dies or is lost, the old king will consort with the young queens of the brachypterous forms; if both king and queen die, a large number of these substitute queens and a small number of similar kings will replace them, but these can only give rise to their own and lower castes. Only macropterous forms can give rise to true kings and queens. The workers are blind with poorly developed mouth parts, they tend the young, take charge of the feeding and the storing of food, as well as building the nest. The soldiers
have well developed heads with powerful mandibles; like the workers, their eyes are either vestigial or absent. They vary in size, the larger types guard the nest and act as body-guards to the king and queen; the smaller ones supervise the workers in the nest urging them on with taps of their antennae. Since termites have organs on the front leg similar to the auditory organs of crickets, they are supposed to be able to communicate by sound. Sentinels stationed at the entrance give the alarm by chirping and tapping. Soldiers in the most specialized groups of termites are the "nasuti" type. A frontal gland secretes a pungent gummy substance which is ejected against their enemies and proves to be an even more effective means of defence against the ants than their strong mandibles. They sometimes use this secretion to dissolve hard substances in the way of the nest builders. The number of polymorphic workers and soldiers varies with the family and genus. In size the soldiers are usually about fifteen times as large as the workers, while the queen may reach the enormous size of being twenty to thirty thousand times the bulk of the average worker. In the South Kensington Museum in London there is a termite queen four inches long. This enormous size is caused by the large number of eggs forming inside which she sometimes lays at the rate of sixty per minute; the total number of individuals in a termite village can hardly be imagined.

Unlike the ants and bees, the termite kings and queens do not have a special supply of food stored in their bodies when they begin their flight. The food of the lower termites consists
chiefly of cellulose. Young termites and the royal forms are fed a special diet by the workers, consisting of this regurgitated digested cellulose mixed with saliva known as stomodeal food. As the young termites grow older, they devour faecal matter of the older forms — this is called proctodeal food. Thus they become infected with the protozoa which will enable them to feed upon cellulose. Brunelli calls this feeding on the digested and partly digested food of the intestine "social rumination." The higher species feed upon vegetable matter rather than upon cellulose.

Galleries in their nests lead to fungous gardens whose exits are carefully guarded by soldiers. These fungous gardens often serve as nurseries for the nymphs. Some nests contain storage rooms for food brought in by the workers. In addition to this food all castes produce excretions from the skin which are licked up by other members of the colony. The queen, being the largest, exudes more than the others; she is always surrounded by a large number and is often licked so assiduously that her skin is perforated.

Termites occasionally vary their food by eating a wounded or sick companion. Many nymphs, particularly if they are not as strong as the rest, are often eaten by their nurses as they help them to moult; by removing the weak in this way, the colony is kept strong and healthy. In the case of the termites all the care and feeding of the young seem to be based on selfish impulses as they receive excretions from the nymphs as well as from the older forms.

Insects of other orders known as termitophiles or guests are often found in termites' nests. They exploit the termites for their secretions; nevertheless, they are tolerated in the nest.
Hymenoptera A - Wasps

"For where's the state beneath the firmament
That doth excel the wasp for government."  

The wasps comprise a large group of at least ten thousand species, but only eight hundred of these can be termed social. We can divide them into two great groups - Sphecoids and Vespoids.

The sub-social wasp Scleroderma belongs to the primitive family Bethylidae, the female parent takes care of her offspring and rears several broods, but they do not co-operate like the social wasps. No caste system has been developed.

Stenogaster, another sub-social wasp, lives in shady forests where it constructs a delicate small nest made of rotten wood or soil, on rocks and trees. The colony is very small, the mother feeds the larvae daily until they are full grown, then the nests are sealed and left until the pupae develop. When the mature forms emerge, they remain in the nest with the mother.

The Epiponinae (Belongaster) is the largest sub-family of social wasps and is usually found in the tropics. Their nests are larger than those of Stenogaster and are made of 'wasp paper'. The female parent feeds the larvae. When they develop, they take care of the feeding of the next generation. They also take part in the building of the nest and as they grow older, they leave the nest and forage for food. The oldest of all takes part in the egg-laying. In the highest forms, two kinds of females are

1 "Wasps Social and Solitary" - Peckham.
produced; one kind develops into a queen capable of laying two kinds of eggs; while the second class, termed the workers, can only lay male-producing eggs. These colonies are perennial; when they become crowded, new colonies are formed by swarming. This procedure is unknown in the wasps outside the tropics. The Ropalidinae are also tropical and are found chiefly in the Old World. The colonies are made up of a small number of queens, males and workers. The Polistinae are found almost everywhere. We are all familiar with their unprotected nests found hanging from trees, rocks and even buildings. The comb is started by a single queen, but as soon as the first brood hatches, they co-operate with her in the care of the colony. As the season goes on, the nest is enlarged, but compared with the Vespoids the colony is comparatively small. It keeps on growing throughout the year and in the tropics new colonies are formed by swarming, but in the temperate regions, only the young queen survives the winter.

The Vespidae (genus Vespa) comprise a large group made up of the truly social wasps. The caste system is well developed consisting of females, males and workers. It is difficult to tell the structure of one caste from another, but as a rule, workers are smaller than the rest. Community life is seasonal rather than perennial. The early autumn frost kills off all the colony with the exception of the young queen. She spends the winter in some sheltered place and in the early spring starts the beginning of a new colony. She selects the site for her nest, usually on some tree, rock or building, and begins the comb by building a few brood cells which are suspended from a central pedicel. New tiers of
combs can be added as the colony increases in number. As many as fifteen to twenty thousand individuals have been found in a single colony. After she has begun the nest, the queen lays an egg in each cell. She feeds the larvae until they develop into workers — a period of about twenty-eight days — the brood then takes care of the nest and the queen devotes herself to egg-laying. She is a mother in the nest rather than a queen. Her salivary glands dry up and she is no longer able to manufacture paper. The duties of the workers depend upon their ages; the younger ones, probably because their salivary glands are more active, help to build the nest, while the older ones forage for food and act as housekeepers and nursemaids. Wasps seem to enjoy the heat and are usually busiest around noon time. Instead of each wasp working at a certain place on the nest, they all seem to work together; the fibers brought in by one wasp are mixed with those brought in by another; hence, the variegated light and dark colors of the wasp paper. The nests are kept scrupulously clean, all excreta and foreign objects are deposited outside. When an object is too large to remove, it is covered over with paper.

Individual social wasps live entirely for the community —

"Alike ye labor and alike repose
Free as the air yet in strict order joined
Unnumbered bodies with a single mind,"

Children are reared by the community, not by the parents. The food supply, when brought in by the foragers, is divided. Some is fed to the larvae and the rest is stored in the nest. Reciprocal feeding, or trophallaxis, is evidenced in the wasps —

1 Evans.
in return for masticated food the wasps receive saliva from the larvae. Sometimes the larva is exploited for its saliva and because of its undernourishment it may develop into a worker with imperfectly developed reproductive organs. Later in the season some of the larvae develop into queens. Their bodies contain large quantities of fat which enable them to survive hibernation. The drones, also, have large quantities of fat stored in their bodies, but they make use of it immediately, thus requiring very little food from the workers which, unlike the worker honeybees, allow the drones to remain in the nest until they perish in the autumn. Although the colonies usually continue until early autumn in the temperate zone, they may break up earlier, particularly if the food is scarce. The loss of the queen, or queens, also causes disorganization in the colony. Unlike the honeybees, the wasps can not produce a new queen in a short period of time, although they may have a large number of perfectly developed females in the nest. These females can not replace the queen in her full maternal capacity because their eggs, not being fertilized, produce only drones. Such a brood could neither replenish the worker caste nor care for the colony, which soon disperses.

Wasps are not as highly developed in their social life as the honeybees and ants, nor are they so intelligent. If food is found by a member of the colony, she does not "tell" the others about it, as honeybees do, nor do they combine like the ants to get desired results, as removing an intruder from the nest.
Bees are found in all parts of the world. There are over twenty thousand described species but only about five hundred of them are social.

The social bees include:

1. Ceratinidae, genus Allodape
2. Andrenidae, genus Halictus
3. Bombidae
4. Apidae
   sub-family - Meliponinae
   genera Melipona, Trigona
5. Apinae, single genus Apis

The social life of Allodapes is very primitive and rudimentary, instead of building a nest, the fertilized female usually selects a soft pithed plant stem in which to lay her eggs. Some of the smaller species make use of the nests made by Coleoptera in dead logs, and some use the long thorns of the Mimosa tree. A few species, as in certain parts of South Africa where trees are not common, build nests in the ground. The colony is founded at any time of the year by a single fertilized female. The pith is removed from the stem and the female lays her eggs, placing them in tiers one under the other. Thus the first to hatch are always on the top.

The larvae are all males and females. There is no worker caste. The offspring co-operate with the mother in the care of the nest and fertilized females carry on the cycle of life by establishing new colonies.
Halictus is the largest of the bee genera comprising one thousand described species found all over the world. As in Alloopes, their social life is very primitive. They sometimes nest in rotten wood but usually in the ground where hundreds of their colonies may be found close together. The fertilized female builds from sixteen to twenty cells; each cell is provided with food and after an egg is laid in each one they are sealed over. They are carefully guarded by the female until the young emerge. **Halictus malachurus**, according to the observations of Stockhert, shows an advance in social life. The female hibernates during the winter. In the spring she builds cells in which the eggs are laid, and the larvae develop about the middle of June. All are infertile females, so different in appearance from the mother that they are given a different name - **Halictus longulus**. They share in the care of the nest; other broods similar to the first are added to the colony, but towards the latter part of the season young develop which are like the original parent. Males are also developed at this time and they mate with the young **malachurus** females, which alone survive the winter. Stockhert has carefully observed the habits of the European species of **Halictus** - **malachurus**, **maculatus**, **sexcinctus**, **immarginatus**, and **puncticollis**, and his observations show that the number of annual generations varied from one to three according to the species, but in every case the males die in the autumn and the cycle of life is started by the fertilized females the following spring.
The summer females of Halictus maculatus, like the longulus females are smaller than their mothers but have a similar structure, while those of Halictus immarginatus differ in structure as well as in size. The summer form of Halictus puncticollis, although of the same size as the mother, is so different from her that, like those of malachurus, they have a different name — villosulus. These summer forms seem to be a primitive form of the worker caste, while the mother malachurus approaches the function of the bumblebee queen. Certain brood cells of Halictus sexcinctus have the form of a rough comb and may be used to store honey. Thus Halictus clearly shows the evolution of a truly social system.

The Bombidae — the humblebees or bumblebees include about two hundred species, and are usually found in temperate regions. The colony is made up of queen, workers and males. The queens alone survive the winter and begin the new colony in the spring. Sometimes the discarded nest of a mouse is made use of. Brood cells are fashioned, eggs are laid and the cells are sealed over. The queen sits on them to keep them at the proper temperature. During this time she makes use of a supply of honey which she has stored for herself in a large waxen pot. The eggs hatch in about four days. The queen opens each cell and feeds the larvae with regurgitated honey and pollen. When they develop into workers, they take over the care of the nest; new cells are formed and additional bees are hatched, more than five hundred individuals having been found in one nest. Towards the end of the season, eggs which will produce males and queens are laid in
certain cells made for the purpose. The larvae, which have developed into queens, receive no special food. It seems to be quantity rather than quality that makes the difference between queens and workers. Males develop from the unfertilized eggs of the queen. The mating between the males and young queens usually takes place out in the open, sometimes in the nest. The queens repeat the cycle the next year. The rest of the colony perish at the end of the season.

Bumblebees are much more advanced in the social scale than the two preceding genera. The caste system of queens, males and workers is well developed for the first time. Some years ago great discussion arose over the so-called "trumpeting" of the bumblebee. Early each morning a bumblebee was found rapidly vibrating her wings at the entrance of the nest. This is now accepted as being the bee's method of ventilating the home.

The Meliponinae are commonly called "Stingless bees", but as a vestigial sting is present in the queens and workers this is a misnomer. There are about two hundred and fifty species found chiefly in the tropical parts of South America. They build their nests in hollow trees. Frequently they make use of termites' nests. Unlike other bees, the drones, as well as the queens and workers, are able to secrete wax. The workers mix the wax with earth to produce a substance called cerumen which they use in comb-building. The nest consists of two compartments; one is used for storing honey and pollen, while the other is used as a brood chamber. After the nest is started by the fertilized
female, her pollen-collecting organs disappear. Her sole function now is to lay eggs. The Meliponine show many striking changes in their social habits when we compare them with other social bees. They are the only members of the Social Hymenoptera whose larvae are reared in closed cells and fed by mass provisioning. The adults do not come in contact with the growing larvae.

Social organization among the bees reaches its highest form of development in the Apidae represented by the genus Apis and made up of four species Apis - *dorsata*, *florea*, *indica*, and *mellifica*.

*Dorsata*, the largest and most primitive species, builds an unprotected comb which is often seen suspended from buildings and trees. No distinction is made in the construction of cells for rearing queens, drones and workers. They are nomadic in their habits. When they have used up all the available nectar from the flowers in one locality, they move on to another. *Apis florea* is the smallest of Apis. They construct a hanging nest, but, unlike the last species, the structure of its cells is dependent upon whether the larva is to be a queen, drone or worker. *Apis indica* is very closely related to *Apis mellifica* - the honeybee. The latter, because of its adaptations to all kinds of flowers and climate, is found almost everywhere. It builds its nests in hollow cavities of trees and caverns. The caste system is well developed in the colony, but unlike the preceding genera the honeybee colony is permanent. The honeybee queen could not start a colony alone, because she is not adapted for cell-building, and she could not gather honey and pollen to
sustain even herself. New colonies are formed by swarming, which is nature's protection against overcrowding and insures space in which to increase their stores. During the last part of May and the first of June, when the days have become warm and settled, a swarm, comprising the old queen and from twelve to forty thousand bees of the older generations, leave the nest to form a new colony. They leave the younger generations in possession of the old hive where a young queen has just emerged. Unlike wasps, the honeybee queen will not tolerate a rival. Sometimes a second swarm leaves soon after the first. A still younger queen remains in the hive, for when the colony is prosperous and swarming active, the queens are not allowed to kill one another. As many as three or four swarms may go off in one season.

In preparation for swarming, unfertilized eggs are laid by the queen in large cells constructed for the larvae which will become drones. When these drones are ready to emerge, special cells are built for the rearing of young queens (swarming, however, only takes place during fine weather and if the weather should prove unfavorable, the embryo queens are not allowed to hatch.) Before the swarm leaves the nest, the workers eat a hearty meal of honey, thus insuring the secretion of wax which will be necessary in the building of the new home. The bees burst forth with a great deal of buzzing. The queen usually alights a short distance from the old hive, the rest of the bees forming a dense pear-shaped cluster around her. By means of hooks on their feet, they are able to hang on to one another, arranging themselves in definite
order with heads up. They do not remain long in the open and soon select the new site for their home. Should the queen be lost or killed during the swarming, the rest return to the old hive.

The operation of building the comb begins. For this purpose wax is used. It is secreted in the form of scales on the ventral side of the body of young workers. On entering the nest, the wax-makers suspend themselves from the roof, clinging to one another by means of hooks on their feet. They remain motionless in this cluster for about twenty-four hours. The heat produced by their bodies during this time is sufficient to soften the dry scales of wax which has formed on the ventral sides of their bodies.

A single bee near the center of the roof drives away the surrounding bees until she has enough space in which to work freely. She is the founder of the comb. The pincers at the joint of her hind legs enable her to convey the wax scales to her mouth where they are mixed with saliva; she makes use of her pointed jaws to work it into place on the roof of the nest. When she has exhausted her wax supply another worker takes her place. When a thin layer of wax has been deposited on the roof, the wax builders are succeeded by the nurse or sculpture bees which begin constructing the cells. These cells are hexagonal and are shaped so that they fit into each other, giving the maximum of available space. As soon as the individual cells are begun three other bees join the original sculptress working with her until the cell is completed. Before the first comb is completed, another one, parallel to the first, is started below, leaving just enough space between the two
combs for two bees to pass one another. A well-filled hive contains many combs with openings or "streets" through them serving as "short cuts" for the busy bees while they are storing honey or tending the young. While these bees are engaged in building the comb, others are out gathering "propolis" from the gummy buds of trees and which is made use of to fill in any cavities in the wall of the new nest.

The cells to be used for rearing workers are always begun first; drone cells are larger than those of the workers and are usually placed below them in the comb. Queen cells, varying in number from four to twelve are built last of all. These are the largest of all the cells. When the queen emerges, the empty cell is torn down and replaced by several workers cells in order that no room may be lost. The remaining cells in the nest are used as store houses for bee-bread and honey. If the honey were all stored in one large cell, it would soon ferment, so it is stored in individual cells and each is capped with an air-tight layer of wax.

Apis has three well developed castes; the eggs which the queen lays in the cells develop into queens and workers according to the nutriment given to the larvae. As the young are attended by nurses, no food is deposited in the cell with the egg. After three days the larvae appear and are daily fed with honey, bee-bread and water. All larvae are given the same kind of food for the first three days. After that the workers are given honey and digested pollen and the drones honey and raw pollen. As they grow larger, they are provided with a larger amount of food. Soon after hatching, the larvae spin a cocoon for
themselves and the workers seal their cells. When they have developed into the pupal stage, they gnaw their way out of the cell and each individual is ready to assume the duties and function of his or her caste.

The only function of the queen is egg-laying. She never leaves the hive except during the marriage flight and swarming. She is the mother of the hive rather than its queen, yet her presence seems to insure order and prosperity in the hive. She is always surrounded by a large number of workers, yet she does not suffer from overcrowding, as they keep at a respectful distance. Langstroth describes this peculiar attention as follows: "The Queen is treated with the greatest respect and affection by the bees. A circle of her... offspring often surround her testifying in various ways their dutiful regard: some gently embracing her with their antennae, others offering her food from time to time, and all of them politely backing out of her way to give her a clear path when she moves over the combs."¹

But this homage is only shown to matron queens and not to princesses. If she is killed, the colony seems to lose all interest in their labors for a time. If it is too late in the season to raise another queen, the colony dwindles and dies out.

The queen must leave the hive in order to mate. Because of frequent cross-breeding, and her swiftness in flight, making it possible for only the strongest drone to catch up with her, a race of swift strong bees is the result. Before taking her mating flight

¹ Honey Makers - Morley. p. 118.
she makes several short excursions around the hive where a large number of drones are flying. She is exercising her wings and orientating herself for her return to the hive. For should she return to the wrong hive she would be killed immediately. If the colony is large and well ordered, no notice seems to be taken of the departure of the queen on her wedding flight, but if the colony is small, and there is no means of raising another queen, it may accompany the queen. On returning to the hive, the work of the fertilized queen is to destroy all the queen cells if the workers allow it. Otherwise, she starts a swarm to a new nest. She sometimes lays as many as two thousand eggs in a day. The egg-laying continues for about eight weeks. In the early season, especially if the queen is very prolific, many eggs are never hatched because the cells are not ready for all of them, yet they are not wasted as they are quickly eaten up by the workers. A queen bee can not digest her own food but has to be fed digested food by the workers. Since she has no responsibility beyond laying eggs, her eyes, antennae and nervous organization are not so well developed as those of the workers. She may live from four to five years.

The drone is unfitted to share in the work of the hive, his only function being to fecundate the queen. He appears just before the swarming season; sometimes thousands are raised in one hive. This large number makes cross-fertilization occasionally possible and insures the mating of the queen in as short a time as possible, as her large conspicuous body is an attractive prey to bee-eating insects. The drone dies from the result of mating,
but the others return to the hive where the workers continue to feed them until the end of the season when, because of their uselessness, they are killed or driven away by the workers. The drone "is by destiny an aristocrat and suffers the fate of the aristocrat born into a communistic society."

When the weather indicates the approach of winter, he is pushed or dragged out of the nest by the workers; if he attempts to return, he is met by a long line of workers which refuse him entrance. If he is not killed by them, he perishes from the frost, becomes a prey to toads and birds, or starves to death. If the colony is small and the honey scarce, drones are sometimes driven away earlier in the season; if it is prosperous, they are sometimes left until November. A few may even be left through the winter, but this happens only when the queen is old and there is the possibility that the drone may be required to fertilize a new mother, but eventually their death is necessary to the welfare of the community and the workers show no compunction in depriving themselves of their brothers.

Honeybee colonies, as a rule, are perennial; some, however, are unable to withstand the rigors of winter. Sometimes when there is an abundance of honey the cells are filled with it, leaving none for the queen to lay her eggs in. Consequently, for lack of a young generation, the colony dies out in the early spring. On the other hand, if the honey supply is low, the colony will starve to death during the winter - but these are

---

1 Honey-Makers - Morley. P. 131.
exceptional cases. Bees prepare their nests for the winter, not only by providing a food supply, but also by stopping up any crevice or opening with gummy propolis. The work of the colony usually ceases around October and the bees remain in a semi-torpid state until the spring. Unlike the bumblebees and social wasps, honeybees will come out of their nests and move around during the winter when the temperature is from 45° F to 50° F. The nest receives a general cleaning up at such times and dead bees are removed. Honeybees never deposit excreta unless their winter stores consist of honey-dew. The queens, which are always in the nest, and the drones, which are there most of the summer, have little or no waste matter because of their pure food supply. Workers, being more varied in their food, deposit their excreta while they are on the wing. In the winter the workers allow it to accumulate in their bodies. Thus these short winter flights give them an opportunity to cleanse their intestines and thus safeguard their health. If the colony is strong, with sufficient food supply, it does not matter how cold, nor how long the winter may be. The bees remain huddled together for warmth; when those on the inside become too warm, they move towards the outside and their places are filled by others.

Since breeding often commences before there are any flowers from which to collect nectar and pollen, they must depend upon their surplus winter supply to feed the growing larvae. Honeybees are careful not to mix the nectar collected from one flower with that of another. When flowers are in bloom, the workers are out foraging as soon as the sun is up. When their pollen baskets
and honey sacs are full, they hasten back to the hive where they store the pollen and honey in their proper places.

Robber honeybees often attack the honeybees' nests to procure honey, but they are met with strong resistance by the members of the colony. By means of propolis - which literally means "before the city" - the entrance to the hive is made as small as possible so that any robber, which tries to enter the nest, may be easily killed by the sentinels on guard. Wasps - usually singly - often attack the nest; since they are quicker on the wing than the honeybees, they often elude the sentries and enter the nest for honey. The wasp has another advantage over the individual honeybee in that she is able to withdraw her sting without fatal results, yet a honeybee will fight to the death with such an intruder.
Hymenoptera C - Ants (Formicidae)

Like the termites all ants are truly social. There are over thirty-five thousand species representing the highest form of social development and organization in the lower animal kingdom. Because of their plasticity in adapting themselves to any climate or locality, they are found all over the world, with the exception of the Arctic regions. Certain social habits of the social wasps, termites and bees, which have proved detrimental to community life, have either been discarded by them or they never acquired them. Termites, because of their sensitiveness to light, have to confine themselves to the ground, but ants are found in trees, and on the ground, as well as in the ground; bees build elaborate stationary homes, but the ant can readily change her place of abode without sacrificing such elaborate homes. Also, unlike the bees, their colonies do not run the risk or disorganization through the loss of the queen, because they provide themselves with several fertile ones. Contrary to the feeding habits of most termites and bees, the ants are able to vary their food and are not dependent upon any particular kind. While the colonies of wasps and bumblebees last only for a season and honeybee colonies are comparatively short-lived, ant colonies may survive for twenty years or more. Espinas thinks this superiority of the ants is due to their terrestrial habits. Living on the ground makes every movement a contact, and when they build their homes they have their material right at hand.

The structure of their nest varies according to the species. Emery and Forel have classified ants according to the following sub-
families:

1. Ponerinae
2. Dorylinae
3. Myrmicinae
4. Dolichoderinae
5. Camponotinae

The first two forms are the most primitive; instead of building a nest they usually make use of some cavity under a rock or occupy the nests of other ants. The remaining three subfamilies however, build large nests varying in form and size according to the locality. Those of the mound-making ants, Formica exsectoides, vary in size from a few inches high to some that are three feet high and thirty-seven feet in circumference at the base. They occur in groups, as many as seventeen hundred have been found within a space of fifty acres. Dr. Forel computes their population to be between two and four hundred million inhabitants living together in active and friendly intercourse. Huber, Wheeler, Tissot and Linder have proved by their observations that these mound-building ants make use of the sun's rays to hatch their young. The morning sun awakens the ants and they begin their labors - the nest being thoroughly warmed by the morning rays, but if their nest was built on a western slope, the afternoon's rays would be so strong, it would lessen the activity of the colony. The nests of the yellow ant (Lasius flavus) of Switzerland, serve as compasses to the mountaineers. They are always placed in the direction east to west with their higher slope turned towards the winter sunrise.
Other species of ants build carton nests in trees. The material used consists of vegetable wood fibers which the workers glue together with a secretion of the maxillary glands. The high social order of specialization in ants is shown in the building of the silk nests of Polyrhachis and Oecophylla. These nests are usually built in the foliage of trees, and the leaves are fastened together by means of fine white webs resembling silk. Doflein has studied these ants repairing a rent he had made in the side of their nest. Some of the ants formed a line of defense against future attacks while others lined themselves on either side of the rent and, all working together, tried to pull the edges as near together as possible. Bits of the old web, which remained along the edges, were carefully bitten off, carried away and deposited at a distance, several assisting one another when the piece was too large for one worker. While the two rows of workers were pulling on the edges of the rent, several workers appeared, each carrying a larva in her mandibles. These workers passed between the ranks that were holding the leaves carrying the larvae from one side of the rent to the other, pausing a short time on each side as though they were cementing the thread spun by the larva to the wall, until the rent in the nest was filled up. Besides co-operating with one another in the work the ants had used their larvae as spools and shuttles. In constructing these leafy nests, the leaves are too heavy for one ant to arrange them in position, so several of them form a chain by hanging on to one another's body. In this fashion they are able to pull the leaf into place while the chain is used as a bridge by the rest of the workers.
The caste system is well differentiated into queens, males, workers and soldiers. The queens and males are usually provided with wings. For a short time before the nuptial flight the excitement of these winged forms is shared by the whole colony, and all work stops for a time. The queens and males depart gradually, collecting in the air where the mating takes place. Enmities between the colonies based on nest smell are disregarded for the time. Thus cross-fertilization often takes place. Unlike the honeybees a large number of queens take part in the nuptial flight. The male dies soon after mating and the fertilized queen returns to the ground where she sheds her wings and usually starts a new colony. She may, however, return to the old nest and share in the egg-laying, or two or three other queens may associate with her to start a colony, but the usual method of starting a colony is by a single fertilized queen even when the colony, as in the case of Atta, may later number one hundred thousand or more.

She excavates a small burrow in the ground, and here she waits until her ovaries are mature; when the eggs are laid, she carries them from place to place, according to the temperature and moisture of the nest, until they develop into larvae. Previous to leaving the old nest, large quantities of fat were stored in the queen's body. After shedding her wings, the substance in the large wing muscles break down and enter her blood; since no food was stored in the nest for herself or the larvae, she has to depend upon this reserve food stored in her body - sometimes for a period of eight or nine months. She feeds the larvae on secretions from her salivary glands. This supply is usually very meagre and as a
result the first brood of workers are always undersized. From now on the queen's only function in the nest is to lay eggs, which she continues to do for ten years or more. The workers, whose life span is around five years, take over the care of the nest and the rearing of the young. Like most social insects, ants undergo complete metamorphosis; although no cells have been built for the young, like those of the bee, and no food has been stored for them as in the wasps, yet the ants take more elaborate care of their young than either of these two groups, for ants not only feed their young but they also wash them carefully and carry them about in the nest so that they may always have the proper temperature and degree of humidity. If their nest is suddenly attacked, they always deposit the eggs and young in the lowest galleries before they rush to the surface to defend their nest. After the larvae are mature, they place them in the ground so that they may have the proper environment to spin a cocoon. Later on the cocoon is "dug up" carefully washed and guarded until the pupa is mature, then they open the cocoon and help the young callow to emerge. The brood is usually reared underground and housed according to age and size in chambers or compartments which are best suited for each stage of development.

The eggs are carefully licked by the nurses. This coating of saliva probably protects the eggs against fungi and also causes them to adhere to one another in masses. Thus they can be quickly transported from place to place. The larvae, when they develop, are usually covered with long chitinous hairs which enable several to stick together probably for the same reason that the eggs are held together in masses. The queen is able to lay an unfertilized
egg which develops into a male, just as in the honeybee. But it is still a matter of conjecture among leading entomologists whether it is the quality or quantity of food or both which determines whether the larva hatching from a fertilized egg will be a queen or a worker.

One of the reasons given for the high social development of the ants is their diverse feeding habits. The most primitive forms, the Pomerinae and the Dorylineae, are carnivorous; the most typical ants feeding in this fashion being the tropical "driver" ants of the sub-family Dorylineae. They have no fixed homes but wander about in search of prey. They usually make their sorties on cloudy days or at night. If they kill a large animal, such as a reptile, and the quantity of their food keeps them out in the rays of the sun they build arches of dirt mixed with saliva over their paths. Sometimes the soldiers will form living arches over the workers with their bodies, hanging on to each other by their hooked claws. They make use of this clustering habit during inundations. They place themselves in a rounded cluster with the eggs and their young in the center. In this way they are able to float upon the water until they reach a suitable landing place. Savage records that by their combined strength these ants sometimes kill animals as large as lizards and pythons. The large soldiers with their powerful jaws seize and tear the prey to pieces. The work of the smaller castes is to carry and tend the brood while on the march. One of the species, Eciton, attacks the nests of other ants to carry off the larvae and pupae which they use to feed their own young. The invading army divides to attack the nest of their prey at different points. Thus they easily overcome them.
Other ants are pastoral and live upon honey-dew which they obtain from aphids which have been called "ant cows" for this reason. The aphids are carefully tended, sheltered during the winter and jealously protected during the summer. The ants place them on suitable feeding grounds near their nest, obtaining the sweet drop of honey-dew by rubbing the aphid with their antennae. These ants are known as honey-ants; since they are unable to store this delectable food in the same way as bees and wasps, they make use of the crops of certain workers as storage chambers. Such workers are known as "repletes." Their stomachs reach such an enormous size that they are unable to move so they suspend themselves from the ceiling of their chambers. When the rest of the ants become hungry, they are able to get droplets of regurgitated honey-dew from the "social stomach" as Forel calls it - by stroking the repletes with their antennae. Another species of ants known as the "harvesting ants" feed upon seeds. These ants are usually found in warm countries where insect food is scarce. They are relatively few in number so that this characteristic is confined to few species. These are the ants to which Solomon alludes when he says, "Go to the ant thou sluggard etc." Loggridge has made a careful study of two of these species, *Messor barbarus* and *structor*. The workers were observed to gather the seeds from the plants, separating them from their shells, which they deposited outside the nest and storing the kernels in special granaries. To keep the seeds from sprouting, while in the nest, they bite off the radicle and when the weather is damp they bring their store of seeds to the surface to dry them in the sun. Other ants derive their main source of food supply from fungus gardens similar to
those of the termites. All fungus growing ants belong to the Myrmicinae of the genus Atta, and are found chiefly in tropical countries. These ants carry leaves and vegetable substances into their underground burrows to serve as soil on which to grow mushrooms. This ant food is carefully transported to the new nest during migration and when a new colony is to be formed the fertilized queen carries some as "seed" to her new nest, breaking up the first egg or two that she lays to serve as manure and soil for the new garden.

Ants are very neat in their personal habits. Every particle of dirt is carefully removed from their bodies. After eating or sleeping, they usually assist one another in "washing up", making use of mandibles and antennae. Forel describes the one being washed as having the pleased relaxed attitude of a dog that is having his back scratched. The nests, like those of the bees, are always kept scrupulously clean. All food refuse, foreign objects and empty cocoons are carried out of the nest by the workers. They combine their efforts to remove large objects, but if they can not remove them they cover them up with soil and saliva. The bodies of dead companions are removed and always placed at a distance from the nest; although ants will frequently suck the juices and feed upon a dead alien ant, they never mutilate their dead companions in this way.

Ants, unlike bees, are not busy all day long. They frequently rest during the day. The sleeping ants are usually huddled together in various positions in some depression of the nest. The period of sleep varies with the species, but observations
have shown that, because of their large size, the soldiers required more sleep than the smaller workers. They slept more heavily and were less easily awakened or disturbed.

Many entomologists credit ants with an instinct for play. They have been observed to be engaged in what seems to be mock fights, tumbling, wrestling and chasing one another. Yet they do not make use of their poison or sting as they do when fighting alien ants.

That they can make good use of their stings and other means of defense is shown in the "wars" they carry on with alien species. This is especially true of the slave makers which belong to the following genera: Formica (sanguina), Polyergus, Strongylognathus and Harpagoxenus. Formica sanguina is provided with a drop of formic acid in its gaster, which is introduced into the wound made by the mandibles. These small red ants wage war on the large black Formica fuscus for the purpose of stealing the larvae of the blacks to raise them as slaves in their nests. Scouts are sent out beforehand to find a suitable nest to attack. This nest is often a considerable distance away and its later attack shows a high development of memory, as well as some means of communication, among ants. The workers and soldiers line up in orderly fashion; the scouts that are following the scent to the slave species are in the lead but there is no real leadership. Those who tend to lag behind are smartly tapped with the antennae of those nearest to them. The first workers and soldiers to arrive at the nest surround it and wait until the "whole army" arrives before attacking. The larvae and pupae are snatched from their victims and brought to the nest of the slave maker; the adults of the slave
species are attacked only when they offer more than ordinary resistance. The captured larvae are not regarded as slaves, but occupy the same social level later on as the other workers. They are carefully reared and develop into loyal workers for their captors. The usual antipathy towards alien nest odor is disregarded by these slave makers. Mixed colonies of ants are sometimes produced where several species live peacefully together.

Miss Fields' experiments have proved that if different members of two or more species are placed together within twelve hours after hatching, and if each ant is allowed to touch all the others with its antennae within the next three days, the ants will live peaceably together. But wars are often waged between similar species, as in the Harvesting Ants, particularly if food is scarce or if a new nest is built too near an old one. These battles are very fierce and the warfare may last for weeks. The slave maker, Polyergus, which Huber christened the Amazons, enslaves Formica fusca; as they spend the greater part of their time in making raids, they have degenerated in their home life to such an extent that they cannot even feed themselves nor take care of their young, depending wholly upon their slaves to carry on the work in the nest. Huber's experiment shows that these ants starve to death, even in the presence of food, but if a slave ant is introduced, she immediately goes to the food and feeds her starving captors.

Sometimes small species of ants live near the nests of larger ones, as if for protection. Certain species belonging to the genus Crematogaster, for instance, are found living in the outer layers of the arboreal nest of larger species of Camponotus, the
larger species living in the center of the nest. Although the broods are reared separately, the workers of both species unite in foraging for food.

The majority of ants' nests are overrun by insects known as "ant-guests" or myrmecophiles, which are really parasites feeding upon the regurgitated food obtained from the ants in return for a sweet oily secretion they exude. These secretions seem to be more attractive than that of their young which the nurses often neglect while caring for these myrmecophiles. Any insect which secretes these glandular secretions is allowed to become a member of the colony. Wasmann and Escherich have estimated there are over three thousand species of such insects to be found in the nests of ants which in their relations to their hosts may be classified as parasites, commensals, assassins, scavengers, satellites, and guests. One of the strangest of these guests is the Staphylinid beetle Lomechusa, which is found only in the colonies of Formica sanguinea. The beetles stroke the workers with their antennae and are given regurgitated food in return for their sweet oily secretion. The larvae of this beetle also exudes this secretion and it is carefully fostered by the ants, even at the expense of the ants' own broods which these beetle larvae prey upon.

The colony of ants would soon die out were it not for the fact that the ants, in their zealous care of these attractive beetle larvae, bury them to spin cocoons, as they do in the case of their own larvae. Thus they unwittingly destroy them because beetle larvae do not spin cocoons and die if they are dug up.
Conclusion

The family life of beetles is the unit of social life which later on forms the basis for the development of the differentiated caste system in the termites, social wasps, bees and ants. Although the termites, social wasps and bees have a well developed caste system, they are not so well adapted to social life as the ants. The termites' sensitiveness to light and their consequent terrestrial habits are detrimental to the full development of social life; ants, on the contrary, can readily adapt themselves to different environments. The short duration of social life among social wasps of the temperate zones prohibits a full development of social organization. Bees approach the ants more closely in their social development than do any of the other social insects. But, although widely distributed, their food consists wholly of pollen and nectar. Ants, on the other hand, have a varied source of food supply, and thus are much better able to adapt themselves to new and unfavorable conditions. Not only is their caste system well differentiated and their society well organized, but ants are also able to wage war against other species to obtain slaves which help them in the work of their colony. They lavish more care and protective watchfulness upon the rearing of their young than other social insects do, and were it not for the fact of their tolerating so many parasitic guests in their colonies, they would probably have reached an even higher form of social development than that of the present time.
BIBLIOGRAPHY

(Books)

Alverdes, Friedrich - Social Life in the Animal World
1927 - Harcourt Brace and Company

Avebury, Sir John Lubbock - On the Origin and Metamorphosis of Insects
1874 - MacMillan and Company
- Ants, Bees, Wasps
1882 - D. Appleton and Company

Banks, Nathan and Snyder, Thomas E. - A Revision of the Nearctic Termites

Donisthorpe, H. St. J. K. - British Ants
1915 - William Brendon and Son

Dudley, Mrs. Lucy B. - Contributions to the Knowledge of the Termites

Espinas, Alfred - Des Societes Animals (pp. 163 - 264)

Fabre, J. Henri - Social Life in the Insect World (pp. 136-149, 102-120)
1912 - T. Fisher Unwin, London, Publisher
- Sacred Beetle and Others
1918 - Dodd, Mead and Company
- The Mason Bee
1925 - Garden City Publishing Company. Translated by Alexander de Mattos.
Forel, Auguste - Ants and Some Other Insects

1904 - Open Court Publishing Company. Translated by William Morton Wheeler

- The Social World of the Ants
  (Vol. I, pp. 125-143, 263-280, 328-368, 405-518;
  Vol. II, pp. 119-164, 208-273.)


Huber, M. Pierre - Natural History of the Ants

1820 - Longman, Hurst, Rees, Orme and Brown, Publishers.

Translated by J. R. Johnson.

Huxley, Julian - Ants

1930 - Jonathan Cape and Harrison Smith.

Imms, A. D. - Social Behavior in Insects

1931 - Lincoln MacVeagh.

Jenyns, Rev. F. G. - A Book About Bees


Kellogg, Vernon L. - American Insects (p. 99-110, 465-561)

1908 - Henry Holt

Kenly, Julie Closson - The Astonishing Ant

1931 - Appleton and Company.
Mace, Herbert - A Book About the Bees
1921 - E. P. Dutton and Company.

McCook, Henry C. - Agricultural Ant of Texas
1879 - Lippincott and Company
- Ant Communities
1909 - Harper and Brothers.

Moggridge, J. I. - Harvesting Ants and Trap Door Spiders (Vol. I and II)
1873 - L. Reeve and Company.

Morley, Margaret Warner - Honey Makers
1899 - A. C. McClury and Company.

Ormerod, Edward Latham - British Social Wasps (PP. 220-270)
1868 - Longman's Green Reader and Dyer.

Peckham, George and Elizabeth - Wasps Social and Solitary (PP. 1-15)

Rau, Phil and Nellie - Wasp Studies Afield (PP. 244-298)
1918 - Princeton University Press.

de Réamur, Rene Antoine Ferchault - Natural History of Ants (PP. 131-217)
Sedgewick, Sinclair and Sharp - Peripatus, Myriapods and Insects. (Part I)
1922 - MacMillan and Company.

Sladen, F. W. L. - The Humble Bee (Pl. 1-94)
1912 - MacMillan and Company.

Thompson, J. Arthur - Study of Animal Life (PP. 67-95)
1901 - Charles Scribner and Sons.

Treat, Mary - Chapters on Ants
1879 - Harper and Brothers.

Wasmann, Eric - Comparative Studies in the Psychology of Ants and of Higher Animals
1905 - Sands and Company

Wheeler, William Morton - Ants
1910 - Columbia University Press
   - Social Life Among the Insects
1923 - Harcourt Brace and Company
   - Emergent Evolution and the Development of Societies
1928 - W. W. Norton and Company.
   - The Social Insects - their Origin and Evolution
1928 - Harcourt Brace and Company
BIBLIOGRAPHY

(Monographs, Magazines, Pamphlets)

Buckingham, Edith M. - Division of Labor among Ants

1911 - Contributions from the Zoological Laboratory of the Museum of Comparative Zoology at Harvard College. No. 218.

Creighton, W. S. - Slave Raids of Harpogogenus americanus


Prison, Theodore H. - Notes on the Life History, Parasites and Inquiline Associates of Anthophora abrupta Say, with some comparisons with the Habits of Certain other Anthophorinae (Hymenoptera).

Heath, Harold - Habits of Californian Termites


Rau, Phil - Ecological and Behavior Notes on Missouri Insects


- Ecology of a Sheltered Clay Bank - A Study in Insect Sociology


Snyder, Thomas E. - Termites or "White Ants"

The Termites "Adaptations" to Social Life
1916 - Smithsonian Miscellaneous Collection. Vol. 76, No. 12

- Communism among Insects

1925 - Scientific Monthly. PP. 466-477.

- Biology of the Termite Castes


Wheeler, William M. and Taylor, L. H. - Vespa arctica Rohwer, a parasite of Vespa diabolica De Saussure

1921 - Psycho. Vol. XCVIII, No. 5-6.