BEE NEWS & VIEWS

The Mississippi Beekeepers Association Newsletter

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November-December 2013

4-H Beekeeping Essays Due on January 20, 2013

The American Beekeeping Federation and The Foundation for the Preservation of Honey Bees continue to sponsor an annual beekeeping essay contest for 4-H members. The topic for this year's contest is "Beekeeping in Colonial Times." Official rules for entry can be found at MSUCares (http://msucares.com/4h_Youth/4hentomology/bee_essay_contest.html).

Essays will be judged by a team of entomologists from Mississippi State University. State winners will receive prize money (1st place - $100, 2nd place - $75, and 3rd place - $50) and a plaque from MBA at our next annual convention. We may even ask the first place winner to read the winning essay at the banquet. The State first place winner will receive a book from the sponsors. National winners will also receive prize money (1st - $750, 2nd - $500, and 3rd - $250). Submit your essay and all required documents to Jeff Harris (JHarris@ext.msstate.edu) by close of business on January 20, 2014.

Specialty Crop Block Grants Awarded to MBA

The Mississippi Department of Agriculture and Commerce awarded a couple of grants to MBA in October. The money will be available over the next two years to help fund specific activities for our organization.

First, $10,500 will be used to conduct beekeeping workshops (4 per year). Specifically, two workshops each year will be targeted to beginners, and two will focus on teaching pest management for parasitic mites and diseases.

Second, $9,000 was allocated to a cost-share program in which $180.00 will be paid to help offset the costs of starting the first two colonies of bees for brand new beekeepers. Although the amount is nominal, the idea is to help stimulate interest in our wonderful hobby and/or livelihood. The intent is to provide funds for 25 new beekeepers per year over the next two years. If you would like more details, send me a message at JHarris@ext.msstate.edu.

Third, $7,325 was allocated to conduct a demonstration experiment with beekeepers. Many people learn more by doing than by either reading or listening to presentations at meetings. The goal of these experiments is to show beekeeper volunteers the usefulness of non-chemical methods for controlling varroa mites.

I will ask for beekeeper volunteers to conduct the experiments and collect data under my direction. We will test two methods for controlling varroa mites. The first will be the use of drone brood as traps for mites, and the second will be the use of mite-resistant stocks of bees. I will provide more details in the near future when I ask for volunteers to participate.

I will write the results of these experiments in a popular article for either the American Bee Journal or Bee Culture. I may also ask beekeeper volunteers to report the results and implications of the experiments to their local bee clubs or to beekeepers at next year's MBA annual convention. The point is to learn and SHARE information with other beekeepers.

Finally, I will conduct a couple of surveys to judge the effectiveness of the workshops and the demonstration experiments at influencing beekeeper behavior. I will periodically ask all MBA members to fill out a survey about their beekeeping activities (either online or on paper or both). I strongly encourage you to participate and help show MDAC that the grant money was used wisely.

MBA Convention in Tupelo a Success

By Jeff Harris

The annual MBA convention was held on November 15-16, 2013 at the Clarion Inn & Summit Center in Tupelo, MS. The attendance was much higher than I had expected. I had been told that as a general rule, attendance drops as the convention location moves northward. I do not know the final head count, but we probably exceeded 200 folks in the auditorium during the opening session.

I was told by many folks that this convention was one of the best, and they emphasized the quality of the invited speakers. I also think that our local speakers did their usual great jobs at presenting information. It is my sincere hope that we continue to invite speakers with high national and/or international prominence to speak at our future conventions.

Of course, no convention can be successful without careful planning and attention to details. I want to thank Gerald Jetton and the Northeast Mississippi Beekeepers Association for handling the local arrangements and for helping with the on-site registration at the door. Gerald had everything under control, and I did not have to scurry around putting out small fires during the meeting. I think the only groans came when the morning coffee was late on the first day. Despite the grumpy caffeine addicts, the mood was good throughout the meeting.

A special "thank you" goes to Cheryl Yeagley and Linda Tullos for manning the MBA merchandize table where shirts and caps were sold. Additionally, I thank Harry Fulton, Johnny Thompson and Audrey Sheridan for serving as moderators during the split sessions of the meeting.

Finally, I would like your input on how to make our MBA conventions better. Is there a person who you think would be a great speaker? Would you like the way we run the convention to change? For example, the current formula is a dual meeting (general and beginner sessions) over 1 ½ days on a Friday/Saturday. Is there a different way to run the convention? Please send suggestions for either format changes or names of future speakers to me at JHarris@ext.msstate.edu.

MBA Honey Contest

By Jeff Harris

The annual MBA Honey Contest was held in conjunction with the convention in Tupelo, MS. All entries were received on the first morning of the convention. I judged the contest during the night after the banquet. I used the same set of standards that were used for judging entries at the Mississippi State Fair in October.

The prize money for each category was allocated as follows: 1st place - $40, 2nd place - $30, 3rd place - $20 and 4th place - $10. Here are the winners:

Liquid Extracted Honey

Light Class (1st place – Walter McKay; 2nd place – Carson Boutwell; 3rd place – Austin Smith; and 4th place – Curtis Waites)

Amber Class (1st place – Leon Boutwell; 2nd place – Walter McKay, 3rd place – Paul Watson; and 4th place – Jeff Thomas)

Dark Class (1st place – Paul Watson)

Chunk Honey (1st place – Bill Nadeau; 2nd place – Stanley Holland)

Beeswax articles (1st place – Laura Thomas)

Thanks for all that participated. I will make the judging rules available early next year for those who might consider entering the contest. Pay close attention to type of jars to be used for a legal entry.

If you would like a copy of these rules, send me a message at JHarris@ext.msstate.edu.

Wonders of Worker Bees

By Jeff Harris

The honey bee colony can be viewed as a **super-organism**. In this model, the workers are the somatic tissues, or the skin, muscle and bones. The queen is the reproductive tissue, and drones are the gametes of the colony. Workers perform all the nest duties, and each worker usually performs multiple duties throughout her life. The progression through different tasks is called polyethism by animal behaviorists. The jobs performed by a worker are driven in part by her **physiological age**, and age-related changes in duties are called age polytheism.

One interesting consideration in looking at worker duties is that **chronological age** and p**hysiological age** are not always congruent. Chronological age refers to the number of days or weeks post-emergence. For example, a particular bee may be 14 days old, which means that she emerged from her brood cell 14 days ago. The physiological age refers to the state of the worker's endocrine system. Usually, the physiological age and chronological age are correlated. For example, the hypo-pharyngeal glands are most developed and active at 10-14 days old when a worker bee is normally nursing brood.

However, environmental and nest conditions can change the physiological age of a worker. For example, the hypopharyngeal glands and mandibular glands of foragers that are aged 4-5 weeks are inactive in terms of brood food production. If a bunch of nurses are removed from the colony by an experimenter, many foragers will undergo retrograde development of brood feeding glands to become nurse bees again.

Bees perform duties from the time they emerge from the brood cell until they die. However, they do not work non-stop. An individual worker may appear idle for long periods of time which are interspersed with periods of intense activity. In young workers, there is no set pattern for active and inactive periods. These bees do not display circadian rhythms in activity. Circadian rhythms are cycles of activity that repeat on a roughly 24-hour period.

Unlike young bees, foragers display distinct circadian rhythms in activity. They forage during the daylight hours, and they actually sleep in the evening and into the night. They closely resemble humans in these sleep-wakefulness cycles. Scientists have put tiny electrodes into the brains and neck muscles of foragers to show that they actually do SLEEP. I don't think anyone knows what they dream about. Perhaps a field of nectar-filled clover…?

Worker bees pass through a set pattern of behavioral and physiological development as they age chronologically. Roughly, workers perform in-nest duties when they are young and out-of-nest duties when they are older. The ontogeny of various tasks is plastic and responsive to external environmental stimuli, nest conditions and genetic programming within a particular bee.

In the literature there is large variation in the chronological age at which certain activities are performed by bees, which probably reflects differences in experimental manipulations and colony environments that influence age polyethism. Any particular worker may perform more than one type of duty at any particular age. Usually, these

Table – **Average age when workers begin to perform various tasks.**

Mean age (days)	Behavior
7	Cell cleaning
6	Capping brood
9	Tending brood
10	Attending queen
13	Receiving nectar
12	Cleaning debris
14	Packing pollen
16	Comb building
17	Ventilating
19	Guarding
23	First forage trip

duties are closely related. For example, a young worker may clean the nest and feed brood and build comb in the same day (all in-nest tasks), but she will not forage until later in life.

The four basic phases that worker bees sequentially pass through are: (1) cell cleaning and brood cell capping, (2) brood and queen tending, (3) comb building, cleaning and food handling, and (4) outside tasks which include ventilating, guarding and foraging.

There is some evidence that certain workers or subfamilies of workers in a colony may have genetic predispositions to preferentially perform certain tasks. For example, some worker bees will perform "undertaking duties" (removal of dead or diseased brood from the colony), and other workers having a different drone father may never act as undertakers.

Cell cleaning has two broad categories of activities. *Cell preparation* is performed by newly emerged bees. They remove cocoons, larval bee excreta, and remains of varroa mites from brood cells near the cell from which they emerged. These young bees then lay down a thin layer of wax (either it is secreted by them, or they obtain wax from older workers) into the clean cell to provide an egg-laying site for the queen. *Hygiene*, the other type of cell cleaning, is performed by bees that are 11-15 days old. These bees remove moldy pollen, old cell cappings, diseased and dead brood, and dead bees from the colony. Undertakers are a sub-group of these bees that actually fly out of the colony with corpses.

Brood tending consists mainly of *nursing*. Hypopharyngeal and mandibular gland secretions related to brood food production are high from 3 days post emergence. Most bees begin nursing between 6-16 days post emergence. A single bee larva is cared for by many nurses, and each nurse may raise 3-4 larvae during her nursing period. The number of brood cells that are tended per nurse bees is directly related to population of the colony. Nurses in small colonies will tend more larvae than workers in larger colonies. Nurses can control the relative proportions of hypopharyngeal gland to mandibular gland components in the brood food and adjust it to the age of the larva. They do not feed the larvae directly; instead, food is added to the pool near the larva's head. Larvae are not fed on every inspection by workers (e.g. 7200 visits in the life of a worker larva but only 1140 visits involved feeding).

Queen tending is usually done by workers that are < 12 days old. The queen produces pheromones (mainly from her mandibular glands) that cause a court of 6-10 of these young bees to surround her at all times. This court forming behavior is known as the retinue response. A single worker tends the queen for < 1 minute per visit to the court. During court formation workers lick and antennate the queen and use their forelegs to touch the queen. These actions groom the queen, and transfer pheromones to the workers. The pheromones are distributed among other workers during subsequent trophallactic exchanges. The transmission of pheromones by queen court attendants help to disseminate information about the queen to the entire colony. Workers also feed the queen. During peak egg production the queen is fed every 20-30 minutes, and each feeding bout lasts 2-3 minutes.

Comb building has two categories of activity. *Capping cells* is performed by young workers aged 2-3 days. These workers secrete some wax themselves, or they can use wax scales provided by older bees to mold the cappings. A single worker larva is capped by many workers, and the capping of a single cell may take minutes to hours depending on many variables. *Comb construction* is performed by workers aged 8-17 days. The wax glands on the ventral surface of the abdomen (between the sternites) will produce wax scales. These scales are removed by the worker herself, or by neighboring workers. The scales are molded by the mandibles and placed into areas of the comb that are being constructed or repaired. Workers that secrete wax often build comb for a little while during the day, then they tend brood. Nursing gives the wax glands time to generate more wax scales, and building combs gives the hypopharyngeal and mandibular glands time to secrete new brood food.

Food handling is performed by workers age 11-16 days. Nectar is unloaded from foragers to these young bees. A single forager offers part of her load to 2-3 receivers. Each recipient will fold the nectar with the mouthparts to begin the evaporation

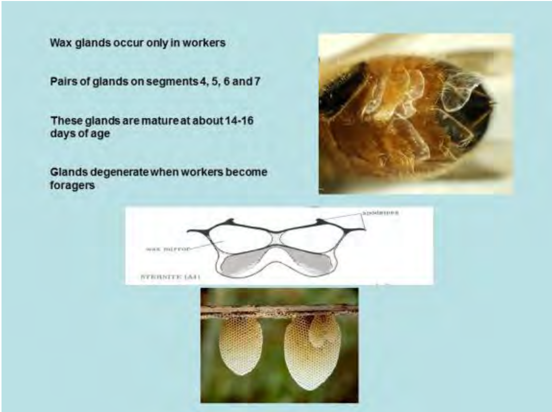

Figure – Wax glands occur on the abdomen of a worker bee

process. When a certain viscosity is reached, the worker will deposit the nectar into an unripened cell of nectar for further drying. The nectar requires 1-5 days to evaporate moisture until the water content is below 18%. This evaporation is caused by the warm nest temperature and fanning activities of bees on the comb. The ripened nectar is called honey, and a full cell is capped with wax.

Pollen is unloaded by foragers directly into empty cells in a comb. The food handling workers regurgitate honey and enzymes in saliva onto the pellets of pollen. This moistens and softens the pollen pellets so that they can be molded into a thick paste by the mandibles. Once a cell is about 2/3 full of pollen paste, the food handling workers will place a thin layer of honey (which is antiseptic) over the top of the pollen to prevent mold growth.

Ventilation is performed by workers that are about 18 days old, and it marks the first task that brings workers to the outside of the nest. Fanning bees can be found at the colony entrance or on the surface of combs. Each bee lowers her abdomen, and rapidly oscillates her wings. Bees ventilate for many reasons including, (1) maintaining proper hive temperature by cooling the colony when it is hot, (2) evaporating water from nectar to make honey, (3) to decrease the humidity inside the brood nest, and (4) to decrease the carbon dioxide levels from the nest. The implication is that workers can sense temperature, humidity and carbon dioxide levels with their sensory systems.

Guarding is performed by workers 12-25 days old. A guard patrols the entrance to the nest looking for intruders (bees from other colonies, marauding ants, humans, etc.). They have a characteristic posture as they greet returning foragers: they stand on the two pair of back legs and reach with the forelegs to briefly touch incoming bees. During this brief encounter the guard can decide if the bee is friend or foe. Usually, at any one time, only 2-5% of the bees will guard the nest. Guards will chase smaller intruders like some ants with pinching mandibles. Larger insect intruders (wasps and bumble bees) are mobbed by guards and other defenders recruited to the attack by pheromones. Large intruders are chased and stung.

Orientation flights begin when workers are about 23 days old. They usually last for < 5 minutes. During these flights a worker spirals in circles from the entrance of the colony to gain information on landmarks need for successful navigation to and from the nest during subsequent foraging flights. Interestingly, the central nervous system undergoes some instantaneous changes in morphology and activity when flights are taken for the first time in a bee's life. Many bees will also void their feces during these short flights.

Foraging begins from 23 days. Most bees only forage for a few days before they die. Foragers average about 10 trips per day, but there is considerable variation. Foragers may gather water, nectar, plant sap and pollen; but some bees may only gather one of the resources. Interestingly, the physiological mechanism of fueling the flight muscles breaks down after about 500 miles of flight. The work dies soon after reaching this distance of total air time.

Which has the biggest influence on worker physiological age, genetic programming or environmental conditions? Both are extremely important and can override the other. Three main factors control the ontogeny of temporal behavior in workers: (1) genetic programming, (2) external environment and (3) the nest environment. All three factors probably act on either the central nervous system or directly on the endocrine system to affect hormones that ultimately affect behavior.

One powerful hormone regulating worker behavior is juvenile hormone (JH). The actions of JH in adult worker bees control the behavioral-endocrine programs that mediate specific tasks. Low levels of JH in adults produce in-nest tasks like nursing; high levels of JH produce out-of-nest tasks like foraging.

What are some physiological indicators of age? Nursing and comb building usually occur in workers that are 5-15 days old. The hypopharyngeal glands, mandibular glands and wax glands reach maximal size and activity during this period. Hypopharyngeal and mandibular glands produce brood food. The wax glands secrete wax from the ventral side of the abdominal sternites. Experimental manipulation of bees to produce low JH levels in the blood will cause all of these glands to become active.

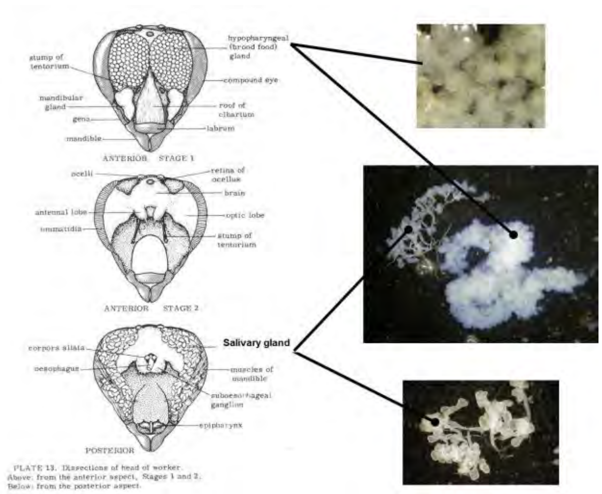

Figure – Important glands in the heads of worker bees.

All three of these glands dramatically decrease in size and activity when workers become food handlers at about 12-25 days old. Nearly simultaneously, the salivary glands (postcerebral and thoracic glands) reach peak activity, and the hypopharyngeal glands secrete invertase rather than brood food when a bee is 15-25 days old, which is predominantly the time of food handling and comb construction. Enzymes for food handling are secreted by these glands. These changes occur in response to gradually increasing blood levels of JH in the workers.

The hypopharyngeal, salivary and wax glands have the lowest activity during guarding and foraging. The mandibular glands produce 2-heptanone (an alarm pheromone) and the venom glands reach maximal activity during this time. Metabolic rate and glycogen storage of the thorax increases in foragers. They need these changes to power their flight muscles during flights of long duration in the field in search of food and water. Additionally, the abdomen loses 40% of its weight (loss in fat body, etc.) to allow for maximal expansion of the crop which is where nectar is carried.

The next time you visit your bees, take a moment and consider all of the things that workers do to ensure the survival of the colony. It is easy to forget the importance of workers, but the intricate processes that control worker behavior are mysterious and fascinating and deserve our appreciation.

Source: The Biology of the Honey, Mark L. Winston; 1987, Harvard University Press.

Eusociality in Insects

By Jeff Harris

Eusocial insects are characterized by three traits: (1) cooperative care of young by more individuals than just the mother, (2) sterile castes, and (3) overlap of generations so that the mother, adult offspring (usually sterile) and young offspring are all alive at the same time. Thus older sterile offspring aid their mother (or parents) in raising younger siblings. Honey bees are a good example of eusocial insects, but they are not the only ones.

In many, but not all, eusocial insects there is also division of labor and caste differentiation among the sterile individuals. Eusociality occurs in 3 orders: Hymenoptera (all ants, some bees, wasps), Isoptera (termites) and Homoptera (rarely in aphids).

Termites

Termites are eusocial. They are in the order Isoptera and are related to cockroaches. They are diploid, and both sexes are equally involved in social behavior. The most important factor that probably favored the evolution of eusociality is the need to transmit symbiotic cellulose-digesting microorganisms between individuals after hatching and after each molt (the wall of the gut is shed during each molt). Defense was probably also important factor in the evolution of eusociality: primitive termites have only one non-reproductive caste, the soldier. Soldiers and other non-reproductive castes are "neotenics", lacking the ability to reproduce.

David Barash and Peter Lenz formulated one potential model for the evolution of eusociality in termites. The first step likely depended on the necessity of transfer of anaerobic symbionts for the digestion of cellulose from mother to offspring. Thus, mothers would be selected by evolution to remain near their offsprings and transfer symbionts to them upon hatching. The very act of eating cellulose digestion allows safe residence within food sources, e.g., logs. A termite mother becomes larger as she feeds and can gain tremendously in egg-laying ability. For example, a queen *Macrotermes natalensis* can produce 36,000 eggs in a day.

A male is evolutionarily more fit by staying with a large egg-laying female than searching for a new mate. In present-day termites, matings are monogamous and the male and female remain together throughout their lives. Monogamy means that offspring are full siblings. The relationships between workers and their parents provide incentive for cooperation. By helping produce additional soldiers and workers to protect the king and queen, workers also ensure that their genes are transmitted to the next generation. This is called kin selection.

Queens are intolerant of reproduction (unless they are ready to produce young that will disperse and breed), and they transmit sterility pheromones to female workers. Kings likewise inhibit reproductive development in males. Termite eusociality is explained largely by parental manipulation of young and perhaps the benefits of kin selection to the non-reproductive castes.

<u>Hymenoptera</u>

In the eusocial Hymenoptera a colony consists of reproductive females (queens) and sterile females (workers); males (drones) do not aid in the colony and are produced only when fertilization of new queens is about to occur. Typically, there is only one queen in the colony and the workers don't ever breed. There are exceptions, however, of both multiple queens and reproductive workers in some species. Because workers never mate, they can only produce male offspring (drones) from unfertilized eggs and cannot produce daughters.

Sex determination

W. D. Hamilton realized that a key to understanding the evolution of eusociality in the Hymenoptera may lie in how sex is determined in this order. Unfertilized haploid eggs develop into males (drones); fertilized eggs develop into females (queens or workers). Sex is actually determined by a single gene or locus. A single copy of any sex allele (as in a haploid animal) causes a male to be formed. In diploid animals, females arise when two different sex alleles occur at the sex locus. This sex determination system is called haplo-diploidy.

Among females, caste depends on the type of food provisioning of the larvae and has no genetic basis. A queen is diploid and the probability that she provides a particular allele to a son is 0.5. On the other hand, the son receives all of his genes from his mother (remember that he is haploid), therefore, the son's coefficient of relatedness to his mother is 1.0. Males don't have sons in this system.

Since males are haploid, all the sperm they produce will be identical. If a queen mates with only one male, all of her daughters will have an identical set of paternal genes. There is a 50% chance that a daughter and mother will share a maternal gene. Therefore, daughters of monogamous mothers have a coefficient of relatedness to their mother of 0.5, but they have a coefficient of relatedness to each other of 0.75 (1/2 of genes from mother and all of the genes from the father are identical). Therefore, full sisters are more closely related to each other than they would be to their own daughters! They are called super-sisters. In this system, it would benefit a worker more to support reproduction of her mother than to reproduce herself.

What's the catch to Hamilton's idea, especially for honey bees? Queens are polyandrous - they mate with between 15-25 drones. Therefore, the relatedness among workers is greatly reduced within a colony. There are actually sets of super-sisters that correspond to each male that mated with the queen. Relatedness for workers having different fathers is only 0.5. With this degree of relatedness, a worker could pass on more of her genes if she were to reproduce herself, rather than support the reproduction of her mother. However, there are specialized workers that police the brood nest and eat eggs from that tiny percentage of workers in a colony who cheat and try to reproduce.

So, there are many theories about how eusociality arose in honey bees. The difficulty when studying the evolution of a complex behavior is that there is no fossil record for a behavior. We may never fully understand how social organization developed in bees.

Ecological factors

Many bees and wasps are not eusocial, and some are primitively eusocial. In the paper wasp *Polistes metricus* sometimes queens solitarily establish nests and sometimes two sisters jointly establish nests. There is a clear dominance order between the sisters when they establish a nest jointly, and the dominant female does nearly all of the egg laying.

Because 2 females are far better able to defend their nest against predators and parasites, even the subordinate female has higher inclusive fitness than do solitary females. Therefore, sharing nests may be one avenue to eusociality. Eusociality also may have arisen through advantages of young remaining in the mother's nest.

Like termite queens, Hymenopteran queens are essentially egg-laying machines and have been called "super-reproductives". Perhaps by helping their mother reproduce, sterile workers benefit more through kin selection than they could benefit genetically by their own reproduction. Like the termites, however, queen suppression of reproduction in workers may be a key factor.

Michener and Brothers (1974. Proc. Nat. Acad. Sci. 71:671-674) studied a species of primitively eusocial bees, *Lasioglossum zephyrum* , and concluded that queens dominate the workers, inhibiting them from becoming queens. Queens have high activity levels and nudge the workers in agonistic interactions. Workers do not develop functional ovaries, and queens nudge the workers with the largest developing ovaries the most.

Queens also eat worker-laid (drone) eggs. Queens constantly draw young workers back into the nest, keeping them there by force. Workers may benefit though kin selection because they would have a very low chance of successfully establishing their own nest.

Young colonies of the neotropical wasp, *Metapolybia azecoides* , contain a different type of female. These are mated egg-layers (subordinate queens) that produce workers during the initial stages of nest construction. These queens are forced out of the colony or become non-reproducing workers before the colony produces new queens or drones. These temporary queens resemble workers in that they make no genetic contributions to future generations, instead enhancing the development of the colony and the eventual reproductive success of the dominant queen. The subordinate queens are thought to be sisters of the dominant queen who dispersed from the natal colony with her.

Lin and Michener (1972. Q. Rev. Biol. 47:131-159) suggested that it is necessary to consider ecological factors closely when considering how sociality could have developed in the Hymenoptera. Examining the less social grades of bees and wasps, they found that much of the social behavior is mutualistic. The need for defense of the nest or hive is probably the initial reason for sociality beyond mating.

In many primitively social and even in some eusocial species, workers may be reproductive and may produce most, if not all, of the male offspring (drones). In primitively social bees, both queens and workers benefit from associating with each other, queens simply benefit more.

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