Collection and Maintenance of Ants
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Studying Ants
DuBof
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Editor's Note: This issue of the Naturalist addresses general ant biology, follows our "Ants of Kansas" issue, and consists of two brief articles. The first article is written for teachers and provides directions for collecting and raising ants for classroom learning. It is directed to beginners and should be of particular use by elementary teachers. DuBois gives an in-depth treatment of ants that can be immediately used as a reading by secondary biology teachers, with activities to spur the interest of advanced high school students. Since the articles may be used separately, a few concepts are repeated.

Top Cover Photo: Digging into a mound of Formica podzolica near Bovill, Idaho in October. This mound is about 2.5m by 0.7m. The mound is somewhat flattened as the colony was preparing for winter. At this time, the mound has no external tunnels since the ants have allowed them to be closed by rainfall.

Bottom Cover Photo: A parasitic ant, Polyergus breviceps, mandibles greatly enlarged to show scimitar shape. Scanning electron microscope photograph by Mark DuBois.

Other Kansas School Naturalists on insect topics:
"Checklist of Ants of Kansas" Vol. 40 No. 2, April 1994 [in-print and free upon request]
"Collembola" Vol. 39 No. 1, October 1992 [in-print and free upon request]
"Snowflies" Vol. 38 No. 2, May 1992 [in-print and free upon request]
"Making An Insect Collection" Vol. 35 No. 1, October 1988 [out-of-print; photocopy for $1.00]
"I Didn't Know That! (Insects)" Vol. 25 No. 4, April 1979 [out-of-print; photocopy for $1.00]
"Tiger Hunting in Kansas" (Tiger Beetles) Vol. 19 No. 2, December 1972 [out-of-print]

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INTRODUCTION

Insects are a readily available resource that should be used more in teaching so that the students can observe and manipulate live animals, an always exciting exercise. However, questions immediately arise. How do you collect insects? Then what must you do to maintain them? How difficult is the collection procedure, and how much and what types of equipment are needed? The purpose of this article is to show how simple it is to collect and maintain ants for classroom use. We also suggest several simple exercises using ants, but many books and pamphlets, including those listed in the reference list, cover many teaching exercises that use ants. Therefore, the main purpose of this article is to show you how to collect and maintain ants with the minimum amount of work and expense. The exercises you can do with these ants are limited only by your imagination.

Ants are the undisputed ecological dominants of the terrestrial world in the amount of biomass, and in energy used for foraging and maintenance. An often quoted statement from the books by Wilson (1971) and by Hölldobler and Wilson (1990) states that the biomass of ants in the Amazon Basin is much greater than that of vertebrate animals. Presently there are 8,800 species of ants that have been described, but this number will ultimately be about 20,000.

Ants are so numerous and occur in so many habitats that it is unbelievable that more use has not been made of the many ideas and accomplishments that we can gain from even a brief study of them and their social organization. Ants have a social organization no matter what species is involved because there are no solitary ants. The basic features of all social insects include an overlap of generations (mother/offspring), the adults care for the young, and a reproductive division of labor.

Ants belong to 12 diverse subfamilies but we suggest collecting Formicine (subfamily Formicinæ) ants as they are at the top of the scale in social behavior and they are easily maintained. They do not have a stinger so they pose fewer potential problems to children. However, they do squirt formic acid for defense.

We recommend that the ants Formica neoclara or *F. podzolica* be collected in the Pacific Northwest (PNW), and that *F. montana* be collected in the Midwest or East. These ants are mound builders, and they are polygynous (many queen’d). They are easily located, collected, and maintained (Figure 1 and cover). They are also relatively nonaggressive ants.

Figure 1. Close-up of the inside of the mound showing the ant tunnels. At about 15 centimeters deep into the mound the ants are aggregated into dense clusters that can be easily shoveled into plastic bags.

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can be collected at any time, but the best time to collect colonies is when they first emerge from diapause in the spring (April-May), and the workers are very active. Use a shovel to excavate a colony and soil into a heavy (6-8 mil) plastic bag. The bag is then tied for transport to the classroom where the bag is emptied into a clear plastic storage box. A lid (screened or otherwise vented) is then placed on the box. In two-three days the ants will have many tunnels established in the soil in the box, and then you can began to manipulate the ants. If you want to extract the ants from the soil, drip water slowly into the box (the water level should not exceed a rise of 1.5 cm per hour so the ants will have time to move), and the ants will move upward as the water level rises. Eventually most of the ants will be on the soil surface where they can be vacuumed (Figures 4-5). These ants can then be placed back into a container with several sheets of heavy paper for cover. Add a water source (cotton swab in a small plastic dish) and food (insects and/or honey). These ants are very easy to see and to manipulate. If workers or queens are needed for specific experiments or observations, these are easily collected with a vacuum into a small container (Figure 5).

**Figure 4.** Bon-Aire "Super Vac" canister. A. Motor housing and filter. B. 4.5 liter tank. C. Cord with cigarette lighter plug and battery clamps. D. Vacuum hose.
MAINTENANCE, OBSERVATION ANT FARM

An observation nest for the ants can easily be made from a pine strip 2" X 3/4" X 62". Since most window glass is 3/32", a 1/8" thick blade on a table saw is used to cut 1/4" deep grooves into the strip, 1/4" from the edge (Figure 6). The strip is then cut into 3, 17" pieces and one 151/2" piece. The 151/2" piece will be on the bottom, the two 17" pieces will be used for the sides. They are fastened together using glue and nails. A piece of glass cut to fit is inserted into the grooves and pushed into place. These glass panes will permit observation of the ants.

A lid, made of the same pine strips, is routed out so that it can be inserted between the glass strips and wooden sides at the top of the nest. Three 1/2" holes are drilled through this lid for ventilation and for access to feed the ants, and the ends of the lid are notched so they rest on the side strips. The lid is pushed into place and will fit tight just by friction.

The nest is then filled with soil (remove large stones and debris) from the nest site (not sand), and >200 ants are added to the soil surface. The ants will start excavating tunnels immediately, and will soon make nest chambers in which to keep their larvae. Up to 3,000 workers and 100 queens can be maintained and observed in this nest. If the colony is fed and watered, colonies will survive for 10 years or more.

A variation of this observation nest can be constructed by placing one container inside another so only the outer 1" is available to the ants with soil to excavate (Figure 7).
Figure 8. Clear plastic box container, side and top views. The top has a hole covered by screen.

Figure 9. Clear plastic plastic boxes connected by tubing. One is the main nest, the other the feeding chamber.

Figure 10. More than two chambers can be connected with clear tubing to form an intricate three dimensional maze. Smaller containers (clear 35 mm film containers) can be used as feeding chambers. They can readily be detached and cleaned.

MAINTENANCE, CLASSROOM USE

Nests: Any of a variety of clear, plastic containers can be used as nests for ants. Rectangular boxes, storage jars, round containers with lids, and even old soda bottles can be converted into nests (Figures 7-10). All must be vented (various nylon or metal screens, Figure 8), and all must have easy access to add water and food. It is probably best to use a large container (Figure 8, 12" X 12" X 6") as a container for the main colony; usually a large number of ants. This container can also serve as a reservoir of ants as they are needed for experiments. Smaller containers, with feeding chambers attached (Figures 9-10), are used for individual experiments.

Plastic containers can easily be connected using plastic tubing (available in hardware stores or pet shops as air or water tubing). Holes are made in the containers with a heated cork borer or a piece of copper tubing. The tubing is then inserted and cemented into place with silicone cement or hot melt glue.

Many ants are unable to cross barriers of “ant goop” made of a 2:1 mixture of petroleum jelly and mineral oil. However, nearly all species of Formica run across these barriers rapidly so the goop is without value. However, the barrier will work well with carpenter ants and some other species. Test the goop before using it extensively.
PROJECT OBSERVATIONS:
1. Follow the ant. Many ants lay chemical trails that other ants follow. A student can be a "foraging worker" making a trail with toilet paper for other students to follow. The "trail" can start at the nest and go to water or to a food source. Then real ants can be observed to determine if they lay chemical trails. The trail can also be mechanically disturbed to see how this section is treated by the ants. How do they re-establish the trail? Observe individual ants touching the tip of their gaster (abdomen) to the soil surface. Individual ants can be marked on the thorax or gaster with paint (Dope® model enamel works well) for identification.

2. Biology. Remove sheets of paper placed into the ant container to observe the immature stages. What stages are present (eggs, larvae, pupae, adults). What do the workers do as the brood is uncovered? Ants that tend the brood are called nurses or nurse workers. What do these workers do if you lightly dust the brood with talcum powder? If a worker is dusted, what does it do? How long does it take for the ants to clean themselves? Ant larvae are covered with hairs that interlock with paint (Dope® model enamel) for identification.

3. Foraging. Add various foods to the feeding chamber of a nest to determine how long the workers take to find the food, what food is preferred, and how they bring it back to the colony. Calculate the speed of a traveling forager. Compare the speed of the initial forager to ants recruited to the food. If possible, feed the ants colored food or dye marked food. Then sample ants that have not left the main container to determine if they have any dye inside them. Crush a worker on a white sheet. Ants touching the tip of their gaster usually feed each other (trophallaxis) within minutes of finding food.

4. Communication. These ants use formic acid as a trail material and as an alarm pheromone. Place some formic acid (purchased or crush 10 worker ants) on a white sheet. Ants usually feed each other (trophallaxis) within minutes of finding food. Place some formic acid on sheet of paper and introduce it into the colony by holding the sheet with forceps. Does it change color? How much does each ant contain? Roll a worker between your fingers and then smell it. It should be very pungent.

5. Give workers various pieces of food that they cannot readily reduce in size. What is the largest piece they can transport? Do they cooperate to carry the food? What would happen if an ant grew to 200 pounds? Could it lift a building? Why not?

LITERATURE CITED:

BOOKS FOR CHILDREN ON ANTS
It is difficult to venture outside without encountering ants, especially during the warmer months. Although many people see or step on ants, most do not understand the basic biology of ants—they are just another insect. Actually, scientists do not understand many details in the life of most ant species. We believe there may be nearly 20,000 species of ants, with roughly half of these formally described and named. For a list of ants encountered in and around Kansas, see the April 1994 issue "Checklist of Kansas Ants", Volume 40, No. 2 of the Kansas School Naturalist.

MALES, QUEENS AND WORKER ANTS

Most ants you encounter are sterile females called workers. In Kansas, most colonies contain a single reproductive female—the queen. She is typically larger than workers and has a modified thorax which contains flight muscles. I find queens of the carpenter ants (genus Camponotus) quite impressive. They are often longer than one inch and can often be found under loose bark in late summer and autumn. When you look at them with a magnifying lens, you can locate their wing scars. These large ants have a strong bite but they don’t sting. Male ants exist for the sole purpose of inseminating the queen. Once finished, most die within a few days. Typical colonies contain several thousand workers and one or several queens.

The gender of an ant is determined based on whether it is fertilized: fertilized eggs develop into females and unfertilized eggs grow to become males. If a developing female receives abundant food and the proper chemical cues, she develops into a queen; most females merely become sterile workers. Ants contain the widest range of chromosome numbers found in the animal kingdom: from $n=1$ to $n=59!$ Since male ants are haploid, the entire ant [in the case of the $n=1$ species found in Australia, Myrmecia pilosula] is defined by just one chromosome in each cell nucleus.

ESTABLISHING A COLONY

In the Midwest, most queen ants establish their colonies alone. They shed their wings after a nuptial flight, dig a chamber in the soil or in rotten wood, and lay their first eggs. While her offspring are developing, the queen obtains nourishment by metabolizing her flight muscles. She survives on this and on accumulated fat reserves until her young have developed into adult workers and begin bringing food into the colony. The queen often lays infertile eggs which she feeds to her developing larvae. Because of the reduced food supply, the first workers are often quite small and are called nanitics. They emerge from their nest and begin foraging for food. Since queens have limited reserves, they must rear workers rapidly and successfully the first time.

CARING FOR YOUNG

Ants pass through life stages: egg, several larval stages, a pupal stage and the adult. Ant eggs are extremely small, usually less than 0.5 mm. When nests are disturbed, the larger oval "eggs" ants are seen carrying are actually the pupae. Ant larvae are often covered with "hairs" which cause them to stick to each other.

In more primitive species, the workers deliver the larvae to their food; in the more advanced species, the workers bring the food to the larvae. In both cases,
workers tend to move larvae within the nest. Since many species have the "hairs" mentioned above, a single worker can move several larvae at once.

GROWTH OF AN ANT COLONY

Ant colonies usually undergo three stages of growth: a founding stage, an exponential growth stage, and a maturity stage. Behaviors of workers differ during these growth stages. In a new nest, the smaller nanitics forage immediately after emerging from the pupal stage. Their colony is being established and it is imperative to locate nourishment rapidly (once the queen has exhausted her body reserves, the colony would starve without outside sources of food). In older colonies, when workers emerge from the pupal stage, they spend most of their time in activities within the nest, caring for developing young, tending the queen, housecleaning, and constructing new tunnels. Older workers are usually the ones to venture outside the nest, except for nanitic workers in new nests. It is these older workers who are the first to defend their nest from predators and competing colonies. Ant colonies fight their territorial disputes or "wars" using mostly old females.

Figure 1. Trachymyrmex septentrionalis, body, lateral view. Legs removed.

ANT SENSES

Ants do not perceive the world in quite the same way humans do. They are surrounded with an exoskeleton. Imagine trying to sense air currents or the texture of objects when surrounded with this suit of armor. Although most ants have eyes, they are unable to sense red light—to them it appears dark. Since they live underground, most ants do not depend on vision but rely upon smells to communicate. Antennae serve the same function as our noses. Some ants are completely blind; others, such as army ants, are only sensitive to light versus dark. Although ants lack external ears, many are sensitive to vibrations. When ants of some species become trapped by a tunnel collapse, they make a rasping sound (a process called stridulation) which attracts nestmates and signals them to dig rapidly. Several species in the Midwest will stridulate when held with a forceps. This noise is loud enough to be heard by human ears.

GARDENING ANTS

Trachymyrmex septentrionalis are gardening ants related to the "leaf-cutting" or "parasol" ants of the New World tropics. Kansas, Illinois and New

Figure 2. Trachymyrmex septentrionalis, head, full face view.
Jersey form the northern limits of their range. Colonies are relatively small with roughly 200 individuals. Nest entrances are easily recognized by a semi-circular crater and are usually discovered in open oak woodlands with sandy soil. Although these ants are much smaller than their tropical relatives—and have correspondingly smaller nests—they share the trait of fungal cultivation and ant behavior only known to occur in certain species in the New World.

Gardening ants are unique because they harvest material to cultivate a fungus. The ants then dine on the fungus; without access to the fungus, they starve. Newly mated queens must take a small culture of the fungus with them when they leave their parental nest. After finding a new nest site, such queens often nourish the fungus with their excrement or feces. They may also place trophic eggs into the fungal mat. As the small nannitics emerge and begin to forage for food, they search for insect feces and excrement, not typical ant food. I have encountered numerous workers carrying bits of vegetable matter and insect feces to their nests. Once inside, the ants chew the material to moisten and soften it and then place it so the fungus can grow. For more information about these ants, see Weber, 1972.

HARVESTER ANTS

I have fond memories traversing the plains of western Kansas and finding the conical, pebble-covered mounds of the harvester ant, *Pogonomyrmex occidentalis*. Six species of harvester ants had been recorded from Kansas and I encountered five during my studies. These ants harvest ripe seeds from the ground and nearby plants, then husk and store them for use in times of scarcity. They will eat dead insects as well. These supplies sustain the ants through the colder months. These ants possess a "beard" of long hairs (called a psammophore) located on the underside of the head. This structure enables an ant to carry a larger amount of dry soil than she would be able to carry without it. Most species of harvester ants are found in western and southern states; one is found as far east as Florida.

Density of harvester ant nests appears higher near human disturbances such as roadways and railroads. Perhaps water collects alongside and softens the soil. Many nests are visible because most of the species also clear the vegetation surrounding their nest. Piece by piece, they cut them up with powerful mandibles. Harvester ants can be of economic importance when they harvest seeds from cultivated crops. They also damage range lands when nests are abundant.
Female harvester ants have a potent sting. With a large investment in harvesting seeds and storing them, they readily defend their nests. Some small mammals try to invade these larders in search of seeds. I have experienced numerous stings from these ants; the localized swelling and redness is followed by a throbbing pain which lasts up to several hours. The skin around the sting becomes moist. If someone is hypersensitive to ant venom, they may go into anaphylactic shock which requires prompt medical attention.

PARASITIC ANTS

Parasitic ant species depend upon another ant species during part of their life cycle. They exhibit parasitic behavior in differing ways. Some queens invade another colony, kill the queen, and depend upon "host" workers to care for their offspring. Eventually, all "host" workers die and leave a pure colony of the temporary parasite ants. In Kansas, *Formica subintegra* represents this lifestyle. Species such as *Polyergus breviceps* take this step to an extreme and raid other "host" colonies to replenish the supply of workers as original workers die. Species such as *Monomorium talbotae* dispense with their own worker caste entirely and depend on the "hosts" for food, defense, and rearing of offspring. It is presumed that "host" queens are not killed by these invaders.

One species found in northeastern Kansas, *Lasius umbratus*, has a distinct lemon aroma, especially noticeable when a nest is first disturbed. This species is thought to rely upon *Lasius alienus* when it establishes a colony. Although details of colony founding by *Lasius umbratus* in North America are poorly known, it may follow *Lasius niger* which has been extensively studied in Europe. A newly mated queen lands and begins searching for workers of its host species. She either encounters isolated workers or briefly enters a nest and pulls one or two defending workers to the surface. There she proceeds to bite and eat the workers. It is thought this allows her to obtain the colony odor of her host. After several hours, the queen proceeds to enter the nest, then locates and kills the host queen. She deposits her own eggs in the invaded nest and the host workers rear her offspring. Since no additional host eggs are laid, the host workers age and die off. Eventually, a pure colony of *Lasius umbratus* develops. This approach to starting a colony may be an adaptation to cold climates; the parasitic queen does not need to spend as much energy rearing her first offspring. Indeed, queens of this species are much smaller than the host queen which may reflect less need to store nourishment to feed developing offspring.
Another species is even more dependent on the host species. *Formica subintegra* lives in open woods and sunny meadows. Besides entering a host colony of *Formica subsericea* and killing the queen, these ants depend on their hosts throughout their life cycle. Once worker offspring have developed in the host colony, they begin raiding other colonies of the host species and carry off pupae. Captured pupae develop into worker ants which begin to care for the parasite ant. Ants that emerge from the kidnapped pupae form an image of their nest within the first few hours of adulthood. They accept their captors as nestmates and even accompany them on raids on nests of their own species.

Workers of *Formica subintegra* have an enlarged Dufour's gland in their abdomen. They produce decyl, dodecyl, and tetradecyl acetates which they spray during their attack on a host colony. Wilson calls these "propaganda substances" since they evaporate slowly, exert their influence over a period of time, and alarm and disperse the defending workers. These chemicals attract attacking nestmates of *Formica subintegra*.

In many instances, the attackers move their nest into the raided colony. Ants usually raid in the afternoon and have been known to raid every day in the summer. Once raided, *Formica subsericea* workers typically attempt to block their nest entrances with bits of grass, pebbles, or soil particles.

Another species, *Polyergus breviceps*, has evolved scimitar shaped mandibles (cover). These are highly effective for fighting and piercing their opponents, but are so ineffective as mouthparts that these ants are dependent upon their hosts to feed them. Experiments with isolated workers suggest they will starve to death when surrounded with food unless a host worker is available to feed them. There are a number of parasitic species in the Midwest and Plains regions and most have been poorly studied.

ACROBAT ANTS

These common ants are easily recognized by the way they hold the gaster (tail segments of the abdomen) over the thorax with the tip pointing forward, like a scorpion tail. These ants are often seen walking single file along a twig or vine—hence the name. They are also identified by their heart-shaped gaster (when viewed from above). Their nests are usually constructed in the soil, in rotting wood, or in hollow stems. Most nests contain several thousand workers. They are quite aggressive and many workers will emerge from a nest once it is disturbed. Although they lack a sting, they possess a strong bite which can be painful.

Most *Crematogaster* feed on "honeydew" and on dead insects. Honeydew is produced by insects such as aphids, scale insects, and leafhoppers that ingest large quantities of plant sap for food. Since sap is high in sugars and

Figure 7. *Crematogaster punctualata*, head, full face view.

Figure 8. *Crematogaster punctulata*, alitrunk petiole, and postpetiole, lateral view (slightly from above). Legs removed.
water, but low in proteins, these insects must consume large quantities of sap to obtain a full diet. The excess sugar and water is passed through their digestive tract almost unchanged and is defecated as honeydew. When extremely abundant, these small insects can damage plants and transmit diseases between plants.

Aphids and scale insects are relatively immobile throughout most of their lives since their mouthparts are inserted deep into plant tissues. In the absence of ants, aphids forcibly expel the honeydew droplets or kick the droplets away. However, if an individual is tended by ants, it retains the droplet of honeydew until its abdomen is touched by the antenna of an ant. It then defecates the sugar droplet which the ant licks up.

Both ant and aphid benefit from this relationship. The ants are provided by a relatively stable food supply and insects tended by ants are less likely to be eaten by predators. Although ants do not actively protect aphids, they respond to rapid or erratic movements which force predators to move elsewhere. *Crematogaster* species even carry aphids into their ant nests and expose them to roots to feed while being protected from bad weather.

However, when the food requirements of the ants become more restrictive, such as when there are many larvae and a need for increased protein, the ants may ignore the honeydew. If there are shortages of foods high in proteins, ants may attack aphids and kill them for food.

**ARMY ANTS**

Species of army ants do occur in North America and several are common in parts of the Midwest and Great Plains. Army ants do not construct permanent nests but periodically engage in raiding swarms during which they kill and consume other insects, including other ants. William Wheeler called these the "Huns and Tartars of the insect world." Contrary to graphic pictures in horror movies, army ants are no threat to humans in North America. Since these ants are shorter than a centimeter and are able to move only several yards per hour, anyone can easily walk away from a raiding swarm. In fact, I have been covered past my knees in these ants with no harm done.

Raids are usually conducted in the evening and at night; they may continue during daylight hours on warm, cloudy days. These raids usually cover an area of variable width and may be up to 40 yards long. Raids begin at the bivouac and proceed outward in one direction. Ants in the lead are continually overtaken and replaced from behind. Since army ants are nearly blind, they follow odor trails laid by the temporary leaders. Insects encountered are killed, cut into pieces and returned to the bivouac. These ants only consume fresh prey and make no effort to store excess food.

The colony usually bivouacs in a new location each night. Workers find a sheltered place somewhere in the area of the raid. Sometimes, they use the nests of ants they have raided. The army ant queen moves to the new bivouac during the night accompanied by a group of workers that constantly surround her. Army ants do not conduct mating swarms since the queen is permanently wingless. Instead, winged males fly from their colony in September and October to find another queen. Unmated queens remain with their mother's colony and wait for a male to find them. Once the new queen has mated, she entices some workers to follow her and the colony splits; some workers follow the new queen while others remain with the old queen.

Army ant colonies can sometimes be discovered by searching for their raiding swarms along paths or sidewalks after dusk. They are occasionally found under rocks or in colonies of raided ants. However, they are usually discovered through luck rather than diligence of the collector.
QUESTIONS, ACTIVITIES AND INVESTIGATIONS WITH ANTS

Note: There are a number of species of ants which can inflict a painful sting. Before attempting any of the following investigations, select species that do not have large and conspicuous nests. Most ants with conspicuous nests are advertising to potential predators that they can be formidable defenders.

Nuptial Flights: Select the common species in your yard and observe them when they conduct their nuptial flights. Document which factors seem to come before the flights (temperature, rain, barometric pressure changes). Carefully observe and record the flight itself. How would you describe the mating swarm? Is it near some prominent object? How far above the ground is the swarm? How many males and females are present in the swarm? What do the females do after mating? How far do they fly before landing? What are their behaviors upon landing? What do the males do after landing?

Colony Founding: Select newly mated queens and isolate them in test tubes partly filled with water and separated from the ants with a cotton plug. How long before the queen begins laying eggs? How many days until the first larvae appear? How long before the larvae become pupae? How long before the first workers emerge? Be certain to record daily temperatures where you keep the ants.

Nest Disturbances: When an ant colony is disturbed, do the ants first carry off the pupae or the larvae? Why would this make a difference to the survival of the colony? Do different species behave similarly?

Food Preferences: Many ants prefer different types of food. Select different foods to use as bait and learn which ants are attracted. To begin, try the following items: honey mixed with equal amounts of water, cookie crumbs, peanut butter, cooking oil, cereal flakes. Do the same species always prefer the same foods, even at different times of the day or different times of the year?

Ant Trails: Can you determine which direction leads to a newfound food source and which direction leads back to the nest without tracing the ends of the trail? Place a sheet of paper across an ant trail. After the ants have re-established a path across it, turn the paper slightly sideways. What happens to the path the ants take on the paper? Does this suggest any ideas about how the ants follow a trail? Pick up an ant that is running along an ant trail or brush her off to the side. Can she find her way back?

Parasitic Ants: Can isolated queens of parasitic species establish colonies on their own? What longterm effects do the parasitic species cause to the host species? Are the parasite ants limited to one species of host or will they take another if the preferred species is unavailable? What happens when raiding workers of Formica subintegra or Polyergus breviceps encounter another nest of the same species. Is there a pattern to the raids of parasitic ants across a field, or over time?

FURTHER READING

These references represent a start toward learning more about ants. Check the literature citations within these works for even more sources. At last count (1994), there were over 18,300 scientific publications on ants!


