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NATURAL HISTORY AND CAPTIVE MANAGENENT OF LEAF-CUTTING ANTS IN THE GENUS *ATTA* (HYMENOPTERA:FORMICIDAE)

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The display potential and educational value of Atta was recognized as early as 1938, when the Bronx Zoo temporarily maintained a colony for public viewing (Ditmars, 1938). In 1978, the Cincinnati Zoo Insectarium began exhibiting Atta, and was then one of few institutions working with the ants. In recent years, there has been a dramatic increase in the number of zoos, museums and related educational organizations keeping Atta. Currently this includes at least 21 organizations in North America and Europe, with another five planning to acquire ants in the near future (Table 1).

Atta colonies are now recognized as important and highly effective educational exhibits (Morgan, 1991).

Considering this interest in Atta, there is relatively little information available on its captive husbandry. This paper summarizes the relevant natural history of Atta, outlines the basic principles of captive management, and describes a simple system for keeping colonies. Field collection procedures and permit requirements are also noted.

NATURAL HISTORY OF ATTA

Ants in the genus Atta harvest plant material used to grow fungus gardens for food. The biology and behavior of Atta and other fungus-growing ants has been the subject of detailed reviews (Wheeler, 1907; Wilson, 1971; Weber, 1972, 1982; Lofgren and Vander Meer, 1986; Holldobler and Wilson, 1990).

Biogeography: The genus Atta, containing 15 species, is native only to the New World and occurs primarily in moist tropical habitats in South and Central America, and Mexico. However, a few species have adapted to harsher climates, like A. mexicana, found in the hot deserts of Mexico and southern Arizona, and A. texana, occurring exclusively in Texas and Louisiana.

Social organization: Atta demonstrates one of the most complex social organizations known for any kind of ant. Its colonies typically consist of a single fertile queen and numerous sterile female workers.

The massive queens, over 20-mm long, are specialized for egg production and give rise to worker populations as large as several million individuals. The workers-are strongly polymorphic, varying in length from about 2-15 mm, permitting a high degree of task specialization. Generally, the smallest workers tend to remain in the nest and serve as nursemaids and gardeners, medium-sized workers gather plant material and maintain the nest, while the largest workers function as soldiers.

Nest structure and function: Established nests are large, extend several meters or more into the ground, and contain hundreds of fungus gardens. The nest architecture is complex and adapted to control the fungus gardens' environment. Subterranean garden chambers provide high humidity conditions required by the fungus. Central passageways above the gardens vent stale air and heat produced by fungal decomposition, while the nest is ventilated in turn with fresh air drawn in through peripheral tunnels. A lower system of passages drains the chambers to prevent flooding. In dry periods the ants reduce nest openings, abandon gardens in the upper tiers, and move deeper into moist soil.

Colony reproduction: Mature colonies annually produce winged reproductive forms, or males and virgin queens; mass mating flights often occur at the start of the rainy season. The young queens carry a bit of fungus from their parental nest within their mouthparts. The males die shortly after mating, while the queens shed their wings and quickly excavate shallow burrows. Each queen rears her first brood (eggs, larvae, and pupae) and fungus garden in isolation.

Developing workers assume domestic duties and soon begin to forage for plant material. Colony growth is slow at first, then proceeds rapidly, and maturity is attained in about five years.

Fungal substrate: The plant material used by the ants to grow their gardens is called fungal substrate. Since Atta is an agricultural pest, research has focused on substrate selection and foraging strategy (see Cherrett, 1968; Rockwood, 1976; Bowers and Porter, 1981; Waller, 1982). Atta naturally utilizes a wide variety of fungal substrate, but prefers introduced or agricultural cultivars over native plants, new leaves and flowers over mature leaves, and plant material with a relatively high water content. Plants with tough or distasteful leaves are generally avoided.

Gardening behavior: Fungal substrate is collected and manipulated assemblyline style. A worker straddles a leaf to be cut, measures a portion with her legspan, then rotates and shears the leaf with sharp mandibles. Columns of returning foragers carry small disks of plant material held over their heads. Plant fragments brought into the nest are processed by series of progressively smaller workers. The substrate is broken apart, macerated finely, treated with enzymes,-and added to the upper and outer regions of the gardens. The ants fertilize their gardens with fecal droplets, meticulously weed out undesirable species of fungi, and harvest portions used for food. Old and exhausted pieces of the gardens are removed from basal regions and discarded as debris.

Fungus garden structure and function: The gardens look like globular masses of gray, sponge-like material, and are typically 10-25 cm in diameter. The ants' gardening behavior determines the appearance of a garden, which varies along its height. The upper and outer regions are formed into relatively large gray cells with thin granular walls. The base of the garden is compacted from the weight above and consists of smaller, yellow-brown cells. As a garden matures, it becomes peppered with light colored clusters of fungal mycelium. These nutrient-rich growths are the principal diet of the colony (workers also ingest sap from cut leaves). Both the queen and brood are held within the maze of fungal chambers.

Ant-fungus mutualism: The ants and fungus evolved in close association resulting in a mutualistic relationship where both species benefit and are completely interdependent. While the fungus provides the ants with food, the ants' behavior is directed principally toward sheltering the fungus and bringing it substrate, protecting it from-competing fungi and other organisms, and helping it reproduce and disperse. Neither the ants nor the fungus can survive for long without the other.

CAPTIVE MANAGEMENT OF ATTA

Laboratory maintenance of research colonies has been detailed by Weber (1972, 1976, 1979, and 1982) and summarized by Holldobler and Wilson (1990). Colony development by newly mated, wild-caught queens has been reported most recently by Weber (1972),

Mintzer and Vinson (1985), and Mintzer (1987). Also, the design and care of display colonies has been briefly described by Ditmars (1938) and Morgan (1991). The husbandry requirements of all species are virtually identical.

Standard housing and care: Weber's now conventional method of husbandry employs small containers, called garden chambers, to house the colony and its fungus gardens; clear plastic containers serve as observation nests. The shape and size of the garden chambers are relatively unimportant, as the ants are highly adaptable, and given an optimal environment, will readily grow their fungus in any small protective cavity.

To accommodate an expanding colony, garden chambers are linked together with tunnels made from clear tubing. Tunnels can be almost any length, but an optimal width is 2.5 cm in diameter. Wider passageways may be used by the ants as gardening sites, while much narrower tunnels restrict the free flow of workers carrying substrate.

Plant material is placed in a separate container, called the foraging area, also connected to the observation nest with tubing.

Captive colonies are typically maintained on fresh plant material that the ants cut and process as they would in nature. Foraging area debris, consisting of unused substrate, spent fungus, and dead ants, is periodically removed.

If the garden chambers and foraging area are not otherwise contained, it is crucial that all components be well constructed and fit precisely. The ants will eventually chew open and escape from any small space, and begin to forage outside of their enclosure. Aquarium sealant can be used to temporarily repair small cracks or holes used by escaping ants.

The moisture and temperature requirements of the fungus gardens are much stricter than those of the ants, thus the environment within the garden chambers is critical, while that of areas occupied only by the ants is of secondary significance.

Moisture requirements: The fungus gardens need a constant, highly humid atmosphere, preferably at or near the saturation point (100% RH). Weber placed clean moist sand in containers housing small colonies, which have less ability to regulate moisture levels, but noted that sand was unnecessary for most large colonies with established gardens. A related problem is the accumulation of water within garden chambers from condensation, which is detrimental to the fungus if left unchecked.

The ants, in contrast, tolerate a wide range of humidity levels. They will survive in a dry atmosphere as long as they have access to drinking water. Weber recommended that humidity levels in the foraging area be kept relatively dry (20-50% RH) to prevent the formation of molds. At the Insectarium, foraging areas are kept humid (>60% RH) and regular debris removal eliminates mold problems. In a humid atmosphere, plant material remains fresher and ants do not require drinking water.

Temperature and lighting: Room temperatures of 25-27°C are ideal for fungal growth, while temperatures of 20°C and 30°C are suboptimal for fungus grown in laboratory cultures (Weber, 1972).

The ants function well within a broader range of temperatures. Their metabolism slows at cooler temperatures; if briefly chilled they become torpid, but recover when warmed. Temperatures below freezing or above 35°C are lethal.

Colonies readily adapt to lighting at normal room intensities, and can have additional illumination for viewing provided the garden chambers are not overheated. Observation nests should never be exposed to direct sunlight.

A simple method of housing: At the Insectarium, surplus or reserve colonies are maintained as small populations. Each colony is housed in a single garden chamber held within a glass aquarium. The garden chamber is a clear plastic l9x14xlO cm specimen box (Table 2) with a 2.5 cm diameter hole in one end for the nest entrance.

The garden chambers are modified for moisture control. An important component is Hydrostone (Table 2), a material used like plaster-of-Paris but is more durable when cured. A 2-cm thick layer of Hydrostone is cast into the floor of each garden chamber. Since Hydrostone absorbs water, this base layer acts as a moisture reservoir and also wicks away any excess condensation. The plastic bottom of the garden chamber is drilled with four 6-mm holes, one near each corner. These holes extend part way into the Hydrostone and allow for drainage. While not essential, tan Mortar Color (Table 2) can be added to the Hydrostone during preparation to give it a natural color.

A standard 37.8-liter (10-gal.) aquarium provides a convenient foraging area for a small colony. If desired, larger tanks can be used for more populous colonies housed in several garden chambers. It is not necessary to interconnect garden chambers with tubing as the workers travel freely between boxes. To deter escape, sealant in the inner corners of the aquarium is removed with a razor, and about a 1O-cm wide band of 3-in-One Household Oil (Table 2) is smeared on the glass around the upper inside perimeter. Atta workers are adept climbers, and the slippery barrier works best if the surface is wiped clean and the oil reapplied at weekly intervals.

Foraging area cleaning and ant population reduction, when needed, are accomplished simultaneously. The garden chamber is transferred to a clean aquarium and the old foraging area, containing debris and excess workers, is placed in the freezer.

Fungus garden management: Proper fungus garden management is the key to successfully keeping Atta. Fungus gardens are routinely monitored to distinguish healthy, actively growing gardens from ones that are shrinking or otherwise failing. Management practices are directed towards helping the ants maintain an optimal environment for fungal growth.

Seasonal variables have a profound affect on management strategy. Spring and summer bring high atmospheric humidity and moisture-laden plant material. Consequently, excess moisture typically condenses in the garden chambers and must be eliminated. Winter brings low atmospheric humidity and reduced plant moisture, and garden desiccation must be prevented.

Garden chamber moisture levels are controlled by regulating moisture input and output. Excess moisture is reduced by a combination of adequate drainage, increased ventilation, and dry substrate. Moisture levels are raised by providing moist substrate, adding water to the Hydrostone, and reducing ventilation.

Substrate source and utilization: Fungal substrate is obtained from several sources (Tables 3 & 4), and available choices include numerous plant species in about 40 genera and 25 families. Zoo landscape plants and weeds are used predominantly during the growing season. In the winter, the ants depend on plants that are winter-hardy, grown in the greenhouse, or acquired as grocery produce. Substrate acceptability was determined by experimentation. Plant material offered to the ants is free of insecticides and fungicides.

The amount of substrate needed depends on colony size. Very young colonies benefit from continually available substrate, but several heavy offerings per week are sufficient for large established colonies. Plant species are routinely varied because the ants typically lose interest in the same material offered on several consecutive days.

GETTING STARTED WITH ATTA

New colonies cannot be started from captive colonies, which are normally maintained at population levels far below those of mature colonies, and are thus unlikely to develop winged reproductives. Further, the mating flights of most ants follow environmental conditions, which are nearly impossible to duplicate (Holldobler and Wilson, 1990). Surplus colonies are sometimes obtainable from suppliers, but their availability ultimately depends on some method of field collection.

Field collection: Newly mated queens are easy to collect as they wander over the ground or excavate burrows. The principle difficulty is the need to be in the field following the mating flights, which occur infrequently and are not easy to predict. Colony excavation is the most consistently reliable means of acquiring livestock.

Collecting a mature colony, deeply entrenched and well-defended, is a formidable task. However, colonies less than are year old are easily collected and can often be found near mature colonies. Young nests of some species can be identified by their characteristic turret-like opening, which later disappears (Weber, 1972), and relatively small foraging processions.

The single garden, containing the queen, attendant workers and brood, can be exposed near the surface and gently scooped into a small container; it is unnecessary to collect foraging workers. The gardens are fragile and should be handled carefully during collection and transit, although workers quickly repair damaged gardens.

Importation permits and pest potential: Leaf-cutting ants are agricultural pests and should be treated responsibly. U.S. Department of Agriculture - Animal & Plant Health Inspection Service (USDA-APHIS) Plant Protection Quarantine (PPQ) Form 526 must be approved by both your state entomologist and federal officials before non-native species can be obtained from a supplier or imported into the United States;

other countries may have similar regulations.

The pest potential of a captive colony is negligible since the queen is the only reproductive individual, and given the opportunity to escape, is unlikely to abandon the security of the gardens. It is also improbable that tropical species could establish in temperate regions.

Casa Hormiga

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