A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

Volume 8, Issue 4 • April 1999

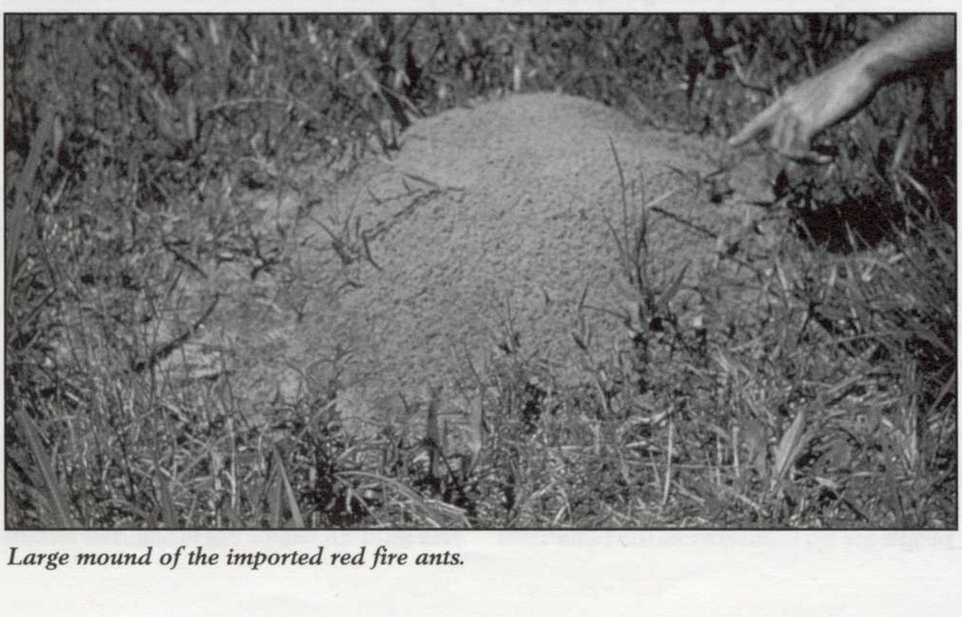
ENTOMOLOGY

Red Imported Fire Ants
Continue to Spread North and West

Dr. Beverly Sparks, Professor and Extension Entomologist, The University of Georgia

Solenopsis invicta (Buren), the red imported fire ant, was accidentally brought into Mobile, AL in the ballast of ships from South America in the 1930s. Since its introduction, this species has spread throughout the southeastern United States and now continues to expand its northward and westward distribution into areas with mild climates and adequate moisture and food. The ants currently infest over 240 million acres and can be found throughout Puerto Rico, Florida, Georgia, Alabama, Mississippi and Louisiana and in portions of South Carolina, North Carolina, Tennessee, Arkansas, Oklahoma and Texas. In addition, infestations of the red imported fire ant were recently found in Fresno, Kern, and Orange Counties in California.

Fire ants disperse naturally through mating flights, through colony relocation over short distances or by floating to new locations in floodwater. Humans also assist in the distribution or movement into new locations through shipments of ant infested nursery stock, sod, soil, hay, pine straw or beehives. Despite quarantine efforts aimed at preventing the movement of fire ants, it is not uncommon to find that imported fire ants "jump ahead" of the natural distribution due to movement of infested products.



Large mound of the imported red fire ants.

IN THIS ISSUE

TURFGRASS TRENDS

Executive Editor
Sue Gibson
440-891-2729; 440-891-2675 (fax)
sgibson@advanstar.com

Managing Editor
Bruce F. Shank, BioCOM
805-274-0321

Technical Editor
Nancy Stairs
440-891-2623

Senior Science Editor
Dr. Karl Danneberger

Consulting Editor
Chris Sann

Group Editor
Vern Henry

Production Manager
Karen Lenzen
218-723-9129; 218-723-9576 (fax)
klenzen@advanstar.com

Circulation Manager
Frank Christopherson
218-723-9271

Group Publisher
John D. Payne
440-891-2786; 440-891-2675 (fax)
jpayne@advanstar.com

Corporate & Editorial Office
7500 Old Oak Blvd.
Cleveland, OH 44130-3369

New Subscriptions
1-888-527-7008

Abstracts: 800-466-8443
Reprint: 440-891-2744
Permission: 440-891-2742
Single copy or back issues:
Subscription/Customer Service
1-888-527-7008; (fax) 218-723-9437
Website address:
www.landscapegroup.com

ADVANSTAR
HOLDINGS, INC.

Chairman and Chief Executive Officer
Robert L. Krakoff

Vice Chairman
James M. Alic

VP-Finance, CFO & Secretary
David J. Montgomery

Executive Vice President, Business Development
Skip Farber

ADVANSTAR
COMMUNICATIONS

Executive Vice Presidents
William J. Cooke
Alexander S. DeBarr

Vice President & General Counsel
Eric I. Lisman

Treasurer and Controller
Adele D. Hartwick

Friend or foe?

In some settings the red imported fire ant is considered a beneficial insect. The ants feed on just about anything, but their preferred source of food is other insects. In some agricultural settings they prey on very destructive insects. They also reduce the populations of many human and animal pests, such as ticks, fleas and flies.

Although fire ants can be considered to be beneficial insects in some settings, when looking at the "big picture," one must consider the numerous problems they create. Once fire ant mounds are exposed to environmental conditions, the above-ground portion of their mounds becomes very hardened and causes significant damage to turf and farm equipment. Damage to equipment results in lost time in labor as well as equipment repair costs. Adult ants often move into electrical housing units and chew away insulation from wiring. Fire ants cause numerous power outages or electrical shortages in air conditioners, irrigation control boxes, traffic lights and water pumps. In areas where heavy infestations occur (200-plus mounds per acre), fire ants have significant effects on populations of ground nesting birds, deer and other wildlife. Imported fire ants will also feed on seeds and young roots, causing significant plant loss in some agricultural cropping systems.

Although fire ants damage equipment, cause electrical problems and harm wildlife, the most significant problem associated with fire ants is their stinging behavior. The ants are very aggressive and will readily attack anything that disturbs their mound.

When a mound is disturbed, large numbers of worker ants come to the mound surface to defend the colony. An unsuspecting victim can be rapidly covered with ants. The ants anchor themselves with their mouthparts and then sting repeatedly. Venom injected through their sting causes a burning and itching sensation and often causes a white pustule to form. Although fire ant stings are not usually life threatening and are medically uncomplicated, a few people are hypersensitive to the venom and may suffer chest pains, nausea or lapse into a coma from even one sting.

Look Inside an Ant Mound

Fire ant colonies consist of the brood (eggs, larvae and pupae) and adult ants. The various types (castes) of adult ants include winged males, winged females, one or more egg producing queens and workers. Within a colony, the worker ants vary a great deal in size, but they are all sterile, wingless females. Workers care for the queen and the brood, forage for food and defend the colony.

Winged adults and queens are responsible for dispersal and reproduction. The winged "reproductives" eventually leave the mound in large numbers to mate in the air. This mating or nuptial flight can take place any time of year, but usually occurs in the spring or early summer after a rainy period. Males die shortly after mating. The newly fertilized queen can fly for several miles before she falls to the ground, sheds her wings and begins digging a chamber in which to start a new colony.

The new queen lays a small cluster of eggs that hatch in seven to ten days. The queen initially provides nourishment to this first group of larvae, but later on, she lays up to 200 eggs per day and the care of the eggs and larvae is taken over by worker ants. The larvae develop for six to ten days before pupating. Adults emerge from the pupae in nine to 15 days. The average fire ant colony contains 100,000 to 500,000 workers and up to several hundred winged forms. Mounds may contain only one egg-laying queen (monogyne colony) or have multiple queens (polygyne colonies). Single queen colonies will not accept workers from other colonies and are defensive of their foraging territory. Populations of single queen colonies usually stabilize at 40 to 80 mounds per acre. Multiple queen colonies are more accepting of workers from other colonies and thus their populations often exceed 200-plus mounds per acre.

The mound of a new colony is not conspicuous until several months after the young queen begins egg laying. The size of the mound depends upon soil characteristics and land disturbance. In heavy soils the upper portion of the mound is often conical and can reach a height of 12 to 18 inches, while in sandy soils the mounds are less well developed. The underground portion of the mound is a series of tunnels and chambers that may extend three to four feet deep.

Fire Ant Control Strategies

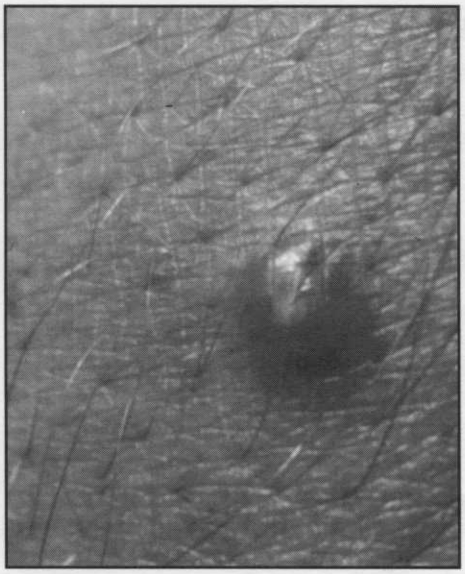
Total elimination of the red imported fire ant in fully infested areas is not technically, environmentally or economically feasible. Temporary control of fire ants can be achieved with the use of chemicals; however they must be periodically reapplied for as long as control is desired. If treatment is terminated, reinfestation is likely to occur as newly mated queens from surrounding areas reinvade the area. Furthermore, it is common for the newly repopulated levels to be larger than the population prior to the initial treatment!

The decision to treat fire ants, once taken, must be accompanied by a long-term commitment to continue periodic treatments. Because of this need for a long term commitment, it may be difficult to economically justify an ongoing control program in many agricultural settings. In high use areas such as parks, playgrounds, recreational turf areas and home lawns, justification for fire ant control programs is more subjective. One must decide when fire ants become intolerable and how much to invest in control efforts. These decisions are influenced by potential health risk due to the presence of fire ants and by the environmental impact of chemical applications.

Treating Individual Mounds

Common methods used to treat individual mounds include drenching each mound with a diluted liquid insecticide; application of granular insecticides to the top of each mound; injection of insecticide into each mound; or application of bait around each mound.

The treatment of individual mounds is a control technique that is best suited for use in small areas where there are low populations of fire ants (less than 20 mounds per acre). Treating each mound requires more labor and monitoring than other treatment techniques and is not suggested for areas where fire ant populations are extremely heavy.



Although fire ant stings are not usually life threatening, a few people are hypersensitive and may suffer chest pains, nausea or lapse into a coma.

To be effective, it is important to time application of these insecticides to when the adult ants and their brood are located in the top portion of the mound. Mound treatment is most effective when applied in the spring or fall of the year or following periods of heavy rain. This technique of treatment selectively controls fire ants but reinvasion of the site by ants is often observed within three to six months.

Time insecticide applications when the adult ants and their brood are located in the top portion of the mound, usually in the spring or fall or following periods of heavy rain.

Mound drenches: Most fire ant control products are formulated as liquid concentrates, although a few are ready-to-use formulations. These concentrated products may need to be diluted in the amount of water specified on the product's label so care should be taken in handling the concentrate to avoid contact. The solution is poured on top of and around the perimeter of an undisturbed mound. It is important to deliver the diluted insecticide to the mound in quantities large enough to reach the queen and the brood. On larger mounds, up to two gallons of diluted insecticide may be needed. Mound drenches generally do not kill ants immediately and may require several days to be effective.

Granular products: Several products containing insecticides have been formulated as granules to be applied to individual mounds at a specified rate. To treat a single mound, the recommended amount is sprinkled on top of and around the base of the mound without disturbing the mound. If instructed, water the granules into the mound without disturbing the colony. Several days may be required for the entire colony to be controlled.

Dusts: A few products, such as those containing the active ingredient acephate, are specially labeled for dusting individual fire ant mounds. The powder is distributed evenly at the recommended rate over the mound. Treated mounds should be eliminated within one week. Acephate can also be used as a mound drench.

Injectable products: Products containing pyrethrins, tetramethrin or chlorpyrifos are manufactured in special aerosol containers to which an injection rod can be attached. The rod is inserted into the mound in a number of places, according to instructions on the label, and the pesticide is injected for a specified time into each mound. Smaller mounds may require less insecticide. Products containing pyrethrins immediately kill ants in the mound; however, foraging workers outside the mound are not affected. Although these products are more expensive and time consuming to use, they tend to give faster results than mound drenches. Injectable products also have the advantage of depositing the pesticide underground out of reach of people and pets.

Baits: These products contain pesticides formulated on bait of processed corn grits coated with soybean oil. Baits can be applied around individual mounds or broadcast over larger areas at specified rates. As an individual mound treatments, bait products are slower acting and often more expensive than drenches, granular or injectable insecticides, but as an area treatment they offer the advantage of covering larger areas for moderately infected sites (greater than 20 mounds per acre.

Using baits as a broadcast application for infested areas prior to individual mound treatment can be an effective longer term treatment strategy. This approach is best suited for larger areas where fire ant populations exceed twenty mounds per acre and there is little or no concern for preserving native ant species. This combined program of area treatment followed by mound treatment provides long term ant suppression and minimizes the necessity of individual mound treatments.

Application methodology

Contact insecticides: Several control products are labeled for broadcast application. The granular formulations are usually applied with either broadcast or drop-type fertilizer spreaders and the liquid formulations can be applied with high volume hydraulic or individual backpack sprayers. Once applied, these contact control materials should be thoroughly watered into the soil.

Products containing carbaryl, chlorpyrifos, diazinon or isofenphos are longer acting, contact insecticides that primarily suppress foraging ant activity and can prevent small mounds from becoming established. In some cases and through repeated use, these treatments can eliminate colonies.

Bait-formulated insecticides: Bait products contain different active ingredients that work in unique ways.

Hydramethylnon kills ants that ingest it by interfering with the ants' ability to convert food into energy. When applied at the broadcast rate, approximately 80 percent of the mounds in the treated area will become inactive within about five weeks.

The active ingredients fenoxycarb, abamectin, pyriproxyfen or s-methoprene act as "insect growth regulators" when applied at broadcast rates. These products do not kill worker ants or queens; instead, they render most queens incapable of egg production and cause the brood to develop into winged males and sterile females. Reduction of mounds within a treated area is slow, requiring several weeks to many months for the worker ants to die off. However, during this period, the weakened mounds in the treated area apparently prevent recolonization by newly mated queen ants, providing an extended period of suppression which may last up to a year after treatment.

The time required for ants in treated mounds to die depends on the active ingredient used. Hydramethylnon usually eliminates ants in about a week. Avermectin has some toxic effect on worker ants at high dose, but still requires several weeks to achieve control. Ant activity in mounds treated with fenoxycarb, pyriproxyfen or s-methoprene may be seen for five weeks or longer following treatment as worker ants slowly age and die.

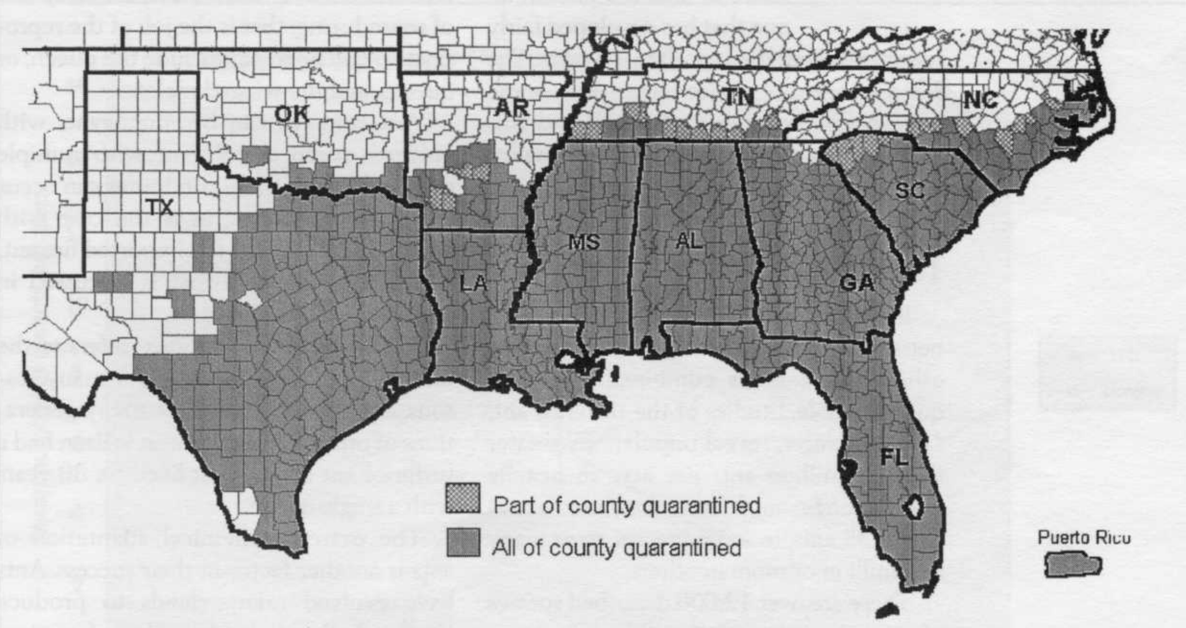
Conclusion

Managing imported fire ants requires is a multifaceted strategy.

- Managers must decide if the current location of any mounds requires control efforts.
- Once a control decision is made, managers should quantify the level of infestation at the site.
- Areas of light infestation can be managed with individual mound treatment strategies.
- Moderate infestations can be managed with broadcast treatments.
- Heavier infestations can be managed with a combination of broadcast and mound treatments.
- Extensive site infestations in heavily infested regions of the country usually require some accommodation be made between human and ant activity, in addition to control measures, for satisfactory results to be obtained.

Beverly Sparks, Ph.D., is professor of entomology and extension program coordinator in entomology for the University of Georgia, Athens, GA.

Imported Fire Ant Quarantines



Restrictions are imposed on the movement of regulated articles from the quarantined (shaded) areas into or through unshaded areas.

Consult your State or Federal plant protection inspector or your county agent for assistance regarding exact areas under regulation and requirements for moving regulated articles. For detailed information see 7 CFR 301.81 for quarantine and regulations.

June 12, 1998

The Turfgrass Ant
Lasius neoniger

By Sean F. Werle, University of Massachusetts, Amherst

What are ants? This question has almost as many answers as there are people who might consider it.

To your child, ants may be the industrious residents of an antfarm on a bookshelf or the fascinating combatants that engage in epic battles on the pavement of your driveway. To an ecologist, they are members of the insect family *Formicidae*, and are one of the most important cogs in the complex biological machinery that they study, exerting an effect on every other part of a given ecosystem.

The pest status of ants is a phenomenon that has developed fairly recently, within the last 20 to 30 years.

If one is in the business of managing turf however, ants are more and more often becoming a problem that has to be dealt with. The pest status of ants is a phenomenon that has developed fairly recently, within the last 20 to 30 years. The reasons are not quite clear, but some hypotheses have been advanced and this article will address those ideas and also try to answer the question posed above.

The Ant World

It has been said that the combined number of ants on the Earth is greater than all other land animals combined, which is quite possible. Studies of the turfgrass ant, *Lasius neoniger*, reveal populations greater than 10 million ants per acre in heavily infested turf. A single ant colony can have as few as 35 ants, in some species, to as many as 1 million or more in others.

There are over 12,000 described species of ants; a large proportion of these are tropical, but there are many temperate and even arctic species. The state of Massachusetts is home to approximately 110 species of ants, and this number is probably a good estimator of the diversity in any temperate area. Ant diversity will increase with decreasing latitude — the closer to the equator one looks, the more species of ants one can find.

Why Ants Succeed

The reasons for the evolutionary success of ants are numerous, but there are several that stand out. These are eusociality, chemical adaptation and general hardiness, probably in that order of importance.

Eusociality refers to the fact that ants are social insects, similar to some of the bees and wasps. E.O. Wilson defines eusocial insects as those that possess three traits: cooperative brood care, reproductive caste differentiation and overlapping generations.

All ants exhibit these traits. Immature ants are completely helpless and depend upon adult "worker" ants to care for and feed them. These worker ants are incapable of reproducing; that is the job of the reproductive castes, which include the queen, or queens, and the winged males.

Ant colonies can be monogyne, with only one queen, or polygyne, with multiple queens. Both of these conditions can occur in the same species, as is the case with *Solenopsis invicta*, the red imported fire ant, a notorious ant pest that is discussed in another article in this issue.

"Overlapping generations" refers to the fact that ant queens survive for many seasons, and thus can produce many generations of offspring in a lifetime. Wilson had a turfgrass ant colony that lived for 30 years with a single queen.

The extreme chemical adaptation of ants is another factor in their success. Ants have evolved many glands to produce chemicals that help the colony function. Some are used to raise an alarm in the case of danger from outside, some are for making trails that other ants can follow to a source of food or water and still others are antiseptic, keeping the colony free of infections caused by fungi or bacteria. This extreme chemical dependence has given ants a highly developed sensitivity to many chemical compounds and some studies have shown that they are capable of detecting and avoiding insecticide applications (Vittum and Werle, unpublished data).

The general hardiness of ants is quite remarkable. Some are able to survive immersion in water for as long as two weeks and others have been exposed to intense radiation with no ill effect. This toughness means that, for many species, an established colony is unassailable by other insects or animals.

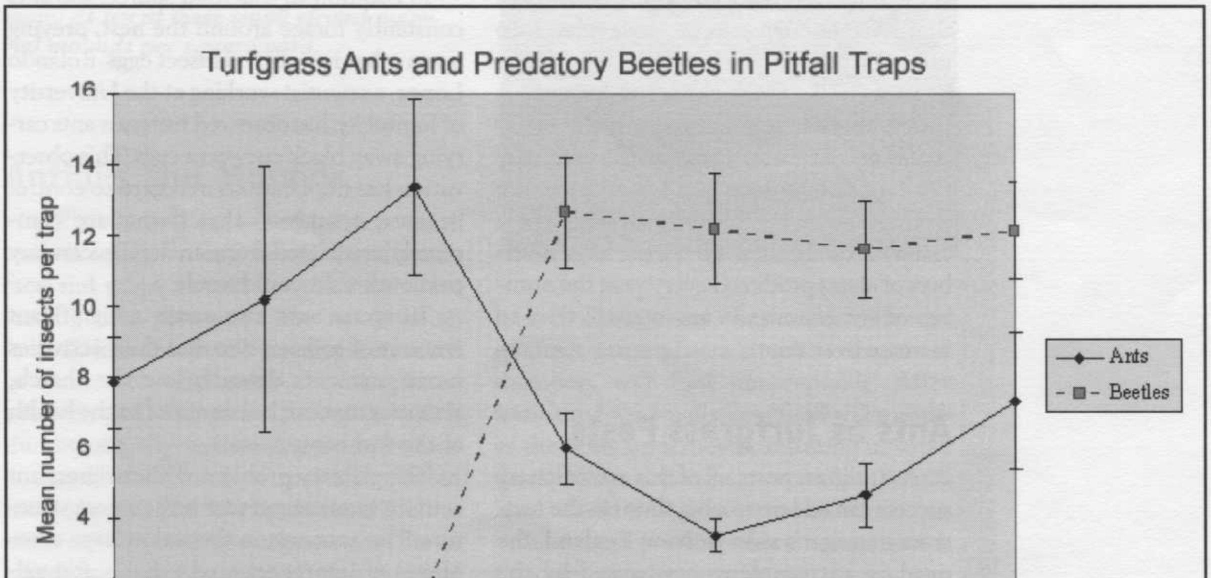
Many ants can both bite and sting, and are very capable defenders of their colony. The tropical ant (*Paraponera clavata*), from Central and South America, is commonly known as the bullet ant because it is said that the sting of this ant is more painful than a gunshot wound, though the accuracy of this is debatable.

Colony Life Cycle

The life cycle of a colony is roughly similar for all ant species. In the turfgrass ant, *Lasius neoniger*, the egg-laying queen spends most of the season laying fertilized eggs that will develop into female worker ants. These workers comprise the majority of the colony and are responsible for all of the food gathering, defense and brood care for the nest. Many ants share food within the colony through a process called trophalaxis where liquid food is regurgitated and passed between workers or from workers to the queen or the brood (larvae).

Late in the summer, the queen begins to lay fertilized eggs and also to feed some of her female larvae differently than normal worker larvae. The unfertilized eggs develop into winged male ants and the specially treated larvae develop into large winged females. These winged ants, called alates, build up in the nest and are prevented from leaving by the workers. Sometime near the end of August, some poorly understood signal causes the workers to allow the alates out of the nest and they take

Late in the summer, the queen begins to lay fertilized eggs. Once hatched, specially treated larvae develop into large winged females called Alates, who will become queens once they mate during a nuptial flight, usually in August.



flight simultaneously across large regions. This is called the nuptial flight and it occurs once every year. During this flight the male and female ants mate and, after flying some distance, settle back to the ground.

The ants don't consume plant material, instead they tend small aphids which feed on the grass roots and produce a sugar-rich excretion, called honeydew, which the ants consume.

The males have served their purpose at this point and are doomed, falling prey to other ants or insects or dying of starvation. The females, now mated and ready to establish new colonies, will fly in search of an open grassy area. Studies have shown that the queens will avoid entering wooded areas. Thus, if they began their flight on a golf course, they will likely remain somewhere on the course. Once they have found a suitable spot, they will chew off their wings, burrow into the ground and lay a small clutch of eggs. These eggs develop into undersized workers called nanitics that immediately begin foraging. Once they have brought back enough food, the queen begins laying eggs that have enough energy to develop into normal workers.

Despite the ant's reputation for organization, this whole process is actually rarely successful. There are many dangers faced by the foundling queen and her tiny nanitic workers. But, when she does succeed, a new colony is established. Given the large numbers of alates produced every year, the number of ant colonies in an area will tend to increase over time.

Ants as Turfgrass Pests

As turfgrass pests, all of this evolutionary success can add up to a big thorn in the turfgrass manager's side. In New England, the primary ant problems are caused by the aforementioned turfgrass ant, *Lasius neoniger*. This is a small light to dark brown ant, about an eighth of an inch long, which primarily inhabits open areas such as turf, cornfields and pastures.

These ants need grasses in order to survive because a large part of their food is indirectly derived from the grass itself. The ants don't consume plant material; instead, they tend small aphids (*Anuraphis maidiradicis*, the corn root aphid), which feed on the grass roots and produce a sugar-rich excretion called honeydew which the ants consume. These aphids, in turn, are completely dependent on the ants.

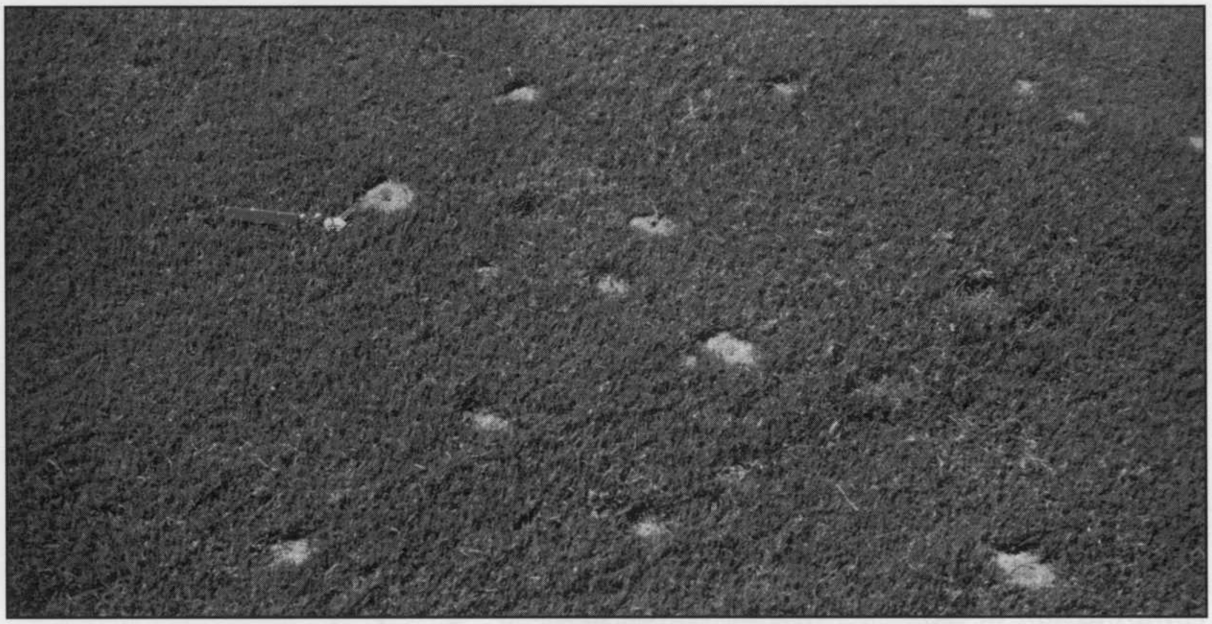
Metcalf described this relationship as follows: "This aphid is rarely found on roots except where attended by the ants and, if placed on the surface of the ground, is apparently helpless so far as finding a place to feed is concerned. An ant finding one of these aphids, however, immediately picks it up, carries it underground and places it on the roots of one of the aphid's food plants."

In the winter, the ants bring the eggs of the aphid down below the frost line and in the spring they place the newly hatched aphids back on the roots of the grass. The root zone of ant-infested turf often supports large populations of these aphids, though seldom enough to cause pathology in the plant.

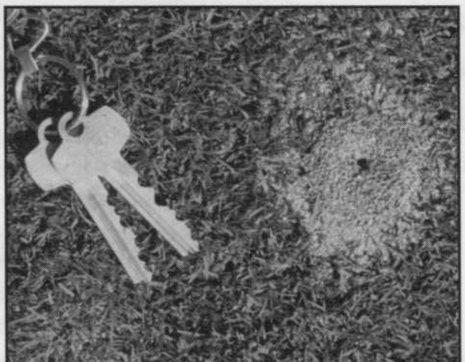
In addition to this food source, the ants constantly forage around the nest, preying upon other insects and insect eggs. Rolando Lopez, a scientist working at the University of Kentucky, has observed turfgrass ants carrying away black cutworm eggs. This observation has implications in regard to control because it suggests that if ants are completely eradicated from an area, secondary pest outbreaks could result.

Turfgrass ants also cause a significant amount of soil aeration and their activities move nutrients down below the thatch; activities that can be beneficial to the health of the turf ecosystem.

The primary problem with turfgrass ant activity in managed turf is their nest structure. The ants nest in the soil in large complexes of interconnected tunnels and galleries that can extend more than three feet into the soil and often have multiple entrances.



The ants nest in the soil in large complexes of interconnected tunnels and galleries that can extend more than three feet into the soil and often have multiple entrances. All of the soil excavated to form these tunnels is brought to the surface. The result is an "anthill" like structure. It is not an ant mound in which the ants actually reside. In an infested area there can be as many as ten of these small ejected material mounds per square yard.



Anthills and Mounds

All of the soil excavated to form these tunnels and galleries is brought to the surface and piled around the entrance holes leading into the nest. The result is an "anthill" like structure. This term is enclosed in quotes to emphasize the distinction between an anthill or ant mound in which the ants actually reside, and an anthill which is simply composed of material ejected from beneath the soil by the ants such as those constructed by turfgrass ants. In an infested area there can be as many as ten of these small ejected material mounds per square yard and this causes a number of problems.

Aesthetically anthills and mounds can greatly degrade the appearance of turf and, on golf course greens, they can detrimentally affect game play, a situation that most members will find unacceptable. After some time, the small piles of soil will smother the grass underneath, resulting in small dead patches that remain even after the ants have ceased using that entrance.

The most pressing concern, however, is the damage to equipment that results from mowing over the mounds. The small soil particles dull mower blades and clog rollers, causing a significant increase in equipment maintenance costs.

Why ants increase

Among a number of possible causes for the recent increase of ants as turf pests, the two that stand out are decreased mowing height and the loss of organochlorine insecticides. For many years, chlorinated organic compounds such as chlordane were used extensively in turf to control a number of pests, mainly scarab beetles. These compounds are highly toxic to ants and thus ant populations were probably secondarily controlled by these applications. Since the use of these materials was discontinued in the 1970s, ants have possibly been released from this chemical constraint and thus are able to emerge as pests.

The best long-term solution is probably to find ways to coexist with the ants, using a combination of carefully timed pesticide applications and adjustments to fairway and greens mowing heights.

Another possibility is the "Stimpmeter factor." As golf courses have competed to increase green speed, mowing heights have steadily decreased. Turfgrass ants are seldom cited as home lawn pests and their presence is difficult to detect in a golf course rough. This is because the grass is mowed at a height that masks ant activity. On short-mowed fairways and greens, this masking is removed and ants that may have been present but undetected at a slightly higher mowing height are revealed as pests.

Controlling Turfgrass Ants

Lasius neoniger has proven difficult to control. Many insecticides are ineffective against them and, as mentioned before, they are capable of detecting applications and avoiding materials in some cases. Studies at Dr. Vittum's lab at the University of Massachusetts have revealed no material that is effective for more than a few weeks in controlling mound-building activity.

Some patterns have been seen that may be helpful, however. Since the ants spend the winter deep in the soil and move rapidly to the surface in the spring (early April in western Massachusetts), timing of application can be an important factor in control. If an effective material is applied at this time, the colony will suffer a serious setback in its initiation of warm weather activity and this can delay the onset of turf management problems.

Another possible avenue of control is to adjust mowing height in order to mask ant activity. Fairways mowed at three quarters of an inch are unlikely to exhibit ant problems because the soil ejected from the nests will not reach above the grass. Often changes such as this are unacceptable to club memberships and so ants remain a difficult and expensive problem for the people in charge of managing turf.

Conclusion

It is appropriate to return to the question posed at the beginning: what are ants? Hopefully the point has been made that while ants are a serious problem in many turfgrass settings, they are beneficial in other ways also.

Understanding what ants are and how they fit into the local turf ecosystem (i.e., identifying and controlling food sources) is important for responsible ant management. However, if all your efforts prove fruitless, then the best long-term solution is probably for turf managers to find ways to coexist with the ants, using a combination of carefully timed pesticide applications and adjustments to fairway and greens mowing heights.

Think of it this way: With all of the myriad insects out there that eat grass, can insects that eat other insects be all that bad?

Sean F. Werle is a graduate student of Dr. Pat Vittum in the Department of Entomology at the University of Massachusetts, Amherst.

Using Et_o
To Improve Irrigation Efficiency

By William E. Richie, Robert L. Green and Victor A. Gibeault, University of California, Riverside

Water is a valuable resource in the arid Southwest. Therefore, it is in the best interest of turf and landscape managers to practice irrigation scheduling that leads to wise water use. Fine tuning irrigation scheduling can maintain acceptable aesthetic quality, eliminate luxury consumption by plant material, reduce disease susceptibility and save money.

Water vs. Aesthetics

How much water needs to be applied to maintain acceptable aesthetic quality and function or to meet a competitive standard? The turf manager can calculate water needs with currently available formulas.

Ideally, the amount of water required by turfgrass can be quantified by the equation:

$$Et_{crop} = Et_o \times K_c$$

In the above equation, Et_{crop} is the actual turfgrass water use, Et_o is the reference water use and K_c is the crop coefficient. The last step in determining irrigation quantity is to divide Et_{crop} by the irrigation system distribution uniformity (DU):

$$\text{irrigation need} = \frac{Et_o \times K_c}{DU} = \frac{Et_{crop}}{DU}$$

Basically, as the distribution uniformity (DU) decreases, more irrigation water will need to be applied, though the water used by the turfgrass has not changed.

Reference Water Use

Et_o, reference evapotranspiration, is an estimate of the amount of water used by a healthy stand of cool-season turfgrass four to six inches in height. Reference ET values can be obtained from different sources, such as CIMIS (California Irrigation Management Information Service) and AZMET in Arizona. These programs use an equation (modified Penman model) to convert recent weather data into Et_o values, which can be retrieved by irrigation managers using a modem. Some central irrigation controllers have the ability to perform Penman calculations with on-site weather data.

Reference ET can also be estimated from pan evaporation and atmometers. Certain irrigation controllers can be connected to atmometers to facilitate ET-based scheduling. Some turf managers also schedule irrigation with the help of soil moisture sensors. Moisture sensors, such as tensiometers, gypsum blocks or granular matrix sensors, can be interfaced with some irrigation controllers to interrupt irrigation when soil moisture is adequate for plant needs.

Crop Coefficients and Crop Water Use

University research over the past two decades has yielded monthly crop coefficients or plant factors (K_c) to facilitate ET-based irrigation scheduling of warm- and cool-season turfgrasses. These coefficients were developed under coastal California conditions and can differ slightly in other regions of the country. When multiplied by Et_o, crop coefficients provide a relatively accurate estimate of ET_{crop} or ET_{turf}, the amount of water (depth) used or required by the turfgrass.

Crop coefficients can be averaged to yield quarterly, semi-annual or annual crop coefficients. Averaging crop coefficients reduces monthly precision. Ideally, managers should employ monthly, or at least quarterly, crop coefficients in their calculations for turf water requirements. Table 1 provides monthly, quarterly and semi-annual cool- and warm-season crop coefficients. Historical data on crop coefficients is available in some areas.

Water Use vs Requirement

Distribution uniformity (DU) of an irrigation system is a measure of how uniformly a system applies water to a crop surface. Rainfall, in most cases, would be considered 100 percent uniform. Many irrigated sites have a DU ranging from 50 to 70 percent.

DU is important because it influences the amount of required irrigation, even when Et_{crop} remains unchanged. To make sure the turf receives the required amount of water, as calculated by multiplying the Et_o by the crop coefficient, you need to divide by the DU (i.e., 60 percent = 0.60). By dividing by a number less than one, the amount of water required to satisfy plant water use increases. Poor irrigation uniformity increases the irrigation requirement. Irrigation systems with high DUs can apply less water and still satisfy plant water needs.

Poor irrigation uniformity increases the irrigation requirement.

Determining Run Times

Once a recommended water quantity is determined for a particular turfgrass, a series of calculations are required to convert this quantity to an actual run time on an irrigation controller.

The first step calculates how many inches of water need to be applied. To do this, you multiply Et_o for the region at the particular time of year by the crop coefficient (K_c) for your particular turfgrass. The result is then divided by the irrigation system distribution uniformity.

$$\frac{Et_o \times K_c}{DU} = \text{water need in inches for period}$$

For example:

$$\frac{6.2 \text{ in. (monthly } Et_o) \times 0.94 \text{ (July } K_c)}{0.60 \text{ (distribution uniformity)}} = 9.7 \text{ in.}$$

This "depth" of water is converted to an actual run time (minutes) for the period by dividing the system precipitation rate (inches per hour) and then multiplying by 60. The final step is to calculate run time for the period by the number of irrigation events for the period.

$$\frac{9.7 \text{ in. (depth of water)}}{1.5 \text{ in. (precipitation rate/hour)}} = 389 \text{ min.}$$

Catch Can Test

Two variables are required for this calculation. They are distribution uniformity and system precipitation rate. Both can be obtained by conducting a catch-can test.

This test can be done with any number of straight-sided containers placed in a grid across the turf area. Information is more accurate when more cans are used. Once the cans are in place, run the irrigation zone for 15 minutes. If this is not long enough, run the system for 30 minutes. Measure the amount of water in each can with a ruler. Convert the readings to inches per hour (multiply by 4 for 15-minute tests and 2 for 30-minute tests).

System distribution uniformity (DU) is determined by comparing the amount of water collected in the containers. To do this, you first need to identify the 25 percent of containers with the least amount of water. Divide the total number of containers by four. If you have 12 containers, you want to find the three that had the lowest amount of water in them. Then, determine the average depth of water in the 25 percent of the containers with the least amount of water and the average depth of water for all the containers.

$$DU = \frac{\text{mean of low quarter (volume or depth)}}{\text{overall mean (volume or depth)}}$$

Precipitation rate is the average depth of water collected in all of the cans multiplied by four (assuming a 15 minute run time). If the average measured depth is 0.25 inches, then the system precipitation rate would be 1 inch per hour.

Alternatively, precipitation rate can be calculated using the following equation:

$$\frac{\text{gpm (one head)} \times 96.25}{\text{head spacing on row (ft)} \times \text{row spacing (ft.)}}$$

$= $ *inches/hour precipitation*

TABLE 1. COOL- AND WARM-SEASON TURFGRASS CROP COEFFICIENTS (K_c)

COOL-SEASON TURFGRASS					WARM-SEASON TURFGRASS				
Month	Monthly	Quarterly	Semi-An.	Annually	Month	Monthly	Quarterly	Semi-An.	Annually
JAN	0.61				JAN	0.55			
FEB	0.64	0.67	0.68		FEB	0.54	0.62	0.55	
MAR	0.75				MAR	0.76			
APR	1.04				APR	0.72			
MAY	0.95	0.96			MAY	0.79	0.73		
JUN	0.88		0.90	0.80	JUN	0.68		0.71	0.60
JUL	0.94				JUL	0.71			
AUG	0.86	0.85			AUG	0.71	0.68		
SEP	0.74				SEP	0.62			
OCT	0.75				OCT	0.54			
NOV	0.69	0.68	0.68		NOV	0.58	0.56	0.55	
DEC	0.60				DEC	0.55			

Crop coefficients are for arid Southwest. Coefficients may differ slightly in other regions.

For example, a catch can test is performed with 20 cans, spaced five feet apart. Measuring depth of water in each can, the average depth in the five lowest cans is 0.22 inch. The average depth of all 20 cans is 0.35 inch. The precipitation rate for this system is 0.35 x 4 = 1.4 inch per hour. DU is 0.22 divided by 0.35 = 0.63.

The next step is developing an efficient irrigation program to calculate run time per irrigation event. This requires knowledge of the number of irrigation events per time period. In the following example, we assume the manager wants to irrigate twice per week. Examination of a calendar shows nine irrigation events for an average month, or 35 irrigation events for a quarter. Total run time needs to be divided by this many irrigation events. Continuing with the preceding example:

run time per month (389 minutes)
number irrigation events per month (9)
= *43 minutes per irrigation event*

This is the amount of time that will actually be programmed into the irrigation controller to apply a total amount equivalent to 94 percent Et_o, the recommended replenishment for cool-season turf in July.

Optimizing Application

Maximizing irrigation system uniformity is one of the most important steps an irrigator can take to optimize his irrigation. To illustrate, let's take the preceding example and apply it to two irrigation systems with different DUs. Notice how much more water must be applied with system 2 to achieve a similar result, compared to system 1. The less uniform a system is, the longer the sprinklers will have to run to produce a uniform turf appearance or performance over the entire irrigation area.

Irrigation system uniformity can be improved in many ways. The first is to ensure that the system operating pressure is within the manufacturer's recommended range for the head being used. Manufacturer's catalogs also list optimum operating pressures for specific heads.

High pressure causes atomization and loss of fine droplets to wind, not to mention unnecessary wear and tear on system piping and equipment. Low pressure causes insufficient diffusion of sprinkler spray patterns. Donut-shaped dry areas are the result. Operating pressure can be measured with a pitot tube held against the nozzle of a rotor or impact sprinkler head or by a gauge affixed to a pressure-regulating valve.

If system pressure is too high, it can be reduced with an adjustable pressure regulator or a pressure-regulating solenoid valve. Pressure regulators are generally located downstream of the backflow device. One can also use a pressure-regulating master valve. A third option is installing pressure-regulating valves leading to particular zones or stations, such as low-flow zones. This provides the greatest flexibility by allowing adjustment of each zone to an optimum operating pressure.

Pressure regulation at the sprinkler head is also possible. Sprayheads can be purchased with pressure compensating devices that reduce operating pressure to an ideal range for a specific nozzle.

Shaded areas require less water than sunny areas, and so, ideally, separately valved systems should be in operation for each. Irrigation on slopes requires shorter, more frequent irrigation than other zones and should be treated as unique hydrozones.

System uniformity also can be adversely affected by low operating pressures. Remedies are more difficult than for high pressure. Check galvanized steel supply lines for corrosion and frictional pressure loss; replacing pipe might be necessary. In some cases, a booster pump can be installed to increase system pressure. A third remedy could be to divide existing zones into smaller ones to reduce flow demand by adding additional solenoid valves or index valves.

An easier solution might be to install smaller nozzles on rotor and impact heads. Smaller nozzles will reduce throw radius unless they are designed specifically for lower flow rates. If the source of irrigation water is public mains, schedule irrigation for periods when pressure is highest, usually between midnight and 5 a.m. Be aware of disease incidence caused by foliage remaining wet for long periods of time.

Assuming system operating pressure is within the recommended range, uniformity can often be improved. Rotor or impact heads provide superior uniformity to sprayheads. Nozzles for any type of head should be matched for precipitation rate. This is most important for part-circle heads.

Heads from various manufacturers can have different rotation and precipitation rates and matched precipitation can be lost. Replace damaged or worn heads and nozzles with the same brand.

Heads should be checked for vertical alignment and uniform rotation periodically. Nozzle wear and in-line filters should also be checked routinely. Irrigation should take place when wind disturbance is least.

Don't Set and Forget

Irrigation controllers should be rescheduled as frequently as possible. Run times should be changed weekly or biweekly. Water budget or global adjust features can simplify rescheduling by making percentage changes.

Remote control of irrigation, where programs can be changed via modem or radio, is becoming increasingly popular. Such features encourage frequent controller updating by making adjustments easier.

An irrigation system should be designed with hydrozones in mind. Water requirements of trees and shrubs differ from turf because the former have deeper and more extensive rooting patterns and can be watered more infrequently. The trees, shrubs and turf constitute different hydrozones and separate systems should be used for each if possible. Furthermore, shaded areas require less water than sunny areas, and so, ideally, separately valved systems should be in operation for each. Irrigation on slopes requires shorter, more frequent irrigation than other zones and should be treated as unique hydrozones.

The use of rain switches can prevent irrigation during rain events. Many new controllers have terminals into which a rain switch can easily be installed. Soil moisture sensors can also be used to prevent irrigation when soil moisture is adequate for plant needs. After all, it is the moisture in the soil available to plants that all other calculations are trying to emulate.

ET-Based Irrigation Has Arrived

Applying an amount of water which replenishes turf and landscape water use (ET) is a realizable goal that can result in significant water and monetary savings. ET-based irrigation scheduling seeks to prevent overirrigation, which leads to runoff or leaching into potable water resources. The goal is to irrigate plant materials at the recommended percentage of Et_o as infrequently as possible.

University research has shown that applying an annual average of 80 percent Et_o to tall fescue less frequently (twice per week) can result in improved visual color and quality. Keep in mind that with the longer run times associated with less frequent irrigation, water infiltration becomes a consideration and multiple cycles or lower precipitation rates might need to be used.

Acceptable turf quality and performance can best be maintained when irrigation system uniformity is optimum.

Recommendations for system uniformity include:

- **check & adjust operating pressures**
- **select appropriate heads and nozzles**
- **check head alignment and operation**
- **irrigate at times when wind is minimal**

Finally, nothing is more important than visual observation. The turf manager should inspect turf areas and irrigation systems on a regular basis. If dry areas are apparent, in spite of proper system operation, controller programs should be adjusted accordingly.

With a proficient irrigation system and frequent controller program updates, golf course superintendents should begin to see improved plant quality and performance with savings in water and energy.

Partial funding has been provided by the Metropolitan Water District of Southern California. Sincere appreciation is extended to John Addink, president of A-G Sod Farms Inc.; Jurgen Gramchow, general manager of Southland Sod Farms; Scott Silva with MWDSC; and Dave Skinner, irrigation design specialist with Oasis Irrigation and Landscape Supply, for their helpul review of this article.

In Future Issues

- Application of Humates
- Black Turfgrass Ataenius
- Take-All Patch
- Gray Leaf Spot
- Annual Bluegrass Weevil
- Irrigation With Reclaimed Water

TURFGRASS TRENDS

TurfGrass Trends is published monthly. ISSN 1076-7207.

Subscription rates: One year, $180 (US); $210 (all other countries.)

ADVANSTAR
COMMUNICATIONS

Postmaster: Send address changes to TurfGrass TRENDS, 131 West First St., Duluth, MN 55802-2065.

QUICK REFERENCE NUMBERS

Editorial: *440-891-2729*
Subscription: *888-527-7008*
Permission: *440-891-2740*
Reprints: *440-891-2744*
Single copy or back issues: *218-723-9477*
Website: *www.landscapegroup.com*

USE OF TGT ARTICLES

PERMISSION MAY BE GRANTED ON REQUEST FOR TGT ARTICLES AS COURSE MATERIAL AND FOR REPRINTS IN PUBLICATIONS.

For course material: We can group articles by subject for you.

Please send request to:
TurfGrass Trends
Advanstar, Attn: Permissions
7500 Old Oak Blvd.
Cleveland, OH 44130
800-225-4569, ext. 742

Index and abstracts are available electronically through: www.landscapegroup.com and Michigan State University, TGIF 800-466-8443

TURFGRASS TRENDS
131 West First Street
Duluth, MN 55802-2065

PRSRT STD
U.S. POSTAGE PAID
DULUTH, MN
PERMIT NO. 1900