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The worm turns: earthworm cast reduction on golf courses

A byproduct of the tea tree may provide an organic solution to a long-standing and vexing problem faced by golf course superintendents.

"The 12th green has been infested with thousands and thousands of earthworms. The worm castings were so prolific that mowing was not possible without dispersing them. … The turf was extremely shallow-rooted and about 60% of the bentgrass on the green had died. What can clubs with (excessive) earthworm casts do to overcome this problem?"

— USGA Green Section Senior Agronomist's email to D. Potter

Excessive earthworm casts — small mounds of soil-rich fecal matter — are a worldwide problem on golf courses and sports fields when they disrupt the playability, aesthetics and maintenance of playing surfaces (8,13). A single worm can produce its own weight in casts in 24 hours. In Great Britain, estimates of the quantity of earthworm casts deposited on the surface range from 16 to 20 tons per acre [40-50 tons/hectare] per year on sports turf pitches, and more than 2 tons per year on a typical 5,000-square-foot [465-square-meter] push-up golf green (8).

Casts adversely affect ball roll and muddy and smother the grass when smeared or compacted by tires or foot traffic so that golfers find themselves playing on surfaces that are more mud than turf. Compacted earthworm casts reduce water infiltration and provide ideal seedbed conditions for weed establishment. Casts also blunt mower blades set at low cutting heights, and they may be so numerous that putting greens cannot be mowed without first physically dispersing them. Earthworm casts on the surface of greens and tees may also affect players' perceptions of course quality. In 2009 the Sports Turf Research Institute received more queries about earthworms than any other turf management problem.

Earthworms play a vital role in natural and managed grasslands where they literally plow the soil by burrowing through it (7). Earthworm tunnels reduce soil compaction and provide passageways through which air and water can percolate, enhancing penetration and growth of plant roots. Earthworm feeding activity stimulates microbial decomposition of grass clippings and thatch and accelerates nutrient recycling (12). An acre of turf can support more than a quarter of a million earthworms that collectively eat 4 tons of clippings and other plant debris, and turn over 15 tons of topsoil. A moderate level of earthworm activity,

Dry earthworm castings on a push-up creeping bentgrass green. **Photos by D. Potter**

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therefore, is beneficial — even on fairways.

Excessive earthworm populations can cause serious problems beyond golf and sports turf. Hardwood forests in North America and other parts of the world are threatened by invasive earthworm species that consume too much of the leaf litter on the forest floor, robbing tree seedlings of nutrients and disrupting forest regeneration and other processes (16). Likewise, excessive earthworm populations adjacent to airport runways attract flocks of feeding birds that pose significant risk to aircraft during takeoffs, approaches and landings (13).

Earthworm biology 101

Only certain earthworm species produce surface casts. All of the casting problems on U.S. and Canadian golf courses appear to be caused by a small number of invasive (non-native) species of European origin, especially *Apporectodea* species, familiar medium-sized (2–3-inch [5.1–7.6-centimeter]) worms that form horizontal burrows in the topsoil, and the larger nightcrawler (*Lumbricus terrestris*) that makes deep (3–6 feet, [1-2 meters]) vertical tunnels, emerging at night to feed on fresh surface litter that is pulled down into the burrow (13). *Apporectodea* species seem to predominate on fairways and greens in the eastern United States and nightcrawlers are relatively more problematic in the Pacific Northwest, but both worm types produce casts on golf courses throughout the cool-season and transitional turfgrass zones (1,13).

Earthworm casting tends to be highly seasonal, with most of the activity during cool moist periods in fall and spring. In late fall when the topsoil starts to freeze, or in summer when conditions become hot and dry, earthworms burrow deeper and enter a dormant state called aestivation (7). During aestivation, the earthworm curls up into a knot and becomes pinkish. Overwintering earthworms produce natural antifreeze in their blood. Earthworms breathe through their skin and require a moist environment to allow for respiration, but too much water (for example, after heavy rainfall) displaces oxygen dissolved in the soil, forcing earthworms to the surface where they may be quickly killed by exposure to sunlight.

Reproduction

Earthworms are hermaphrodites, that is, each individual has both male and female reproductive organs (7), and most earthworms require a mate of the same species to reproduce. After mating, each worm deposits one or more capsules containing the fertilized eggs, and one or two fully formed tiny worms will emerge from each capsule. Although each worm may mate and lay eggs several times each year, a single worm may produce only 10-15 offspring annually. The time required for the young to reach full size and sexual maturity varies from about a month to as long as a year, depending on the species and environmental conditions.

Earthworm castings can muddy the turf and interfere with ball roll and play.

Earthworm management

Early turf culture evolved in rainy Great Britain where earthworms are very abundant, so controlling earthworms and casts has long been a concern of golf course superintendents and sports field managers in the U.K. Rolling was the main management practice before 1890, but it had negative effects in terms of soil compaction. Two other main approaches evolved, one based on cultural control and the other on chemical control using pesticides or expellants (8).

Cultural controls

Cultural controls, including use of soil-acidifying fertilizers (most earthworm species are intolerant of acidic soils), clipping removal to reduce earthworms' food resources, or topdressing with angular sands or abrasive aggregates will sometimes reduce casting (1,2,17). However, those methods rarely are effective enough to be relied on by superintendents. Indeed, an extensive study done on golf course fairways in Washington state (1) indicated that "clipping removal, soil acidity, and sand topdressing had no consistent effects on castings deposited on the turfgrass surface by *Lumbricus terrestris* earthworms." Earthworms

thrive under the conditions required to maintain healthy turfgrass and are so adaptable that cultural manipulations alone are unlikely to resolve casting problems. Physical removal of casts by brushing, switching or dragging is laborious and of only temporary benefit (8).

Chemical control

During the past 20 years the problem of excessive earthworm castings interfering with play on golf courses, sport fields and other recreational turf venues has become more serious and widespread. Why? Pesticides historically used to control earthworms included mercuric chloride (also called corrosive sublimate), lead arsenate and even sodium cyanide and have long since been banned because they were highly poisonous (8). During the 1950s and 1960s, a single application of chlordane, at that time the mainstay for white grub control, would kill earthworms and eliminate casting problems for as long as seven years. But the EPA cancelled chlordane registration for turfgrass in 1983 because of its buildup in the environment, harm to wildlife and chronic human health risks. Many turfgrass pesticides used from the 1970s to mid-1990s were applied for grub control but were also acutely toxic to earthworms (14). Most of the older worm-toxic pesticides can no longer be used on turf, and presently no pesticides are labeled for earthworm control in the United States.

Peter Lees' invention

An approach widely used used for earthworm and cast suppression from the early 20th century until about 1960 involved the use of chemical expellants that were applied to irritate the worms, causing them to come to the surface where they were swept or raked up and discarded (8). The method, pioneered by British greenkeeper Peter W. Lees during the 1890s, was so effective that it had become the mainstay for earthworm suppression on European and U.S. golf courses by the 1920s (3,4,9,10,11). (Authors' note: Lees provides a fascinating account of his experimenting with this method on pages 37-43 of his seminal book "Care of the Green," available online at http://archive.lib.msu.edu/DMC/turfgrass/PDF/careofthegreen.pdf).

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