Earthworms, Thatch, and Pesticides

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"The plow is one of the most ancient and most valuable of man's inventions, but long before he existed, the land was in fact plowed and still continues to be plowed by earthworms."
— Charles Darwin

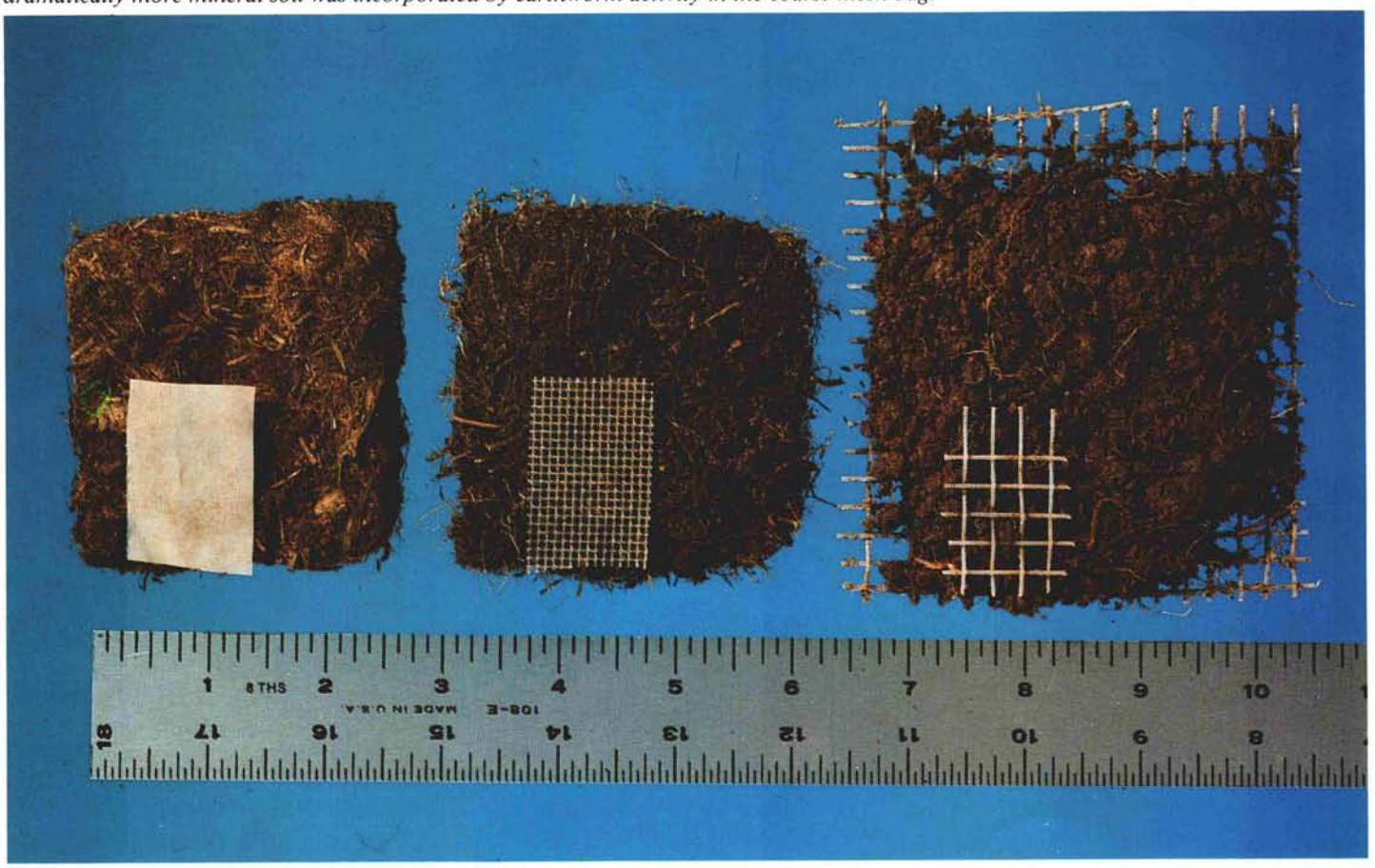
EARTHWORMS are sometimes viewed as a nuisance by golf superintendents and turf managers because their burrows and surface casts disrupt the uniformity and smoothness of fine turf. Moreover, because earthworms and white grubs are regarded as a delicacy by moles, skunks, and other vermin, pesticide applications are sometimes made in the hope of reducing the food supply and causing the moles to go elsewhere. Thus, presence of a healthy earthworm population is viewed by some superintendents as more of a problem than a blessing.

My aim is to present the alternative viewpoint: that earthworms are extremely valuable components of the turfgrass community, and preserving their populations may be essential to the health and long-term stability of the turf. Recent research documents the role of earthworms in thatch breakdown, and also provides information on the relative compatibility of turfgrass pesticides with this process.

Role of Earthworms in Turfgrass

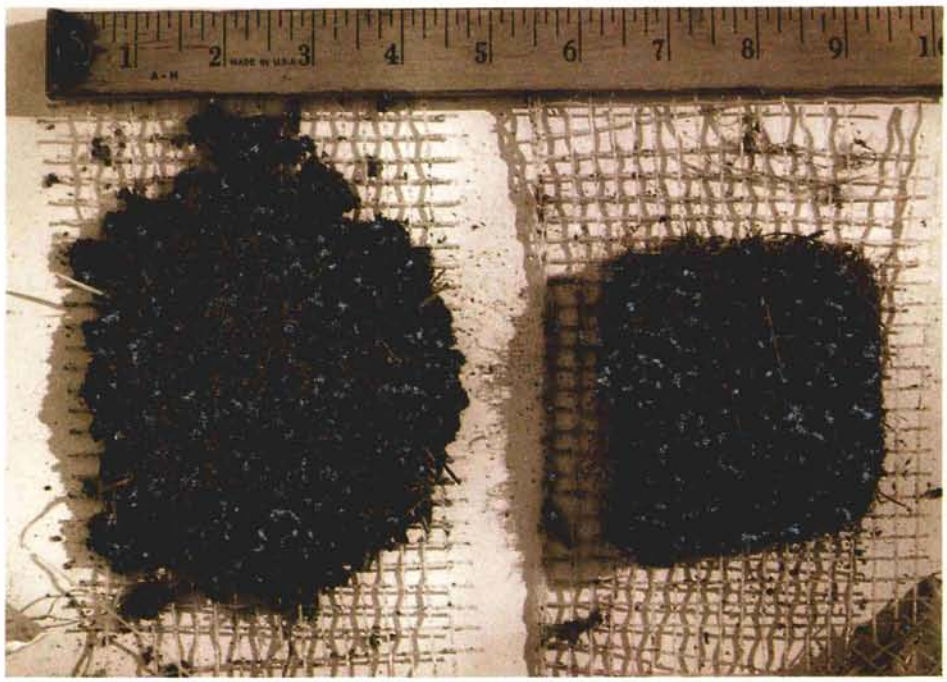
The Greek philosopher and scientist Aristotle called earthworms the "in-

Fine (left), medium (center), and coarse (right) mesh bags containing pieces of thatch were designed to selectively exclude or admit earthworms. After remaining buried 23 months, dramatically more mineral soil was incorporated by earthworm activity in the coarse mesh bag.



testines of the earth." Indeed, their importance in breaking down plant litter and nutrient recycling is well documented in forest and pasture soils. Earthworms mix organic matter into the soil, and help fragment and condition plant debris in their guts before it is further broken down by bacteria and fungi. Many studies have shown that plant litter decomposition occurs faster with the combined action of earthworms and soil microorganisms than with microorganisms alone.

Earthworms affect soil structure by their burrowing and casting activities. Two-thirds of the total pore space in soil may consist of earthworm tunnels. Earthworm activity is critical for air and water infiltration. For example, in one pasture experiment, the presence of earthworm burrows was shown to increase water infiltration rates two-and-a-half-fold relative to the same soil with no earthworms. Earthworms also mix the soil and enrich it with their castings, or excreta. Charles Darwin, better known for his theory of evolution, was an early expert on earthworms. His decades of painstaking research showed that as much as 18 tons of earthworm casts could be brought to the surface per acre per year, about equivalent to a uniform ¼-inch layer of enriched soil being deposited annually. Presence of earthworms has been shown to enhance growth and yields of grass in pastures.



Thatch pieces buried under Kentucky bluegrass turf for three months were more decomposed and dispersed in untreated plots (left) than in plots treated with insecticides (right).

Earthworms and Thatch

Thatch accumulations result from an imbalance between production and decomposition of organic matter at the soil surface. Excessive thatch can lead to long-term problems: reduced water infiltration, restricted penetration of fertilizers and insecticides, shallow root growth, and increased vulnerability to heat and drought stress. Thatch is often a problem in cultivated turf, especially when a high rate of nitrogen fertilization is applied for several years.

It generally has been observed that thatch is rarely excessive where earthworms are abundant, and previous studies have documented increased thatch accumulation following use of certain pesticides that are toxic to earthworms. However, until recently, the relationship between earthworms and thatch degradation had not been specifically studied. Understanding this process is important to thatch management. If earthworms contribute significantly to thatch breakdown, then turf management practices that are harmful to worms should be avoided when possible.

To resolve this question, two long-term studies were conducted at the University of Kentucky's turf research facility, near Lexington. Several hundred pre-weighed pieces of thatch, each about the size and thickness of a kitchen sponge, were sewn into nylon mesh bags and buried just beneath the surface of a Kentucky bluegrass turf. The first experiment used three different bags: fine mesh, to exclude all soil animals except microorganisms; medium mesh, to admit small insects and soil mites, but to exclude earthworms; and coarse mesh, to admit all components of the soil fauna, including worms. In a companion experiment, thatch pieces were buried in identical coarse mesh bags in either untreated turf or in turf that had been treated with certain insecticides to eliminate the earthworms.

Thatch pieces from each test were periodically dug up, reweighed, and analyzed for mineral soil content, microbial activity, and net loss of organic matter. Dramatic differences were apparent in both experiments after only three months. In the presence of earthworms, the thatch pieces were broken apart and dispersed. The worms incorporated large amounts of soil into the thatch, so that by the end of the experiment the earthworm plots contained 80% mineral soil by weight, versus 35% mineral soil without earthworm activity. Rates of thatch microbial decomposition were more than twice as high from plots with earthworms than where worms were physically excluded or eliminated with pesticides. The effects of this natural process are very similar to those achieved by coring or topdressing.

These experiments confirmed that earthworms play a major role in breaking apart and decomposing thatch, and in improving its physical and chemical properties for turfgrass growth. Preservation of earthworm populations is important where thatch is a concern.

Cross-section comparisons of an original thatch piece (top) and thatch recovered from medium (center) and fine (bottom) mesh bags, 23 months after burial. Decomposition was minimal in the absence of earthworms in the fine mesh bag.

Earthworms and Fertilizers

Excessive fertilization encourages thatch accumulation by increasing organic matter production and adversely affecting earthworms. Some fertilizers cause the soil to become more acidic (lower pH), which inhibits microbial activity. Earthworms also are intolerant of low soil pH, and are generally sparse in acidic pasture and forest soils.

In a recent test, we applied ammonium nitrate fertilizer to Kentucky bluegrass at varying rates for seven years to study the effects on earthworms, thatch, and soil pH. Application of 5 lbs. of nitrogen per 1000 sq. ft. per year for seven years resulted in a decline in soil pH (6.2 to 4.8), a 50% decrease in earthworm populations, and an increase in thatch accumulation of ¼ to ⅔ inch.

Earthworms and Pesticides

Other recent experiments at the University of Kentucky concluded that turfgrass pesticides differ markedly in their toxicity to earthworms, and some of the most frequently used products, when applied at label rates, can cause severe and long-lasting reductions in worm populations and reduced thatch breakdown.

During 1988 and 1989 we conducted four field tests to evaluate the short- and long-term impacts of 17 turfgrass pesticides on earthworm populations in Kentucky bluegrass turf. Thatch pieces were buried in the plots to see how pesticides affected thatch degradation rates. The plots, 6 by 10 feet, replicated six times, were treated with the pesticides in April, using labeled rates, and then irrigated with ¾ inch of water within 2 hours after the applications. Earthworm populations were counted 1 and 6 weeks after treatment using a dilute formaldehyde drench, which irritated the worms and brought them to the surface. The thatch pieces were dug up after 6 weeks and analyzed as described earlier.

The fungicide benomyl (Benlate), and the insecticides diazinon (Diazinon), carbaryl (Sevin), ethoprop (Mocap), and bendiocarb (Turcam) all dramatically reduced the earthworm populations. The latter three materials reduced populations by an average of 76-99% across two independent tests. All of these treatments significantly reduced the rate of breakdown of the buried thatch. Other insecticides, specifically isofenphos (Oftanol), trichlorfon (Proxol or Dylox), chlorpyrifos (Dursban), and isazophos (Triumph) caused less severe, but significant earthworm mortality. None of the tested herbicides or fungicides, other than benomyl, significantly harmed the earthworm populations.

In the long-term tests, Diazinon, Benlate, Sevin, Mocap, and Turcam were reevaluated in larger plots for a longer time period. The plots were 13 by 13 feet and treated at labeled rates once in May. Earthworms were sampled at 1, 3, 5, 20, and 46 weeks after treatment. Benlate, Turcam, Sevin, and Mocap had severe impact on earthworm populations, with reductions ranging from 40 to 77% still evident after 20 weeks. Thatch decomposition rates were significantly reduced. However, worm populations had recovered to near normal levels by the following April, approximately 11 months after treatment. We do not presently know how long it would take for earthworms to repopulate larger treated areas such as lawns or golf fairways, but population recovery at such sites would no doubt be slower than occurred in our study plots.

It should be noted that *none* of the compounds tested were registered for use against earthworms in turf. Furthermore, I am aware of no scientific studies that show that use of a pesticide to kill earthworms or white grubs will eliminate or alleviate a problem with moles. Although earthworms can be a nuisance on a golf course, their importance in aerifying and enriching the soil, enhancing water infiltration, and breaking down thatch is very beneficial to the long-term stability of healthy turf. I suggest that when a chemical application is needed to control weeds, pathogens, or insects, golf superintendents and other turfgrass managers would be well advised to select efficacious pesticides that are less toxic to earthworms.

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