Getting the Lowdown on Worms

Anybody who's ever seen a worm smooshed on the street after a rain must have pondered this question: Why did the worm cross the road?

The answer to that is unknown.

But it might simply be: to get to the other side. Even in the rain. Maybe especially in the rain.

Edwin Berry, an ARS entomologist in Ames, Iowa, who has studied worms for 10 years, says the reason is not to avoid drowning. "In our experiments, they've lived underwater for weeks.

"It could be that they're coming up for air because the rain fills air pockets in the soil and leaves little oxygen for the worms in their burrows. Or they might be irritated by a sudden increase in acidity when rain mixes with their urine.

"Another theory is that this is one way that the worms disperse to find new feeding grounds. Perhaps they come out in the rain because it's easier to move across moist, cool ground on overcast days. Or maybe they just enjoy a shower or want a drink. There's still a lot we don't know about worms," Berry says.

The worms certainly came out when it rained on Worm Day in Coshocton, Ohio, last year. But they've never failed to turn up—rain or shine—thanks to the irritating effects of a 0.5-percent formaldehyde solution sprinkled on the soil at the beginning of the biannual event.

For the past 5 years, each spring and fall, the scientists and technicians at Coshocton arm themselves with garden sprinklers and wood frames. About eight of them spread out up and down a hill. Each throws a square plot frame on the ground to outline a random sampling area and then pours the mild formaldehyde solution into it. As the worms wriggle to the surface, Worm Day participants pick them up with tweezers and place them in glass jars for later identification.

Worm Day is hard work at Coshocton, because the Worm Team repeats this scene 56 times—at 8 different sites on each of 7 watershed drainage areas for streams. The scientists separate nightcrawlers from the other earthworms and then sort them by stage of maturity. The worms are shipped to entomologists at Ohio State University in Columbus for final identification.

Soil scientist Bill Edwards and his Worm Team conduct their survey twice a year to compare the effects of different farming practices on earthworm populations.

Edwards explains agriculture's interest in worms: "They're nature's perfect no-till plow, doing everything an engineer would like to have a plow do. They enter the soil with minimal disturbance, leaving only a hole smaller than the diameter of a pencil, and then they open up channels throughout the underlying topsoil. These channels help loosen the soil, provide plants with paths for their roots, work in organic matter, and drain and aerate the soil," Edwards says.

Edwards' research showing that chemicals applied to fields may take shortcuts through wormholes to end up more quickly in groundwater made some people question the value of worms.

But Edwards explains that the shortcut hazard only exists a few days a year—such as during heavy rainstorms occurring shortly after herbicides are applied to a field.

The rest of the year, the wormholes funnel clean rainwater rapidly downward before it can be contaminated by pesticides. He has even found that something in wormholes causes them to soak up atrazine and alachlor, common herbicides, better than other holes in the soil. He suspects that it's the high organic content of residue brought into the burrows.

"We've seen large differences in worm numbers in adjacent watersheds, even if managed the same," Edwards says. "We're trying to find out what accounts for this when the soil is similar.

"Other changes in numbers we can ascribe to differences in management, such as no-till versus plowing."

At Coshocton, a 30-year tillage study—still under way—shows that worm numbers increase after the first few years of no-till. No-till refers to a farming practice in which crops are planted directly in residue—the plant stems, stalks, and leaves left after harvest. A herbicide is used to kill unwanted grass and weeds.

Benefits of the increased worm population show up quickly, too. Topsoil is improved and erosion almost eliminated, partly because rainwater puddles drain through wormholes rather than run across fields, carrying away topsoil.

Edwards explains that the growing popularity of no-till and other tillage techniques that eliminate or minimize the use of the old moldboard plow has drastically changed the worm picture in America for the better.

More than 150 years of churning U.S. soils with heavy-duty moldboard plows have taken their toll. Topsoil layers are thinner, and the soil isn't quite as rich as it once was.

One bellwether of this decline is the earthworm, which is now being recognized as an indicator of soil tilth or quality. Because of their role in soil-building, Berry says worms are "a natural" for research by the National Soil Tilth Laboratory in Ames, where he works.

Surprisingly, fertilizers and chemicals in general don't seem to have harmed worms much, although there are exceptions. With the increasing popularity of no-till and other forms of crop residue management over the past two decades, the worms are coming back.

Edwards says there is a mutually beneficial relationship between worms and no-till: The less tillage, the more worms; the more worms, the better no-till works.

Doral Kemper, the ARS national program leader for soil management, has been doing his own informal surveys to document the disappearance and reappearance of worms on America's farmlands.

Kemper is so tuned in to worms, he claims he can feel their droppings through the soles of his shoes. These droppings, called casts, are often laid in piles and form noticeable mounds —up to an inch or more high—on farmland, as well as urban lawns.

He also looks for middens, which are especially large in the Midwest. Worms form middens by covering fresh pieces of crop residue with casts over a worm hole. "These middens are worms' cross between compost piles and root cellars," Kemper says.

BRUCE ZAKE

By sprinkling on a mild formaldehyde solution, soil scientist Bill Edwards brings worms to the soil surface so they can be counted. (K5844-1)

Each midden is one worm's grazing grounds. By surrounding the crop residue with moist casts, the worms encourage mold growth. They eat the mold's hairlike filaments, or hyphae, using muscular action and suction to slurp the strands in much the same way as people do spaghetti.

Berry says the answer to the question of why worms build middens is as uncertain as many other aspects of worm behavior. There are several possible answers, including food storage—snacks are nearby, ready to be pulled into the burrow. Middens also hide the tops of burrows and control interior climate, much as office workers use doors. Kemper has learned to peel open these middens to find earthworms.

Plowing discourages earthworms by clearing the soil surface of middens and plant residue and breaking up worm burrows by churning the topsoil. Worm homes survive for years if the soil is not tilled.

Kemper says that the residue functions like a log or piece of wood left on the ground. Mold forms on the underside of the moist, decaying wood or crop residue, and worms can feed on the hyphae with protection from birds and the sun.

The residue, like the wood, acts as an insulating blanket for worms: It moderates soil temperature and helps keep the soil moist. Worms can only digest very small things, like the hyphae that are a fourth the diameter of many root hairs.

Worms use a combination of muscular action and silt and fine sand particles to grind organic matter in their intestines and make it digestible. They can only swallow the silt and clay in soils. To worms, large sand grains are like golf balls to people—too big to swallow.

In feeding on beneficial fungi on plant roots, worms digest the soft hyphae. The harder fungal spores remain intact and emerge in the casts, many of which are deposited deep down in the wormholes. As the roots follow these holes, they are infected by the beneficial fungi.

The worm casts are puddled and almost fluid when first excreted. As the fungal spores hatch, their hyphae help hold the casts together, much as reinforcing wire does in wet concrete. At this point, the casts help hold soil particles together, making soil less erodible while still very permeable to water and plant roots.

Kemper and Berry once brought nightcrawlers from Ames, Iowa, to the ARS Cropping Systems and Water Quality Research Unit in Missouri to see if they could help break up a soil claypan layer that reduces crop yields by inhibiting root growth. They chose nightcrawlers because they burrow vertically and deep, unlike many other earthworms that burrow horizontally and usually within the first foot of topsoil. Kemper and Berry had assumed that the scarcity and smaller size of middens in Missouri meant a lack of nightcrawlers.

With the help of an observant technician, John McCowan, they discovered that some Missouri fields were harboring a type of nightcrawler called *Pheretima,* thought to exist only in climates warmer than Missouri's. It is 40 percent bigger and faster and much livelier than other nightcrawlers.

"They whip their tails violently when caught, sometimes leaving their tails in the catcher's hands," Kemper says. "If they had teeth, no one would dare to pick them up.

"Here we were—bringing nightcrawlers from Iowa, when Missouri has these big, tough worms with the muscle needed to push holes through the claypan," Kemper says. "We just need to create the conditions now that will induce them to grow, reproduce, and tunnel where we need them."

Berry is now studying *Pheretima* to see if he can breed them and spread them to Iowa and other northern states..

A Safety Net for Worms?

Berry and Kemper discussed with Gene Alberts and his staff at the Missouri lab the potential benefits of increasing worm populations.

Technicians mentioned finding worms in tanks holding the waters running off the 10- by 90-foot erosion plots. Alberts asked them to count the worms collected in the tanks in future runoff events. When they found up to 900 worms per tank, it became apparent that runoff does more than carry topsoil out of fields and into streams and reservoirs. Though its load of worms helps feed fish, runoff depletes the soil's earthworm population.

Berry says that worms are more numerous in the crowns of grass clumps. There the worms get shade, food from molds and decaying old leaves and roots, and protection from hungry birds. The grass provides an insulating cover that helps protect the worms from temperature extremes.

When the weather improves, they migrate in both directions, spreading their population across the fields.

Berry and the lab staff are monitoring worms leaving the plots with and without hedges. Kemper was surprised by the worm migrations on nonirrigated claypan, but he's known about similar migrations in irrigation furrows since his days as an irrigation specialist at a lab in Idaho.

"On some overcast days or at night when the sun's ultraviolet light wasn't hurting them, I'd see as many as 15 or 20 worms a minute washed out of furrows," he says. "I find this

BRUCE ZAKE

Worms—nature's perfect "no-till plow"—are collected by soil scientist Martin Shipitalo for further identification. (K5844-3)

Dense grass hedges have been grown at the bottom of some of these erosion plots to determine the degree to which they can slow runoff, pond up water, and settle sediment on the uphill side of the hedge. Hedges may also act as a safety net, helping to increase worm populations—especially in claypan soils where water runoff is often greater because the underlying pan layer is so impenetrable.

SCOTT BAUER

(K5842-1)

migration fascinating. We're learning more about worms all the time."

Kemper has also seen worms create so many worm holes in a furrow during irrigation that water ceased to reach the lower end of the field.

Kemper says that 20 years ago he considered earthworm watchers as hobbyists with nothing better to do. "But the more I see of worms and learn what a major role they play in the hydrology of planet Earth—the way they help plants grow, the way they help no-till succeed—the more I am impressed with them."—By **Don Comis** and **Hank Becker,** ARS.

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ALERT: Insectary Workers Can Breathe Easier

Ever capture a moth and accidentally rub the powdery coating off its wings and body? Well, picture thousands of moths all fluttering about at once, in one place—each shedding this powder made up of millions of tiny scales.

Scales and other insect debris kicked up during mass-rearing can trigger sneezing, bronchitis, asthma, or more severe allergic reactions in susceptible people, says ARS entomologist Frank M. Davis. He is at the ARS Crop Science Laboratory in Mississippi State, Mississippi.

It's an occupational safety concern for entomologists and workers in all insectaries—whether they mass-rear hundreds or millions of moths and other insects for use in scientific research and as biological controls for crop pests.

"But now we've developed a management system for dealing with these scales," says Davis. "We call it ALERT, for Advanced Lepidoptera Environment Rearing Technology.

"The system begins with housing scale-shedding insects in separate quarters. We keep them in specially designed cages that facilitate removal of scales as they are produced. And, day and night, we run an improved, state-of-the-art air filtration system."

Davis, along with supervisory maintenance mechanic Stan Malone and lab director Johnnie Jenkins, consulted with a private firm to improve the lab's existing filtration system and bolster its overall scale-removal efficiency. They also implemented exceptional housekeeping practices, such as locating the vacuum cleaner motor outdoors and piping the suction in through PVC tubing. Says Davis, "The ALERT system has solved a problem that's concerned us and others in insect-rearing for years."

According to a 1984 study by the Entomological Society of America, 60 percent of 136 federal and private insect-rearing institutions that were surveyed reported at least one individual experiencing allergic symptoms from insect debris. A 1993 Italian university survey found 7 out of 13 insectary workers suffered allergies.

But in laboratory tests conducted near 20,000 caged moths, the air filtration system cleared nearly 100 percent of scales from the surrounding air. A commercial laser counter used to confirm the system's effectiveness detected about 9,000 tiny 0.5-micron particles per minute in the air entering the system, but only 47 per minute after the filter went to work.

Placed behind moth-holding cages, the air-cleaning system comprises a series of ducts and a special blower to draw larger-sized scales into pre-filters. Smaller debris is forced into a final downstream filter that removes up to 99 percent of remaining particles.

The work has been reported in the Journal of Economic Entomology. Several private firms specializing in natural pest controls are interested in adapting the ARS ALERT technology to their insect-rearing operations.—By **Jan Suszkiw**, ARS.

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