THE WORM BOOK

The Complete Guide to Gardening and Composting with Worms

Loren Nancarrow

and Janet Hogan Taylor

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Thank you all!

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Why Do We Need Worms?

On the small farm we tend in San Diego, California, earthworms do most of the work. Th farm has a 3,000-square-foot vegetable garden. We don't use rototillers because they compa the soil. Instead, earthworms do the tilling. They also help fertilize our crops, condition th soil, and eat our leftovers. In our orchard, they keep the soil near the fruit trees loose an rich. Earthworms are at work twenty-four hours a day helping to keep the farm a showplace

Beyond the horticultural advantages, earthworms provide a diversion for children in th garden. Kids will happily dig and collect earthworms long enough to get some weeding done

Simply put, earthworms are the hardest working creatures on (or under) the earth. The are worthy of our respect and admiration, and yet historically they've evoked fear an loathing. After all, it's worms that crawl in and out and eat our snout, and worms that w have to eat if nobody likes us. It's a shame that a couple of unfortunate children's songs lea us to think poorly of such magnificent organisms. These remarkable workers have man important roles in nature, including mixing and aerating the soil, improving soil structure an water infiltration, helping moderate soil pH, bringing up minerals in the soil, makin nutrients more available to plants, breaking down plant and animal material into compos and increasing beneficial microbial action in the soil. These are no small tasks, but th earthworm accomplishes them easily through its daily feeding habits.

Do you want to get rich? There are many people who will tell you that earthworms ca help you do it beyond your wildest dreams. Don't believe it! Do believe this: there are n enough earthworms in the soil today. Regular plowing and spraying, disturbing the soil, an soaking it with chemical fertilizers and pesticides all take their toll on earthworms. Society beginning to learn what damage these substances do to the soil and its inhabitants; now w can begin the long task of rejuvenating the soil. Perhaps the best thing you can do to help to grow some earthworms in a garden bed outside or in a bin under your kitchen sink. Se some if you'd like, or sell their castings instead, or just grow them to return to the soil, whic is so in need of your earthworms' labor. Along the way you'll learn a bit of husbandry an biology. You'll be amazed at an earthworm's ability to convert what we think of as garbag into gold, and you'll be doing your part to put the natural order back in place. Read on t learn how earthworms work their magic—and how you can be a part of it.

THE SOIL

There are many different types of soil all around the world. Soils can be loamy, sandy, c clay/adobe, just to name a few, but soil itself is made up of two main parts. One part is mad up of rock particles that at one time or another were part of a larger rock or stone. Ove time, erosion of rocks and stones by wind and water produces soil particles. (An example c this kind of soil particle is sand. If you look closely at sand, each particle looks like—and is- a miniature rock.)

The other part of soil is decaying organic material. As plants and animals die an decompose, they are broken up into smaller particles called humus. It's the humus part of so that holds water, feeds plants, and keeps the soil from becoming too hard for plants to gro in. By eating and breaking down large pieces of decaying matter, earthworms play a key ro in increasing the humus in soil.

The United States Department of Agriculture decided to test fertilizer versus earthworn over forty years ago. To do this, the department started with two containers of poor soil. T one container they added dead worms, fertilizer, and grass seed. To the other container the added live worms and grass seed—no fertilizer. To their amazement, the grass seed in th container with the live worms grew four times faster than the grass seed in the contain with dead worms and fertilizer.

> A nightcrawler is very strong for its size. A nightcrawler that weighs only 1/13 of an ounce, has been shown to move a stone that weighs 2 ounces. That is equivalent to a 200-pound man moving over 2½ tons.

It is estimated that in an area with large numbers of earthworms, the worms can cover a acre of land with as much as eighteen tons of new soil each year; but it is also estimated th we are using seventeen times more topsoil than is being produced.

Earthworms are essential in good soil composition. As they burrow through the soil, the open it up and help keep it loose. This tilling action allows oxygen and water to get dow into the soil where they can be taken up by plants; these elements in turn improve so conditions for beneficial bacteria and other microorganisms that contribute to healthy soil Earthworms also bring up soil from deeper soil levels to the top and then bring topsoil bac down again. Over time, soil that is brought up by worms will cover seeds and allow them germinate. This process can bury rocks and other objects.

Plant roots have an easier time getting down into the soil when they follow earthwor burrows. Nitrogen-fixing bacteria, needed by plants for growth and vigor, have been found large numbers along the sides of earthworm burrows.

When earthworms feed, they take in bits of rock and organic matter (humus), digest wh they can, and deposit the rest as excrement (castings). Earthworm castings improve the soil several ways:

- Castings are close to neutral in pH—around 7 on the pH scale—no matter what kind of soil the worm ate. For example, even if a worm fed in a very acidic soil, its castings would be neutral, not acidic. Earthworm castings also contribute to neutralizing soil pH by adding calcium carbonate to the soil.
- Castings are rich in minerals and nutrients needed by plants. A study at Cornell University showed that the nutrient level of castings is usually much higher than that of the surrounding soil. Castings were found to be high in nitrogen, potassium, phosphorus magnesium, and trace minerals. Castings were also shown to supply needed micronutrients to plants. Another study estimated that castings contain five times the available nitrogen, seven times the available potash, and one and a half times the calcium found in good topsoil. So castings are excellent plant fertilizers and provide

nutrients in a form immediately available for plant use.

- Castings are food for other beneficial microorganisms. They will contain thousands of bacteria, enzymes, and remnants of plant and animal material that were not digested by the earthworm. The composting process then continues long after the casting is excreted adding beneficial microorganisms back to the soil and providing a source of food for the ones already there. Some of these soil organisms release potassium, phosphorus, calcium magnesium, iron, and sulfur into the soil ready for plant use.
- Castings increase the humus content of the soil. An excreted casting is 65 to 70 percent organic matter, or humus. Soil rich in humus soaks up and holds water better. The soil is loose and is less likely to become hard and compacted. Humus can also buffer soil by binding with and holding the heavy metals from materials such as manure, sewage sludge, and vegetable waste matter (stems and roots) left over from crops.
- Castings hold their nutrients in mucus membranes that are secreted by the earthworm. This allows the nutrients to be slowly released so they are available to the plants over a period of time as needed.

C:N RATIO AND WORMS

Plants must have a way to take in the minerals they need from their soil environmen Scientists have discovered that for this assimilation to occur, a certain ratio of carbon nitrogen (C:N) must exist. Looking at fallen leaves provides an interesting example. Sever studies have measured the carbon to nitrogen ratio of many common tree species, and in n case does a tree's leaf litter come close to the optimum 20:1 ratio needed by plants. Mo trees have too high a carbon content. A few examples are: 24.9:1 for elms, 42:1 for oaks, an a whopping 90.6:1 for Scotch pines. So how can the dead leaves be converted in decomposed organic matter that has the correct ratio for plants to use?

When plant litter breaks down and decomposition has started, nitrogen and carbon leve decrease with each decomposer that feeds on it. Carbon is a food source and therefo decreases more quickly than nitrogen.

Earthworms play a big role in this breakdown. When an earthworm feeds on leaf litter an breaks the litter down during metabolism, the carbon level falls. The earthworm castings ma still have a C:N ratio too high for plants to directly use the nitrogen, but then othe decomposing organisms can use the castings for food. The castings are further broken dow and, when the resulting organic matter has a 20:1 ratio, plants will be able to directly use th nitrogen the leaves contained.

RECYCLING

Earthworms are excellent composters. They can compost organic material faster than an composting system. Some earthworm species will eat half their body weight in food per da The nightcrawler will come out at night and search for plant matter it can pull back into i burrow. Once the food is pulled in and eaten, the nightcrawler will deposit its castings bac on the surface of the soil. The castings in turn become fertilizer for plants. So, for example, you mow your lawn with a mulching mower—one that returns the clippings to the lawn- earthworms can find and eat the clippings and spread their castings through the top of th soil. This is a simple example of recycling the clippings' nutrients back to the lawn—but th benefits of recycling with earthworms don’t stop there.

Earthworms can be maintained in a controlled situation to compost household, yard, ar animal wastes. The homeowner can easily maintain a household worm bin to take care c kitchen wastes. A gardener can use earthworms directly in his garden soil or in an outdoo worm bin to help compost plant material. Finally, animal wastes can also be composted int rich vermicompost that can be used on garden plants. Approximately 70 percent of th material we send to landfills, including kitchen wastes, farmyard manures, and yard waste can be used to feed worms. If we did feed this material to the worms, the worms could giv us 60 percent of the volume back as vermicompost fertilizer. This fertilizer would be a saf natural soil enhancer and plant food that would be a benefit to the environment.

2

What Is a Worm? Basic Worm Biology

When describing an earthworm to someone who has never seen one, it sounds like you a describing a creature that is too good to be true and can't possibly exist. They don't have ar ears, eyes, or a nose, but they do have senses. They have a mouth, but they don't have jav or teeth. Each earthworm is both male and female—but it still takes two earthworms to mal little earthworms. Earthworms are truly specialized creatures, perfectly adapted subterranean life, and they excel at turning the stuff we would consider waste into a usef product.

EARTHWORM HISTORY

Charles Darwin, father of evolutionary theory, said of the earthworm, "It may be doubte whether there are many other animals in the world which have played so important a part the history of the world." Darwin was fascinated by earthworms and studied them for thirt nine years. He even wrote a book about earthworms, called *The Formation of Vegetable Mou Through the Action of Worms With Observations on Their Habits*.

Earthworms are members of the phylum Annelida, or segmented worms. This phylum h three classes, with earthworms belonging to the class Oligochaeta, of which there are aroun six thousand known species. It is thought that earthworms arose during the Cretaceous er when dicotyledonous plants appeared, but some evidence suggests they arose in the mu earlier Jurassic period. Most scientists agree that earthworms have been on Earth for at lea 120 million years.

Earthworms have been well recorded in history, and not just by Darwin. The Gree philosopher Aristotle called earthworms "the intestines of the soil." He wasn't far off wi this observation. Even in the time of Egyptian pharaohs, Cleopatra herself said, "earthworn are sacred." With a history like this, why don't earthworms get more respect?

In North America earthworms have had their ups and downs. Scientists believe that most the earthworm species were killed here in the last ice age, about ten to fifty million yea ago, by glaciers that dipped down from the Arctic into the temperate regions. But, you ma be thinking, you have seen earthworms in your very own yards. That's because earthworn were reintroduced to North America by early European settlers in the seventeenth ar eighteenth centuries. Most worms arrived in the soil clinging to the roots of favorite plan brought to settle the new land. The settler's ships also used soil as ballast, and this was of loaded at ports once it was no longer needed. The soil contained many earthworms, whic gradually spread out from the many ports. Some farmers, after seeing plants in the port citi do better with the earthworms, deliberately introduced the earthworms to their land.

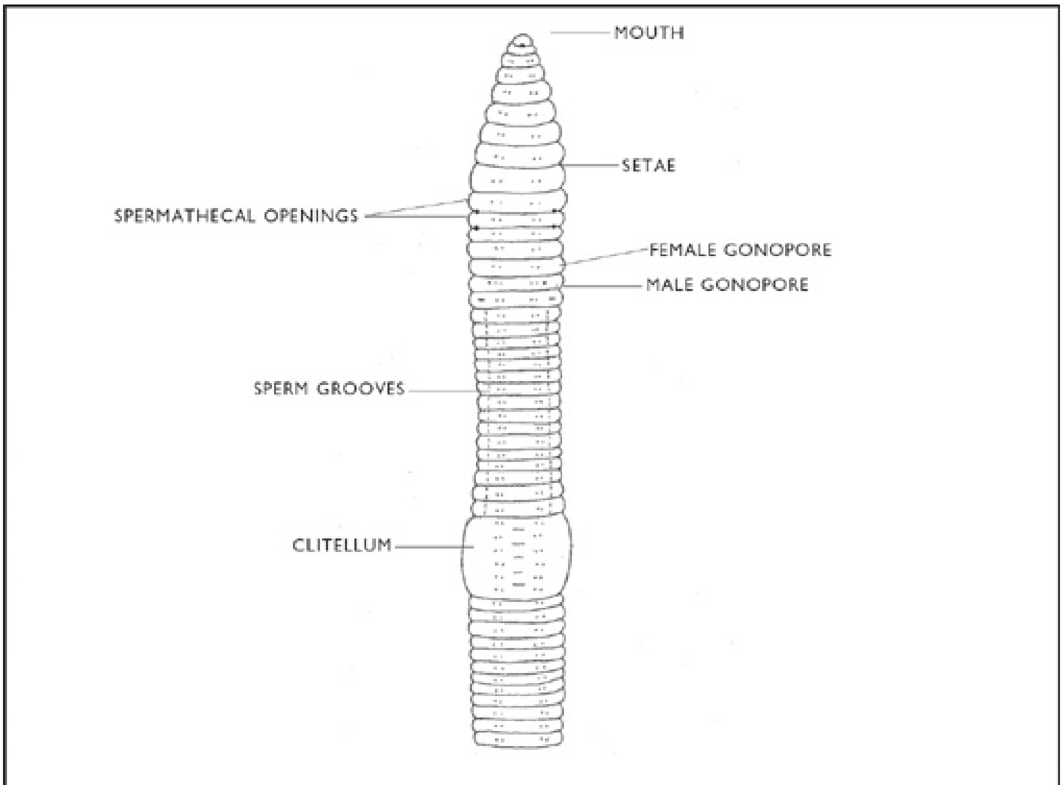
In many localities throughout the world, and in particular the southern hemisphere, ma has played an important part in the introduction of earthworm species. A study of earthwor species in several large cities in Chile found that all the earthworm species there originate from Europe. Of the nineteen earthworm species presently found in Canada, only two them are thought to be indigenous. The rest are imports.

The endemic *Lumbricus*, the genus of nightcrawlers and some redworms, have been foun to form a belt around the temperate regions of Europe, Asia, and eastern North America.

FIVE HEARTS AND NO LEGS:
THE BODY STRUCTURE OF AN EARTHWORM

Earthworms are cold-blooded invertebrates and hence have no backbones. Instead the bodies are broken down into segments that vary in width, with the largest being in the fro region of the worm. The segments are numbered and scientists use the numbers differentiate among earthworm species.

Mature worms have a structure called a clitellum. This structure is the glandular portion the epidermis, or skin, which is associated with cocoon formation. The clitellum can diff widely among different species. Sometimes it appears as a swollen area, and in others as well-defined constriction in the worm. The clitellum can be a different color than the rest the worm—usually darker or lighter in tone, but sometimes a completely different color. Th position of the clitellum on the body of the worm differs in each species as well. *Lumbricus*, the clitellum is positioned between segments twenty-six and thirty-two on th anterior or top part of the body.



OUTER WORM ANATOMY

On every segment except the first segment, earthworms have bristles (setae). There a four pairs of setae per segment for the earthworm, *Lumbricus*, but this number varies wi species. The setae, which appear in a variety of shapes and lengths, come from exteri follicles on the body wall. Most of the setae on *Lumbricus* are curved in shape a approximately one millimeter in length. The primary function of setae is locomotion, b they also play a role in reproduction.

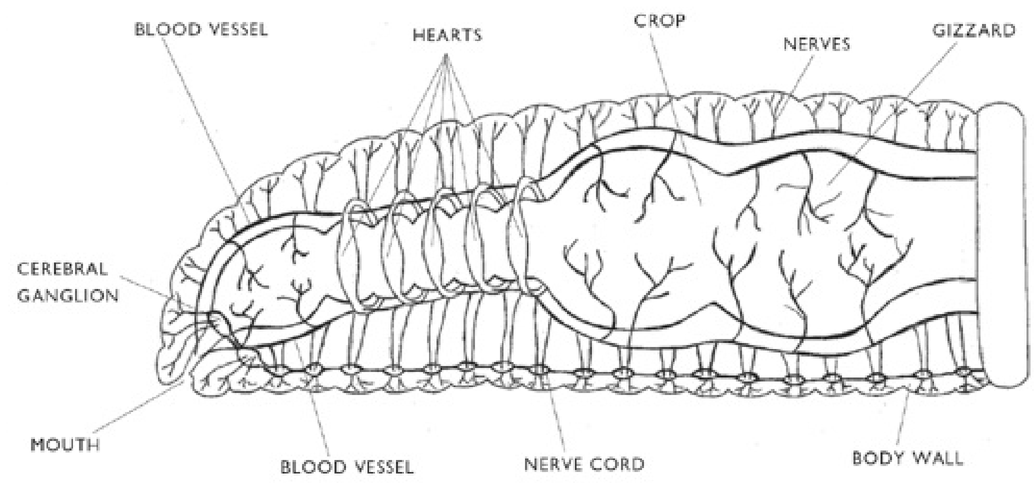
To move, the earthworm extends its body, anchors it with its setae, and then contracts i

body using its longitudinal muscle. Each extension, anchorage, and contraction is called
step. During this process, each segment can move forward two to three centimeters; th
worm can take seven to ten steps per minute.

Earthworms' bodies consist of 75 to 90 percent water, but are high in protein, making them a favorite food of moles, shrews, and birds.

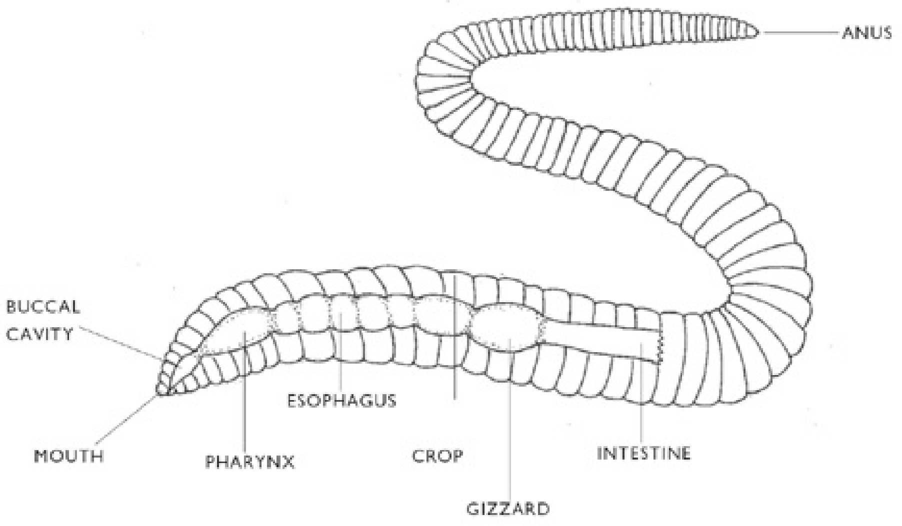
There are several different kinds of pores located on a worm's body. Usually earthworm
have two kinds of pores for reproduction: spermathecal and female. In addition, worms hav
dorsal pores, which are small openings in the segmental grooves of the worm. These por
are excretory structures for secreting coelemic fluid (what we know as worm slime). Som
worm species have a defense mechanism where, when the worm is threatened, it can shoot
stream of mucus several centimeters in the air! I know that would get my attention!

Finally, small nephridiopores located on the ventrolateral surfaces of each segment are th
openings of the nephridia (the excretory organs of the worm); these remove liquid wast
from the body.



INTERNAL STRUCTURE OF A WORM

The body wall itself consists of an outer cuticle called the epidermis, which is very thin ar
helps to prevent water loss. In this layer the mucus or goblet cells can be found. They secre
the mucus that covers the body of the worm. Underneath the epidermis is a layer of nervou
tissue containing large numbers of sensory cells that respond to stimuli such as touch, hea
and light. The epidermis and the nervous tissue are bound together by a basal membran
Inside the membrane there are two muscle layers: One is a circular layer that goes around th
worm's body and the other is a longitudinal muscle layer that is thicker and runs the length o
the worm's body. Finally, the peritoneum, a layer of coelomic epithelial cells, separates th
body wall from the body cavity.



Digestive System of an Earthworm

Worms don't have a defined head, but we consider the end with the mouth to be the hea and the end with the anus to be the tail. We call the head the anterior and the tail th posterior.

Food—consisting of bits of organic matter mixed with soil—is taken in as the worm mov in the soil. Many worms prefer to feed where soils are rich with dead plant roots, dea leaves, decomposing plant matter, animal feces, or soil microorganisms. The food is picke up by the mouth, a small fleshy pad called a prostomium contracts over the mouth, and th food gets pulled into the alimentary canal. This canal is nothing more than a tube th extends from the mouth to the anus. Along the way, the food passes different sections of th tube, which help to break the food down. These sections are the buccal cavity, pharyn esophagus, crop, gizzard, and intestine.

> So does an earthworm "hear," "see," or "smell"? Yes and no. Like a snake, the earthworm uses its setae to sense vibrations and "hear." The body wall contains many nerve receptors that taste chemical changes (or "smell") and other nerve receptors that detect light changes (or "see") in their environment. One interesting fact is, earthworms can't "see" the color red.

The buccal cavity is a small cavity (like the inside of an animal's mouth between the mou opening and the pharynx) that has neither jaws nor teeth. The pharynx is thick and muscul and acts as a suction pump, drawing in food and pushing it down the canal. The esophag starts out as a tube leading from the pharynx and becomes the crop and gizzard. The crop ar gizzard may sound familiar to you because both of these are also found in birds. The structures basically have the same function in the earthworm as they do in the birds. Th crop stores food and the gizzard grinds the food up. The rest of the alimentary canal is th intestine, where digestion and absorption of food nutrients take place. Finally, food and so that are not digested are excreted through the anus as a worm manure called castings.

Lying alongside the intestine are narrow blood vessels that absorb the nutrients from th alimentary canal and feed the rest of the body. They extend almost the entire length of th worm's body. Between the blood vessels in the upper quadrant of the worm's body can b found anterior loops of vessels. These vessels ("hearts") are enlarged, have the ability t contract, and contain valves. *Lumbricus* has five pairs of such "hearts," but the number vari between worm species. Worms also have red blood that contains hemoglobin. Small bloo vessels (capillaries) connect the different body parts to the main vascular network and n only bring nutrients and oxygen to the worm's body, but also remove wastes.

In earthworms there really isn't a brain, just a mass of neurons called a ganglion. Th cerebral ganglion is connected to a pair of longitudinal nerve cords running the length of th worm's body. In each segment there is another pair of ganglia that are connected to th longitudinal nerve cords. Nerve fibers run from the ganglia and extend to the rest of eac segment. On the ends of these nerve fibers on the skin, the sensory organs and cells can b found. These sensory organs tell the earthworm about its environment. The photorecept organs can sense changes in light intensity, and the epithelial sense organs can tell the wor if it's being touched.

Worms do not have lungs (though some of the aquatic species of annelid worms do hav gills). They bring oxygen into their bodies by dissolving the oxygen through the body surfac which is kept moist by the mucus glands. There is a network of small blood vessels in th body wall that picks up this dissolved oxygen and carries it throughout the worm's body.

Earthworms need a lot of water in their environment. Not only do they need it to hel keep them moist, so they can take in oxygen, but to replace large quantities lost throug urination. One earthworm can produce 60 percent of its body weight per day in urine.

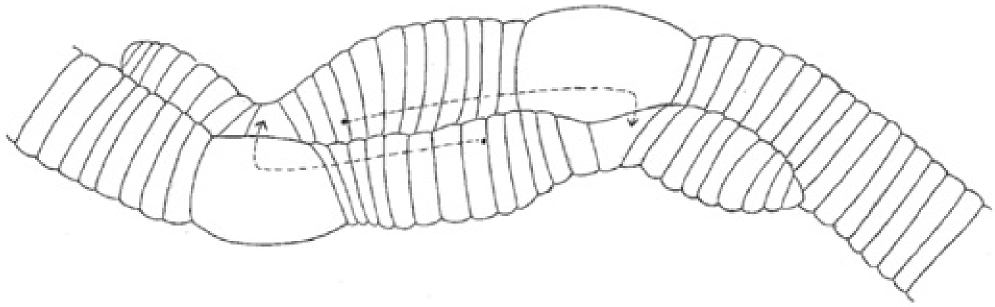
SEXING A WORM: ARE THEY MALE OR FEMALE?

Actually, they are both! Our friend the earthworm has both male and female reproductiv organs, making them hermaphroditic. In *Lumbricus,* there are two male segments and o female segment.

When an earthworm matures in three to six weeks after hatching, the clitellum is formed produce mucus for copulation, to secrete the wall of the cocoon, and to secrete albumin, which the eggs are deposited in the cocoon. In the clitellum there are three layers of glan that perform these three different functions.

To mate, one earthworm will position itself pointing one direction while another wi position itself pointing the opposite direction, so the head of one lies next to the tail of th other. The worms will lie close together and anchor themselves together by the longer set on their reproductive segments. The clitellum of each worm secretes a mucus coat around th two worms, like a collar, further holding them in place.

In some worms, the male and female pores will line up, but in *Lumbricus* the reproductiv pores do not line up. Instead, the semen must travel a considerable distance from the ma pore to the female pore. To accomplish this, muscles in the body wall of the segmen contract and form a pair of sperm grooves. The groove is covered by the enveloping muc layer secreted by the clitellum and thus becomes an enclosed channel.



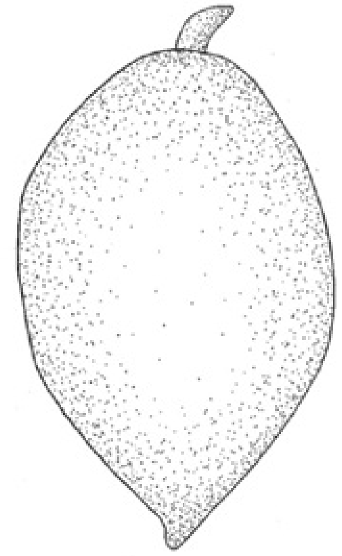
MATING WORMS' SPERM EXCHANGE

The semen moves down the channel, carried by contractions of the muscles that produ the channel. When the semen reaches the seminal receptacles, the semen is passed to th other worm and taken into the receptacles. This process may or may not happe simultaneously in both members of the mating pair. Usually copulation or mating takes plac over two to three hours and then the worms break apart.

A few days after mating, the worm secretes a cocoon in which the eggs will be deposite To produce a cocoon, a mucus tube is secreted around the anterior segments, including th clitellum. The clitellum will then secrete a tough chitin-like material that encircles th clitellum. This will become the cocoon. The clitellum's glandular cells then secrete album for the eggs in the space between the clitellum and the tubular cocoon.

When all of this has been accomplished, the tubular cocoon will slip forward toward th front part of the worm. The eggs are discharged from the female gonopores, and then th sperm are deposited in the cocoon as it passes over the seminal receptacles. As the cocoo slips over the head of the worm, the mucus tube quickly disintegrates and the ends se themselves, forming a completed cocoon. Cocoons can contain various numbers of eggs, fro one to twenty, depending on the species; but, in *Lumbricus*, usually only one or two eggs pe cocoon hatch. Adult worms may mate and produce cocoons continually every three to fou days, throughout the spring and again in the fall months, depending on outside condition Worms kept inside in constant warm temperatures can reproduce throughout the year.

Fresh cocoons are yellowish in color and look like tiny lemons. The cocoons gradual become darker as the embryo grows, feeding on the albumin deposited in the cocoon. Final the young worms hatch from the ends of the cocoons. The length of time for cocoons to hatc varies greatly among species and depending on climatic conditions.



WORM COCOON OR
EGG CAPSULE

Experienced worm growers can double a population of *Eisenia fetida*, a popular compostin worm, in just sixty to ninety days, so, as you can see, the reproductive potential of this wor can be quite high.

WHERE ARE WORMS FOUND?

Earthworms are found in all regions of the world now, except in deserts and frozen Arct areas. They can be found in almost all soil types, provided adequate moisture and food a available.

As we discussed earlier, earthworms need moisture in the soil in order to breathe. Th moisture in the soil, along with the mucus layer of the worm, allows oxygen to dissolve an pass into the worm. Earthworms can be found in soils containing as much as 70 percen water, but most consider a soil moisture content of 35 to 45 percent to be ideal. A commo worm myth is that when it rains earthworms come out of their burrows to keep fro drowning. Well, there are several possible reasons for this behavior—and none of them de with drowning. One reason is that worms come out of their burrows when it rains so they ca find a mate. Another one is that CO_2 levels in the burrow build up due to respiration, formin a weak acid solution that the worms do not like. Whatever the reason, studies have show that worms can remain alive in aerated water. Fish breeders who feed worms to their fis report that worms can live for many months under the filter trays in aquariums. A bigge danger to worms is drying out.

The preferred diet of the earthworm consists of decomposing plant or animal matte bacteria, fungi, and nematodes. Earthworms will even eat the dead and decaying parts of liv plants, leaving the healthy parts alone. In many countries, part of the accepted agricultur practice is to leave cut plant material on the soil for earthworms to eat. This allows th earthworms to naturally fertilize the soil before the next planting.

A WORM BY ANY OTHER NAME

In this chapter we will be taking a closer look at individual earthworm species an earthworms in general. The study of worms is called oligochaetelogy. The “oligochaete” pa comes from the Latin scientific name for earthworms, meaning “few setae” (bristles), and th “logy” part is from the Latin for “to study.” You will notice that we will use the scientif name of a worm along with its common name. Most people resist using a scientific name, b when discussing individual worm species it becomes necessary. For example, the nam “redworm” can refer to many different worms. You may think you understand whic redworm you are ordering, only to find out when it arrives that it wasn’t the worm yo thought you were ordering at all. So, to avoid confusion, we will also use the uniq scientific name of each worm species.

How does a species get a scientific name?

In 1758 a Swedish biologist named Carolus Linnaeus published a book on anim classification called *Systema Naturae*. Included in this book were more than four thousan animals, including man. Linnaeus was the first to give the scientific name *Homo sapiens* man.

Linnaeus’s system works like this: All animals and plants belong to groups that are simila The first group, known as kingdom, includes all animals or all plants together and is the mo general of all the groups. As the groups progress down from kingdom through phylum, clas order, family, genus, and species, the animals become more and more similar in appearan and behavior. The final two groups in the Linnaean system are genus and species. A genu contains organisms of similar characteristics and a species contains organisms that ca interbreed.

In giving a scientific name to an organism, the genus and species names are used togethe Our example of the redworm then becomes: *Lumbricus rubellus. Lumbricus* is the genus nam which is always capitalized, and *rubellus* is the species name, which is not capitalized.

WORMS IN GENERAL

There are thousands and thousands of different species of what we would call a worn Anything that is long and legless, we term a worm or wormlike (for example, the wor lizard). There are nematodes, flatworms, leeches, tubifex, maggots (which are insect larvae polychaetes or bristle worms, lugworms, fanworms, bamboo worms, horsehair worms, ar the list goes on and on. Worms can be found in marine, freshwater, or terrestri environments. They can be free-living or sedentary. Some construct elaborate tubes ar burrows. Others are parasitic and harmful to man.

> Aristotle called earthworms nature’s plows and the intestines of the earth.

In the phylum Annelida, or segmented worms, to which the earthworms belong, there a approximately nine thousand species. A vast majority of these worm species are aquati though we often think of the segmented worms as just the terrestrial earthworms we a familiar with. However, when we look at all the different worms in the soil, it is good t

remember that earthworms and their relatives make up only a small number of the tot
worms present.

EARTHWORMS

The earthworm family of Lumbricidae, which includes the genera of *Lumbricus, Eiseni* *Dendrobaena*, and *Allolobophora*, has hundreds of species of earthworms, but less than a doze of these are important to cultivation. There are an additional twelve families besid Lumbricidae, in the class Oligochaeta, which are classified as earthworm cousins, and a together they total about six thousand species. There are two other classes of segmente worms, the polychaetes and the leeches, which make up the rest of the phylum. The worn can range in size from a few millimeters to the giant Australian earthworm, which can reac three meters. It would be impossible to outline the life histories of all earthworm species, s we will take a closer look at the few earthworms commonly used for vermicomposting ar land improvement.

Terrestrial earthworms can generally be classified into one of three groups: the litte dwellers, the shallow-soil dwellers, and the deep-burrowers.

The litter-dwellers live in the thin litter layer on the soil. In a forest, for example, yo would find them just under fallen leaves or needles.

Shallow-dwelling worms, such as redworms, live primarily in the top twelve inches of so These worms do not build permanent burrows, but prefer to randomly burrow throughout th topsoil. When the weather gets colder in the winter, or the soil heats up and dries out in th summer, these worms will move deeper into the soil. Often you will find them down in th soil at about eighteen inches or so, rolled up into a mucus-covered ball. Shallow-dwellin worms may spend long summers and winters in this state of hibernation.

Deep-burrowing worms, like nightcrawlers, build permanent, vertical burrows that exter down into the soil six feet or so. Nightcrawlers are excellent soil aerators. Their burrow bring oxygen deep into the soil's top layer. Nightcrawlers are large worms reaching lengths four to eight inches, and a few species can even reach twelve inches. A deep-burrowing wor will pull plant material down into the burrow, instead of burrowing through soil to find foo Sometimes the material is left just below the opening of the burrow to soften, and will b eaten later. Nightcrawlers are nocturnal, as their name suggests, and feed at night. The feeding provides good soil mixing as well. When they pull decaying plant matter into the burrows, they mix it with soils from deep in the burrows. Finally, these soils will b deposited back on the surface with the worm's castings.

In areas where the land is constantly being turned over or cultivated, you will not find ver many nightcrawlers. These worms are more active in the spring and fall but do not go in hibernation like the shallow-dwelling worms in summer and winter. Instead they can retre to the bottom of their burrows during temperature extremes.

NIGHTCRAWLERS

(Lumbricus terrestris)

COMMON NAMES: Nightcrawler, Dew worm, Night walker, Rain worm, Angle worm, Orchar worm, and Night lion.

COLOR: Red, brown, or a combination of these colors. Some have been known to b greenish.

ADULT LENGTH: Up to 12 inches

LIFE SPAN: Up to 10 years but generally only a year or two in the garden

HABITAT: Vertical tunnels that can be up to 6 feet deep (deep-dwellers)

DISPERSION: Widespread throughout Europe and North America. Some also found in Ne Zealand.

FOOD PREFERENCES: Leaf litter and mulch

TEMPERATURE: They like temperatures around 50°F (10°C).

COCOON INCUBATION TIME: 14 to 21 days

Nightcrawlers can regenerate lost parts of themselves, an ability that varies widely amon worm species. Nightcrawlers have a relatively poor regenerative ability, but they have bee known to do it. The closer to the middle the worm is cut, the more likely a successf regeneration will occur. However, sometimes a worm gets confused and regenerates a wor with two tails or two heads.

Nightcrawlers are not good for indoor vermicomposting systems. They like their burrow undisturbed and prefer to eat things that are found on the top of the soil. This can cause som problems with composting systems. However, they are a very important organism in natu for land improvement.

AFRICAN NIGHTCRAWLERS
(Eudrilus engeniae)

COMMON NAMES: African nightcrawler, Giant nightcrawler

COLOR: Reddish with cream striping

ADULT LENGTH: Large—up to 12 inches

HABITAT: Top few inches, under litter and mulch (shallow dweller)

FOOD PREFERENCES: Rich compost

TEMPERATURES: 59 to 77°F (15 to 25°C)

The African nightcrawler can be a good worm for vermicomposting but tends to be restles One day they are doing fine in the bin, and the next they are moving out. They require war temperatures and are not recommended in areas that dip below 50°F unless kept inside. Mo work is being done to determine just how good a composting worm the African nightcrawl can be.

Redworms

(Lumbricus rubellus)

Common names: Red worm, Blood worm, Red wiggler

Color: Somewhat iridescent on top, dark red to maroon. Lacks striping between segmen and has a light yellow underside.

Adult length: Up to 3 inches and has 95 to 120 segments

Clitellum: Covering segments 27 to 32, usually raised on top

First dorsal pore location: Between segments 7 and 8

Habitat: Prefers the top 6 to 12 inches of soil

Food preferences: Rich compost and decaying plant and animal material

Temperatures: 64 to 72°F (18 to 23°C)

Cocoon hatching: 12 to 16 weeks

Lumbricus rubellus is a very active wiggler in the presence of light. It is said that this wor is irresistible to fish and makes great bait because the worms exude amino acids that fis lack.

Lumbricus rubellus makes a good compost worm. Like nightcrawlers, they will aerate ar mix the soil. They can be found in soils that have a rich organic component, such as anim pastures and compost piles.

Red wigglers

(Eisenia fetida)

Common names: Tiger worm, Garlic worm, Manure worm, Brandling worm

Color: Rust brown. There is a membrane between each segment with no pigment, and c each segment there are alternating bands of yellow and maroon down the length of th body.

Adult length: Up to 3 inches

Clitellum: Covering segments 26 to 32 and raised all around the worm

First dorsal pore location: Between segments 4 and 5

Habitat: First few inches of soil (shallow-dweller)

Food preferences: Very rich compost, manure piles, and decaying plant and animal materia

Temperatures: 59 to 77°F (15 to 25°C)

Cocoon hatching: Between 35 and 70 days depending on conditions

The red wiggler is an excellent vermicomposting worm. It can process large amounts c organic matter and in perfect conditions can eat its body weight in food each day. It also ha a high reproductive ability and can double its numbers in sixty to ninety days. *Eisenia fetid* isn't too fussy about living conditions in the bin. It can tolerate fluctuations in temperatur acidity, and moisture levels that many worm species cannot. This worm also has som regenerative ability.

Eisenia fetida is used as a fishing worm, and, like *Eisenia andrei*, it exudes foul smellin coelomic fluid. (The Latin word *fetida* actually means stinky or smelly.) Some fishermen sa that certain species of fish are attracted by this fluid, while others say the fish are attracte by the worms' wiggling.

In nature, these worms need soils that are extremely high in organic matter; they ju cannot live in common garden or lawn soils. Of course there are exceptions to every rule, an some soils are very rich in organic matter. But think twice about adding extra *Eisenia fetid* worms to your garden without adding extra organic matter, because chances are they wor survive.

RED TIGER
(Eisenia andrei)

COMMON NAMES: Tiger worm, Red tiger worm, Red tiger hybrids

COLOR: Dark red or purple. There is some disagreement over whether these worms a banded or not. Some worms have been identified with yellow bands between th segments, whereas others have been identified without banding.

ADULT LENGTH: Up to 3 inches

CLITELLUM: Covering segments 26 to 32 and raised all around the worm

HABITAT: First few inches of the soil and under mulch

FOOD PREFERENCES: Manure, rich compost, and decaying plant and animal material

TEMPERATURES: 64 to 72°F (18 to 23°C)

Eisenia andrei is a good worm for vermicomposting. It is a close relative of *Eisenia fetida* an also has the ability to process large amounts of organic matter.

These worms, like *Eisenia fetida*, are used for bait and exude coelomic fluid. They are ver active wigglers in sunlight.

BLUE WORMS
(Perionyx excavitus)

COMMON NAMES: Blue worm, Indian blue, and Malaysian blue

COLOR: Anterior is a deep purple, while posterior is a dark red to brown. The clitellum an underside are light yellow.

ADULT LENGTH: Up to 6 inches

Clitellum: Covers segments 7 to 10 and is not raised. Some are even depressed.

Habitat: Lives just under mulch (litter dweller)

Food preferences: Compost, decaying plant or animal material

Temperature: 68 to 77°F (20 to 25°C)

Blue worms are very active wigglers and make good fishing worms. It is a goo vermicomposting worm in warm climates. It does not like cold weather and would not c well outside in cold regions. When this worm is used in indoor vermicompost, sometimes will leave the bin for no reason. Blue worms fluoresce when exposed to sunlight.

Perionyx excavitus also has an excellent regenerative capacity and can regenerate any part has lost.

Spenceriella species

Common names: Blue Worm, Indian blue, and Malaysian blue

Color: Deep purple on top with a dark red to brown underside. Clitellum is usually a lig yellow.

Adult length: Up to 6 inches

Clitellum: Covering segments 7 to 10, not raised

Habitat: Top few inches of soil and under mulch (shallow-dweller). Australian native.

Food preferences: Compost and decaying plant and animal material

Temperature: 68 to 80°F (20 to 27°C)

This worm looks identical to *Perionyx excavitus* and is often confused with it. A very activ wiggler that fluoresces under sunlight, they make good fishing worms and, unlike *Eisen fetida*, reproduce by self-fertilization (parthenogenesis). They are prolific breeders ar increase their numbers quickly.