Los Angeles County Public Works
Environmental Programs Division

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Smart Gardening Fact Sheet

WORM COMPOSTING

If a healthy soil is full of death, it is also full of life: worms, fungi, microorganisms of all kinds. Given only the health of the soil, nothing that dies is dead for very long.

Wendell Berry, 1977
The Unsettling of America

THE SCIENCE OF WORMS

Worms are members of the phylum Annelida (segmented worms) which has over 9,000 currently known species. Earthworms are members of the class Oligochaeta (bristleless worms) which has over 2,900 known species, including both terrestrial and aquatic members. The class Oligochaeta can be divided into three or four orders, depending on the source, including: 1) the Lumbriculida, which are fairly large freshwater worms, most of which are found only in Lake Baikal, Russia; 2) the Moniligastrida (which may be listed as a suborder of Haplotaxida), which include primarily Asian earthworms, several of which exceed 3 feet in length and some can exceed 10 feet; 3) the Haplotaxida, covering the vast majority of the oligochaete species from all over the world; and Branchiobdellida, another closely related "leech" group that lack chaetae, have a fixed number of somites and lack the complex reproductive structures found in true leeches In addition, they typically lack the anterior sucker whereas all "true leeches" have both an anterior and a posterior sucker.

Within the order Haplotaxida, there are five families (Naididae, Tubificidae, Lutodrilidae, Lumbriculidae and Megascolecidae), with earthworms and virtually all composting worms belonging to Lumbriculidae. Within this family are several hundred species of what we call earthworms, however less than a dozen are commercially important for worm composting.

Earthworms can range in size, depending on species and maturity, from just a few millimeters (tenths of an inch) to over three meters (10 feet) for the Giant Gippsland Earthworm (Megascolides australis) from Australia.

Reproduced courtesy of Museum Victoria in Melbourne, Australia, Photographer Dr. Alan Yen. Copyright © 1998. All rights reserved.

Figure 1
Giant Gippsland Earthworm from Australia

Terrestrial (as opposed to aquatic worms) earthworms can be classified into one of three groups: litter dwellers, shallow-soil dwellers and deep-burrowers. The litter dwellers live in the thin layer of decomposing plant material (litter or floor compost) on the soil. In a forest, these worms are found just below the surface layer of leaves and twigs. The shallow dwelling worms, such as redworms, live primarily in the top 12 - 24 inches of the soil. These worms do not build permanent burrows, but tunnel randomly throughout the soil. Deep burrowing worms, like nightcrawlers, build permanent vertical burrows that extend deeply into the soil, sometimes as much as six feet. Deep burrowing worms are extremely important to the

health of the soil. Their burrows and tunnels help to aerate the soil, while the organic material they pull into their burrows helps to improve the organic content of the soil.

It is commonly believed that most native species of earthworms in North America were wiped out during the last great Ice Age, which ended about 10,000 - 11,000 years ago. This is true only where the ice sheets persisted for many centuries.

In Southern California, the story is somewhat different. Locally, we have several species of native earthworms found nowhere else in the world. Most of the earthworm species native to California have evolved here over the last 100 million years ago, making them some of our oldest residents. As climate and habitats changed, earthworms have adapted accordingly, proving themselves to be hardy, resilient survivors. The only places native earthworms fail to thrive are areas heavily affected by human development, which includes virtually all urban areas. Here, native earthworms have largely been displaced by species introduced from Europe, Asia, and Latin America. These exotic species tend to be more prolific and are better adapted to surviving in urban environments.

Most of the earthworms we see in our yards and gardens today "hitched a ride" attached to the soil of plants carried by these settlers and spread quickly throughout both North and South America. A recent study in Canada found that only two out of nineteen species of earthworms identified were actually indigenous. Locally, in the urbanized areas of Southern California, virtually no native earthworm species are present.

Research conducted by the University of California Berkeley suggests that the presence of non-native earthworm species in California is closely tied to land use and development. In undisturbed habitats, native earthworms predominate. As land use intensifies, the proportion of native relative to non-native species declines rapidly.

THE BIOLOGY OF WORMS

Without going into a lot of details, here's a quick overview of worm biology. The body plan of an earth worm is basically a segmented tube. Each segment is a separate fluid-filled compartment surrounding a central digestive tract, or gut, which runs the length of the worm's body. Many of the worm's internal organs are also segmented, occurring as separate units in each segment, but there is also considerable specialization in the head end of the worm. The "brain", "hearts" and other major organ systems are clustered in the head end. Earth worms have no eyes, but they do possess cells which are sensitive to light. This is why when worms are brought out into the light, they squirm and thrash around. Worms also don't have ears, but they can feel vibrations in the ground. While earth worms don't have lungs, they do need oxygen to survive. Instead of lungs, worms have developed the ability to absorb oxygen directly through their moist skin, which is kept moist by mucous secreting cells. If a worm dries out, it will suffocate.

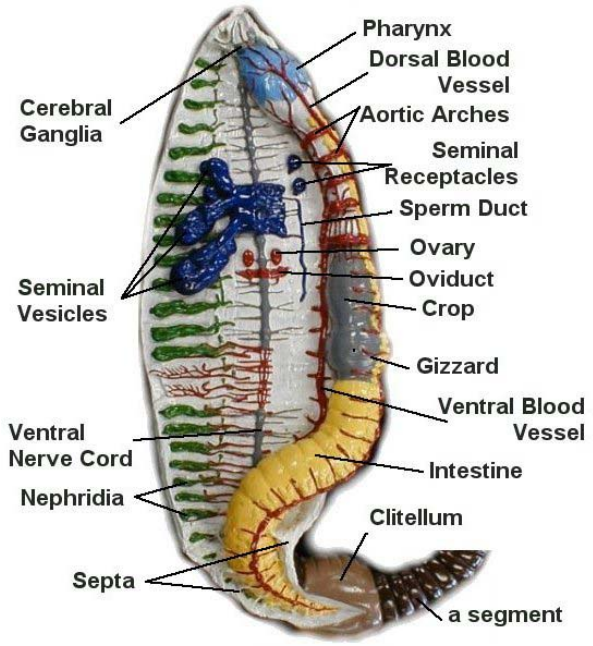


Figure 2
Earthworm Diagram

The common night crawler (Lumbricus terrestris) and redworms (Lumbricus rubellus) generally have a distinct, darker colored "head" end which contains the primitive "brain" of the animal, and this tends to be the end of the worm that travels "forward" most of the time. The "tail" end of the worm tends to be more flattened than the head and lighter in color.

Figure 3
Common Earthworm

Red worms (Eisenia fetida), a very common composting worm, are smaller, bright red and don't have a dark colored head end. All earthworms have a proper top (dorsal) and bottom (ventral) surface, they are not just

symmetrical tube-like organisms. The surface of the worm's skin is smooth and coated with mucus (which makes it feel slimy), but also has many tiny bristles or "setae" protruding from it. These help the worm move and serve to anchor it in its burrows for self defense. The setae are part of the reason that robins have such a hard time pulling worms out of the ground. If you place an earthworm on a piece of cardboard or paper and listen very carefully, you can hear the setae scraping as the worm crawls!

It is commonly believed that worms come out during a rain storm to avoid drowning, but that's not the case. Since earthworms absorb oxygen directly through their skin, they can survive for a long time in well oxygenated water. But why should earthworms crawl around on the ground surface, exposing themselves to predators?

Some researchers suggest that earthworms may be looking for different kinds of food (lots of organic matter gets knocked loose during a rain storm), while others believe that they may be looking for potential mates. The "mating theory" has been documented by several scientists, although the results were not conclusive. It appears that earthworms may be able to find and mate more easily in the moist 2-dimensional plane represented by the soil surface, than while plowing through the more confining 3-dimensional world beneath the soil.

Several researchers have also noted that most of the worms crawling around the surface tend to be large, and presumably sexually mature, members of their respective species. They noted that if there were non-reproductive benefits to being above ground when it rains, worms of all ages would be present. So, rather than being a problem to overcome, the abundant surface moisture after a rain may actually represent an opportunity for worms.

Figure 4
Earthworms Mating

Worms move by a process known as "peristaltic contraction". A worm's body is a fluid filled tube divided into separate segments. There are circular muscles that surround each segment and longitudinal muscles running from segment to segment for the length of the worm. Contraction of the longitudinal muscles shortens and widens the segments of worms body. Circular muscle contraction lengthens and narrows the segments. By alternating these processes in waves down it's entire body length the worms crawls forward or backward. Inside its tunnel, the widening of several segments serves to anchor that part of the body against the tunnel walls. The "leading end" segments are then elongated by circular muscle contraction (squeezing), pushing that end forward, and the "trailing end" is drawn up by longitudinal muscle contraction.

EARTH WORM POPULATIONS

The populations of earthworms vary dramatically with soil conditions. Usually, about 70 earthworms can live per square yard of habitat. However, most researchers estimate normal populations at a more modest 10 - 15 per square yard. Normally, earthworm populations increase from spring until late fall. During the winter, hardships take their toll and earthworm populations generally decrease, although this effect is not as severe in Southern California owing to our relatively mild winters. Each species probably has optimal soil conditions, food types and climatic conditions that will allow it to dominate the overall worm population in its preferred habitat. In addition, earthworm species can modify their habitat, creating conditions which favor that species and help it to maintain a competitive advantage over other worm species.

LIFE CYCLE

Earthworms are hermaphrodites. The term "hermaphrodite" derives from the combination of the names of two Greek gods: Hermes, a male and Aphrodite, a female. Thus, a hermaphrodite is something with both male and female characteristics. With worms, each individual contains both male and female reproductive organs. However, each worm must still mate with another worm of its species in order to reproduce. When two worms mate, they lie alongside one another, and both transfer sperm to the other. Each will lay one or more cocoons which contain the worm eggs.

Once these eggs develop, fully-formed, but very tiny worms will emerge. The familiar thickened "band" near the front end of most worm species is a structure called the

clitellum. It secretes the mucous and other substances that form the capsule containing the fertilized eggs. In nature, earthworms normally mate and lay eggs primarily during the spring and fall, when soil moisture levels tend to be higher.

However, since most Southern Californian's water their lawns and gardens throughout the spring, summer and fall, and since our winters tend to be very mild, the earthworms around your house will likely reproduce throughout the year. Earthworms usually mate and lay eggs several times each year, but produce relatively few offspring per year, perhaps only 10-15 for each adult worm. It may take the tiny worms up to a year to reach full size and sexual maturity.

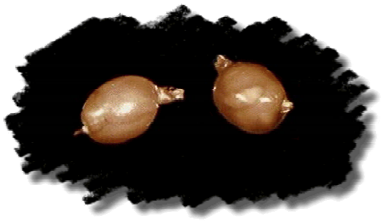


Figure 5
Red worm eggs or cocoons

How long an earthworm can live in the wild isn't certain, but researchers estimate a normal lifespan of about 3 years. Captive earthworms (in a worm composting bin) have been reported to live as long as 10 years! Earthworms can eat many kinds of organic matter, including dead plant materials (dead leaves and other plant debris), soil micro-organisms (protozoa, nematodes, bacteria, fungi, etc.), and the remains of larger dead animals.

They feed by swallowing organic matter or bits of soil containing organic matter. This passes through their gut and is finally deposited as castings (simply put - worm poop) which the worms pass out when they are at the surface. Presumably this helps them to keep their tunnels clean and open.

Earthworms also act as food for a wide variety of soil predators. Just about anything that likes a bit of animal protein will eat worms: insects, fish, frogs, toads, snakes, mice, moles, gophers, raccoons, opossums, as well as most kinds of birds. For animals that weren't originally found in Southern California, worms now occupy a very important slot in the food web.

WHERE WORMS LIVE

Earthworms can basically be divided into 3 groups, with each group preferring to live in distinct areas within the soil. These groups include:

1. Soil surface dwelling or compost preferring species
2. Topsoil dwelling species, and
3. Subsoil dwelling species.

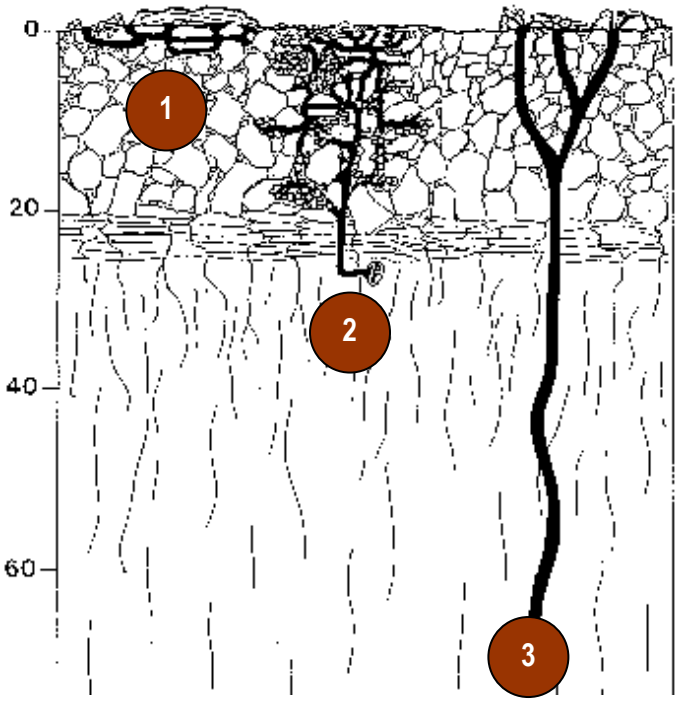


Figure 6
Preferred Burrow Depths

Soil Litter Layer or Surface Dwelling Worms

These worm species tend not to burrow deeply into the soil and prefer to live at or near the soil surface (the so-called litter layer). These worm species also tend to like living in compost bins since they like to eat material which is high in organic matter such as decaying plant material, manure and leaves. Such worm species are referred scientifically as “epigeic” earthworms, which means that they live in the superficial soil layers and feed on undecomposed plant litter. These worms are usually small and produce new generations rapidly. Examples of such

species found include the dung worm Lumbricus rubellus and the tiger worm Eisenia foetida.

Topsoil dwelling species

These species usually live in the top 6" to 12" of soil. They burrow through the soil, ingesting decaying organic material as they find it. Their burrowing action helps mix the topsoil layer and provides needed aeration. As they burrow they produce stable earthworm casts which help to improve the soil structure and they increase the soil permeability by creating cracks and channels in the soil. Such worm species are referred to scientifically as "endogeic" species because they forage below the soil surface in horizontal, branching burrows. These species ingest large amounts of soil, showing a preference for soil rich in organic matter. Endogeics may have a major impact on the decomposition of dead plant roots, but are not important in the incorporation of surface litter.

After soil has passed through the gut of a worm, the nutrients in the soil can be changed forms more accessible to plants (this is called bioavailability.) Therefore, the presence of worms usually makes the soil more capable of sustaining plant growth.

Subsoil dwelling species

These species tend to make permanent burrows in the soil which can be from 12" to more than 3' in depth. They survive best in undisturbed areas where their burrows can remain intact. Such worm species are referred to scientifically as "anecic" earthworms because they tend to build permanent, vertical burrows that extend deep into the soil. This type of worm comes to the surface to feed on manure, leaf litter, and other organic matter. Anecics, such as the nightcrawlers, Lumbricus terrestris and Aporrectodea longa, have profound effects on decomposition of organic matter and the formation of soil.

They can be particularly useful species in situations where large amounts of organic matter are left on the soil surface. In orchards for example, they help in the removal of the large number of leaves that annually fall onto the soil surface.

COMPOSTING WORMS

Although there are literally thousands of species of worms, only a few, such as the six species listed below, are used commercially for worm, or vermicomposting. These species are particularly well suited for worm composting. These types of worms thrive on just about any kind of vegetable scraps, eating as much as their own weight per day. If you provide ideal conditions, the worm population will steadily increase, doubling their numbers approximately every 40 days. Although the six species can be used for worm composting, the two most common are Eisenia foetida (Red Wigglers) and Lumbricus rubellus (Red worms). A brief description of each species is shown below.

Red Wigglers (*Eisenia foetida*)

The red wiggler is the most common type of composting worm. It can process large amounts of organic matter and, under ideal conditions, can eat it's body weight each day. It also reproduces rapidly, and is very tolerant of variations in growing conditions. Other names for red wigglers include Tiger worms, Garlic worms, Manure worms, and Brandling worms.

Red Worms (*Lumbricus rubellus*)

The Red Worm is often confused with the Red Wiggler (E. foetida), but is also a very good composting worm. In sunlight, it is a very active wriggler and is thought by many fishermen to be irresistible to fish. Red worms are very effective at aerating and mixing the soil, and consume a large amount of organic material, although less than red wigglers. These worms are commonly found in decomposing animal manure and compost piles. Other names include Redworms, blood worms, and red wiggler (but not the same as the worm described above).

Red Tiger (*Eisenia andrei*)

The Red Tiger worm makes an excellent composting worm. It is a close relative of the Red Wiggler (E. fetida) and are commonly used as a bait worm because they exude coelomic fluid, which attracts fish. These worms are very active wigglers in sunlight. Other common names include Tiger worms and Red Tiger hybrids.

Blue Worms (*Perionyx excavatus*)

Blue worms have become more popular in recent years as a composting worm. These worms do very well in warm climates, but dislike the cold. Although these worms eat fairly large amounts of organic materials and are fairly prolific breeders, they are also very sensitive to changes in their growing environment. If the conditions in the bin change only slightly, these worms have been known to leave. Other common names include Indian Blue and Malaysian Blue worms.

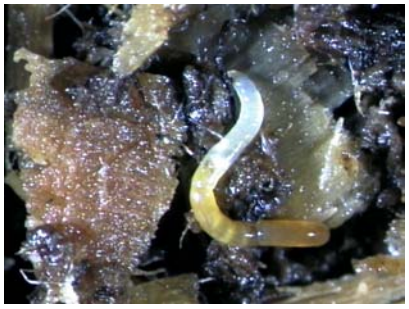
African Nightcrawlers (*Eudrilus engeniae*)

The African Nightcrawler can be a good composting worm, but is very sensitive to changes in their environment. The entire contents of some worm bins have been know to move out in less than a day if growing conditions are not to their liking. These worms also perform much better in warmer climates and are not recommended for areas where the temperature falls below 50° F. These worms do not eat as much organic materials as E. fetida, L. rubellus or E. andrei. The other common name for this worm is the giant nightcrawler.

Nightcrawlers (*Lumbricus terristris*)

Nightcrawlers are one of the most common types of worms normally found in your yard and garden. These worms are popular bait worms because they are large and easy to place onto fishing hooks, are relatively easy to raise and are relatively tolerant of variations in growing conditions. Nightcrawlers are not a particularly good worm for use in a vermicomposting bin, since they like their burrows undisturbed and prefer to eat things found on top of the soil.

White Worms (*Enchytraeids*)



You will often find many tiny white worm-like creatures, usually less than ¼" – ½" in size (10-20 mm) on the food in your worm bin. These could be mistaken for baby worms, but are actually a distant relative of earthworms called Enchytraeids. Also called "Potworms" or "White Worms", Enchytraeids will not harm your composting worms, and actually help eat and decompose the organic matter in your worm composting bin, too. In a worm composting bin, Enchytraeids can reach densities of 250,000 individuals per cubic meter of bin volume. These very simple creatures prefer acid soils, and large numbers of them may be an indication that your worm bin is acidic. They feed primarily on soil bacteria and fungi, but also eat dead organic material and small feces. They have no enzymes for digesting complex polysaccharides, and thus do not digest the organic matter they ingest. They are good for your compost system and harmless to you, your worms and plants.

TAKING CARE OF WORMS

Worms are easy to grow. They're basically vegetarians and like to eat the vegetable wastes from your kitchen, yard and garden. Worms don't eat inorganic materials, like plastic, glass or metals. Worms prefer relatively fresh, hard foods like apples, carrots and other fresh vegetables until they have begun to decompose slightly. If you feed your worms these kinds of foods, don't be concerned if it takes the food some time to disappear. It's all part of worm composting process. It does help to break or cut up hard foods in a food processor, bit it isn't required.

Worms don't have teeth, but do have mouths. They take food in through their mouths and then digest it in their gizzards. A worm's gizzard needs a small amount of grit (from soil) to grind food. That's why it's important to add a handful of garden soil to the bedding material in your bin. Numerous variables affect how much your worms will eat. For example, they are more active at room temperature than at 40°F. A general rule is that they will consume approximately ½ their body weight in food waste per day, so if you purchased 1 lb. of worms, you can expect them to consume about ½ lb. of vegetable waste per day.

Overfeeding your worms can cause odor problems. If you over-feed your worms, just stop feeding them and allow the worms to catch up. As the worm population increases, you should gradually add more food to the bin.

Table 1
Good Things to Feed Worms

Apples	Artichoke	Banana
Bean	Beet	Bran
Bread	Broccoli	Cabbage
Cantaloupe	Cake	Carrots
Celery	Cereal	Citrus Fruits*
Coffee Grounds*	Coffee Filters	Corn Meal
Cream of Wheat	Cucumber	Eggs
Egg Shells	Grapes	Grits
Honeydew	Kiwi	Lettuce
Molasses	Oatmeal	Onions ·
Pancakes	Papaya Pasta	Pears
Peas	Peaches	Pie
Potatoes	Raisins	Rice
Spinach	Tea Bags*	Tomatoes
Turnips	Waffles	Watermelon
Zucchini		

*Feed in Small Quantities Only:

While worms are not fussy eaters, there are a number of things you should avoid trying to feed your worms. These include:

1. Meat, Poultry & Dairy Products: these can produce odors and attract undesirable insects
2. Heavily salted foods: the salts from peanuts, potato chips, etc. can build-up in your worm bin, causing the worms to leave or die.
3. Manure from dogs and cats: pet feces may contain deworming drugs or antibiotics that kill worms. Pet feces may also contain harmful bacteria, like staphylococcus and streptococcus, that can kill your worms and contaminate your worm compost.
4. Animal feeds: these frequently contain antibiotics or chemical additives or ingredients that cause worms problems. Also, such feeds are generally too high in protein for worms to easily metabolize.