ELENA

Experiential Learning and Education for Nature Awareness

Project duration: 2013 - 2016

School activities with living animals based on the Tiere ***live*** approach

ELENA

Educating with living animals

The trans-european project *ELENA* with partners from Georgia, Hungary, Romania and Germany aims to support a sustainable way of living and acting during a human lifetime. Through personal experiences with living animals, the awakened positive emotions can form a link between knowledge an action and motivate children to find ways to live in more harmony with nature. It was funded by the European Comission.

Find more: **www.elena-project.eu**

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Earthworms

Activities with earthworms

Lifelong Learning Programme

Tiere live

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1. Earthworms

Although earthworms are known almost everywhere, they are not widely popular among children. Some may find them disgusting or be reluctant to touch them. By raising children's attention and interest towards this often disrespected species, students become more open and able to expand their knowledge concerning them.

The activities allow children to get familiar with these often overlooked creatures and to make direct contact with them. However, it is necessary to remember that children should make these encounters in their own pace, please do not rush them. The aim of the activities is to gain first hand experience about these animals and it is through experience that children learn.

Fundamental aims of the activities

- to learn about the life and ecology of the earthworms
- to reduce disgust and negative feelings towards these animals
- to learn about the role of earthworms in nature and in the gardens
- to raise interest
- to learn about composting
- to learn that children can make an impact on the living conditions of earthworms through their activities in the school garden

At the end of the project it is a good idea to make a survey regarding the change of their attitude and feelings towards the earthworms. This can be done through self-reflective questions (e.g. Has my attitude changed? If so, then how? etc.) or it may also be useful to ask them what they can personally do in order to protect earthworms (e.g. they do not harm them, or tell others that they should not harm them).

Through the activities children learn about the role of earthworms in the ecosystems. This way they can be more responsible when these animals are concerned . They will know that they are delicate creatures and to be handled with care.

2. Factual information about earthworms

Kingdom: Animalia
Phylum: Annelida
Class: Clitellata
Subclass: Oligochaeta
Order: Haplotaxida
Family: Lumbriciadea

The family of earthworms (*Lumbricidae*) belong to the phylum of ring worms (*Annelida*). Earthworms are abundant almost everwhere in the world except for deserts, areas constantly covered by snow or lands with a rather thin layer of soil or thin vegetation like the mountainsides. These types of areas act as natural barriers for the earthworms blocking their distribution just like salt water which most earthworms can't tolerate(Edwards és Bohlen, 1996). The number of their species in Europe can reach almost 400. The current rate of their spreading goes back to the ice age when the expansion of the ice cap pushed several species'natural habitats to the south, just like in the case of earthworms. Those that were not able to leave their original natural habitat behind went extinct. 8% of all the earthworm species in the world can be found solely in the Carpathian basin. Earthworms are commonly found living in the soil or near the surface of the soil, still there are some species which prefer to live near the water as they can easily move there.

2.1 Typical native species in Hungary

Pic.2: Common earthworm
(Photo: Johannes Bauchhenß)

Pic.3: *Octolaseum lacteum*
(Photo: Otto Ehrmann)

- common earthworm (*Lumbricus terrestris*), occurs: mainly in agricultural areas, natural forests, planted forests, range/grasslands, urban areas, wetlands. Size: 9-30 cm long. Colour: pale pink or greyish colour

- *Dendrobaena rubida*, occurs: mainly under rocks, stones and moss, but can be found in wetlands. Size: 2-5 cm.

- *Eiseniella tetraedra* is aquatic and can be found in mud or under stones in rivers, as well as in damp areas on land. Size: 2-5 cm.

- *Octolasium lacteum*, occurs: mainly on dry land containing lime (forest soil, farm land) but also in wetlands. Size: 4-16 cm

- *Lumbricus polyphemus*, largest native earthworms species in Hungary, size: 15-35 cm but can reach up to 50 cm, Occurs: mainly in mountain forests.

- *Allolobophora rosea*, light colour with some pink patches of pigmenton the body. Cylyndrical body, approximately 100-150 segments. The clitellum is flattened , the posterior region is depressed. Reproduction parthenogenetic. Occurs : mainly in green areas, in mineral soil under the organic soil. (Andrássy I. 1955)

- *Allolobophora caliginosa* one of the most common species, abundant almost in every biotope (sandy, cultivated soils, gardens, wetlands)size: 5-10 cm

- *Allolobophora dubiosa*, rare, occurs mainly in wet areas, near water. Size: 15-25 cm.

- *Eisenia fetida*, colour: reddish, brownish. Body is made up of 60-120 segments. Rarely found in soil, adapted to decaying organic material. These worms thrive in rotting vegetation, compost, and manure. Size: 3-13 cm.

- *Eisenia lucens*, occurs: mainly in the organic soil layer of decomposing wood. When irritated, the worm expels coelomic fluid through pores in its body wall, exhibiting blue-green bioluminescence

- *Fitzingeria platyura*, occurs: mainly in woodlands, size: 7-17 (Bakonyi, Juhász, Kiss és Palotás, 1995)

The average life span of the earthworms can exceed 5 years. The giant earthworms, the largest earthworms in the world are native in South America and Australia. In general they are 1 metre long but some worms can measure up to 3 metres.

2.2 Life in the ground

Earthworms are significant part of the edaphon (collective term that encompasses all the organisms living in soil). From an ecological point of view their species belong to the macrofauna providing important function in the decomposition process. Earthworms break down and recycle the matter from dead plants and animals, as well as waste products, returning it back into the soil. Worms tunnel in soil the also loosens it so oxygen can get in to plant roots. Looser soils also allow plant roots to penetrate deeper and access more resources.

Earthworms do not have a nose, ears, eyes, a tounge, teeth or a spine. Simply because in order to live in the soil they do not need them.

Their body is covered by a special, moist skin which not only protects them but also allows them to breathe. Furthermore they have some special tissues which enable them to detect light even though they cannot see. Under the skin there are two layers of muscle which it uses for locomotion, both of which run the whole length of the worm's body. This provides the animal with a long, cylindrycal tube shaped body. As these muscles can be easily contracted the body can become long and thin or short, so it can burrow through the soil even in narrow, rough spaces.

Earthworms are classified in the phylum Annelida or Annelids. Annelida in Latin means, "little rings". Their body is divided into segments which look like little rings. The front part of the first segment bears a lobe called prostomium plus the earthworm's mouth. The other parts of the earthworms are all identical in shape. The nervous system, the vessels and the digestive system extends the whole length of the body.

Segmentation can help the earthworm to move. The contractions of an earthworm's muscles resemble a wave, contracting and relaxing a few segments at a time. The process is similar to the digestive process of peristalsis. Earthworms use two different sets of muscles. Circular muscles loop around each segment, and longitudinal muscles run along the length of the body. When the circular muscles contract, the earthworm stretches, becoming longer and thinner. When the longitudinal muscles contract, the earthworm becomes shorter and wider. Each segment or section has bristles called setae.

The bristles or setae help anchor and control the worm when moving through soil. The bristles hold a section of the worm firmly into the ground while the other part of the body protrudes forward. Sequentially contracting the muscles of each segment, which can work independently of each other, enables the earthworm to move into small spaces between soil particles.

2.3 Respiration

Earthworms have no respiratory organs like lungs, they breathe through their skin. Oxygen and carbon dioxide pass through the earthworm's skin by diffusion, then in the capillaries the oxygen is picked up by the hemoglobin dissolved in the blood plasma and carbon dioxide is released. For diffusion to occur, the earthworm's skin must be kept moist. Body fluid and mucous is released to keep its skin moist. Earthworms therefore, need to be in damp or moist soil. Earthworms cannot tolerate dry, sandy areas because their skin dries out and as a result of the loss of water they can't breathe any longer. This is amplified by the increase of salt level in their body parallel with the loss of fluid (Frühwald, 1986). Meanwhile, in fresh water filled with oxygen they are able to survive without any long term damage (Frühwald, 1986). In fact, some species have got accustomed to life in water so much that they are able to live in wetlands, and areas covered with water (Edwards és Bohlen, 1996). In times of great downpour or heavy rain we can see earthworms appear on the surface of the soil. This phenomenon is caused by the low oxygen tension in the soil filled with water, so the earthworms escape to the surface, where exposure to direct sunlight can paralyze their respiration.

The dark reddish brownish colour of the earthworms is the result of the red and green pigments in their body.

2.4 Senses

Earthworms do not have recognizable eyes but they have specialised photosensitive cells especially in the front section of their body. It is with the help of these cells that earthworms can find their way in space and differentiate between dark and light. It also allows them to recognise tube like burrows. Based on observations it has been concluded that earthworms react differently to different wavelengths of light, blue light is stimulating, red light is not, so the activities of the earthworms are best studied in red light (Edwards és Bohlen, 1996).

The cells responsible to chemically sense the worm's surroundings are located in the cuticle and in the prostomium, a fleshy lobe, which seals the entrance when the worm is at rest. The earthworms can detect the quality of the food source and process the tastes of the vegetation. They can make a difference between sweet and bitter tastes and can avoid fluids that can be harmful to their skin.

2.5 Earthworms' response to pressure and gravity

The senses of earthworms have perfectly adapted to their living conditions. They can determine the location of various obstacles, can define its location in the ground, can navigate in their dark tunnels. They use their lobe, prostomium, and their mouth to feel their surrounding which can be observed when we place obstacles in front of them. They touch and feel these objects with their head through repeated scanning of the surrounding (Frühwald, 1986).

By sensing pressure they mainly react to the signals in the ground which helps them to escape from their enemies. Anyone can see how earthworms escape when we do some digging around their burrows.

2.6 Reproduction

Pic 4: Cocoons of tiger worms (Photo: Johannes Bauchenhenß)

Earthworms are generally considered cross-fertilization hermaphrodites; that is, they have both male and female sexual organs, still they have to find a partner to fertilize each other. Each adult earthworm develops a belt-like glandular swelling, called the clitellum, which covers several segments toward the front part of the animal. This is part of the reproductive system and produces egg capsules. During mating, the two worms line up facing in opposite directions, with the ventral surfaces of the anterior ends in contact with each other. This lines up the clitellum of one worm with the genital segments of the other worm. The clitellum secretes a mucous sheath that covers the anterior halves of both worms and holds them in place. They both give and receive sperms. Following copulation, the clitellum forms a cocoon for the deposition of eggs and sperm. The worm backs out of the cocoon (which is mostly mucuous and albumen) and deposits both eggs and sperm inside as it does so. As soon as the cocoon is no longer wrapped around the worm, it seals itself at the ends to protect the eggs inside. The tiny cocoon has the shape of a lemon and its colour is generally yellowish brown. It hardens and protects the eggs until they are ready to hatch which takes about 7-12 weeks but it varies in each species and depends on the temperature. Some species need only 16 days while for others it may last for 135 days. At this point the baby worms will emerge. The first food source of the baby worms is the protein rich castings of the parent.

2.7 Habitats

Earthworms are the perfect indicators of soil fertility as their occurence depends very much on soil quality. In some cases the pH of soil can also have a crucial role: for instance there are species which prefer pH value of about 5-7.5.

This chart below sums up the frequency of earthworms on various types of land on a square metre basis. Higher rate of earthworms is ususally caharcteristic on lands covered with vegtation.

Habitats	**Individuals per square metre**
Coniferous forest	10
Grain field	40
Rough pasture	80
Deciduous forest	100
Pasture	200
Clover field-fallow	250

One way to describe where earthworms live is the position of the species within its habitat. Soil-dwelling earthworms fall into three main categories: compost and soil-surface dwellers (epigeic), topsoil dwellers (endogeic) and deep-burrowing subsoil dwellers (anecic).

Surface -dweller earthworms

- feed on leaf litter, decaying plant roots or dung
- dark skin colour which acts as camouflage as they move through the leaf litter, also helps to protect them from UV rays
- typical species: *Lumbricus rubellus*

Pic. 5: Earthworms tied up in a knot in a hybernated condition (Photo: Johannes Bauchhenß)

Topsoil dwellers

- live in the the top 20 cm of the soil, root zone
- feed on soil and the organic matter in it (in case of sufficient amount of food they do not eat the parts of the vegetation)
- have some pigmentation
- typical species: *Octolasium lacteum*

Subsoil dwellers

-live in permanent vertical burrows as deep as 2 or 3 m below the soil surface which are essential for vegetation with deep roots

-feeds mainly on the organic matter of the soil or collects food from the surface and moves it into the burrow

- have low pigmentation except for the head to protect from UV rays and for camouflage

- typical species: common earthworm -*Lumbricus terrestris*

Other forms

- species living in the compost
- there are also a number of aquatic earthworms that live in semi-saturated habitats *Eiseniella tetraedra*

Earthworms absorb and lose moisture through their skin. If soils are dry like in hot summers, earthworms may move to deeper soil layers, die, or revert to a hibernation condition called diapause. Earthworms in diapause are tied up in a knot in a little hole that is lined with a slimy substance to avoid moisture loss. The ideal temperature for earthworms is between 0-5 °C degrees, this is when they are the most active. This temperature occurs mostly in autumn and spring, in winter they are mostly out of sight as they retreat to deeper layers and spend that time in areas which are not frozen.

3. Benefits

Earthworms are sometimes known as 'ecosystem engineers' because they significantly modify the physical, chemical and biological properties of the soil profile. They play a vital role in preserving the soil healthy as their activities can influence the habitat and the activities of other organisms within the soil ecosystem:

• burrowing improves soil aeration (important for both plants and other organisms living in the soil) and enhances plant root penetration. It can increase water infiltration to deeper layers of the soil

• improve the water absorption of the soil

• decompose organic material , recycle leaf litter this way incorporating organic materials into the soil and unlocking the nutrients held within dead organisms and plant matter

• nutrients like phosphorus and nitrogen become readily available for the plants

• bring minerals to closer contact with the plant roots

• they mix soil particles with organic material which is the so called clay-humus complex

• one earthworm can digest 20-30 times of its own body weight in a day and can concentrate minerals in their castings in a form that is easy for plants to absorb, these little heaps of castings can be found on the surface of the soil

• earthworm casts cement soil particles together in water-stable aggregates which can absorb water faster than soil and hold more water than the equivalent amount of soil

• the tunneling activity of worms helps breakup compacted soils and brings up minerals from deep in the subsurface that are often in short supply in surface layers

• The compost castings form aggregates or mineral clusters that are held together by mucus from the worms which acts as a „glue". These aggregates combine in such a way that they can withstand water erosion and compaction; thus, they can remedy both sand and clay soils.

Provided that approxiamtely half a million earthworms live in an area of a bit more than an acre then they can produce 50 tonns of humus in a year. If we wanted to visualize it then we can imagine 100,000 half litre coffe mugs filled with humus. On the same land earthworms can build tunnels of about 610 metre in length. These burrows can significantly improve soil drainage. In an area of a bit more than 2 acres even 2 million earthworms can live.

Pic. 6: Worm castings on the surface of the soil. The presence of earthworms is the indicator of soil fertility.
(Photo: Johannes Bauchhenß)

Earthworms are omnivorous feeding on organic matter. They prefer dead grass and leaves filled with microorganisms. Their feeding habit is in correlation with their movement. Some species specialize on leaf litter or compost. Meanwhile species living in soil rich in organic matter prefer the roots of dead plants and microorganisms inhabiting the soil, while in times of heavy rain they consume the organic matter of the soil. At nights they pull dead leaves into their burrows (one earthworm is able to take even 20 leaves in one night). Bacteria living in the soil start to break up the outer coat of leaves so earthworms can more easily digest these dead leaf parts. Food is broken down mechanically by grinding in a tough gizzard - thus even coarse gritty particles are reduced into finer ones. The useless inorganic matter goes through the worm with no change. This is often left on the surface of the ground in the form of castings. This creates humus which has a high capacity to absorb water and contributes to the mineral material of the soil. The castings of the earthworms contains five times more nitrogen, seven times more phosphate and eleven times more kalium than in the plough land or garden soil. This is due to the digestion of the earthworms, a process through which the intaken soil becomes rich in nutrients. These nutrients are already present in the soil except that they are locked up. It is through the earthworms work that they become available for plants.

Pic. 7: Plant roots following earthworm burrows in the soil (Photo: Otto Ehrmann)

It is estimated that on one hectare of field 100 tonns of earthworm castings can be found. On agricultural lands where they are more frequent they create a 0.5-1 cm thick cover of the soil. The vermicompost is neutral, independent from the pH value of the soil around, whether it is acid or alkaline. As a result of this the great number of earthworms can keep the pH value of the soil on the desired level. This valuable compost couldn't be formed if the farmer immediately collected the leaves on the ground.

The burrows made by the earthworms can go as deep as 8m into the ground. This process provides effective mixing of the soil by clearing away decomposing organic matter from the surface, adding solid substrates and increased oxygen to deeper layers of the soil, and returning nutrient-rich castings back to the topsoil layer. On one squaremetre of field 1000 burrows can be found . This soil acts as a sponge in a summer rainfall enhancing the porosity of the soil by ten times.

4. Their role in the ecosystem

Earthworms like all creatures are part of food webs, where they have a vital role. Numerous animals feed on them such as mammals (shrew-mice, hedgehogs, moles), amphibians and reptiles (toads and lizards) plus birds. On the other hand earthworms are key actors of decomposition.

5. Effects of tillage on earthworms

Early in history it was recognized that earthworms have a vital role in improving soil fertility. Back in ancient China and Egypt people knew the impact of their work in the soil, Cleopatra even banned the transportation of earthworms beyond the borders. In Egypt besides the annual flood of the Nile earthworms were cherished contributing to the blooming agriculture of the country. Aristotle regarded them as the „intestines of the earth".

In the second half of his career Charles Darwin published his last research in 1881 exploring the earthworms' behaviour and ecology. Earlier earthworms were regarded as pests, but in his book Darwin shared his findings on how earthworms take their share in healthy soil maintenance.

Modern agriculture has many hidden dangers for the earthworms like pesticides, soil compaction, tillage or ploughing. Earthworms are sensitive to these components because these disturb their lives and habitats.

In the past 30 years there have been some significant changes regarding the cultivation of lands due to the structural changes in agriculture. One of the results is erosion because of intensive farming, plus it was also a damage that areas which used to be fields earlier were turned into farming lands (for instance for growing maize or sugar beet.)

Heavy machinery deytroys the tunnels of earthworms. Soil gets contracted under the weight of the vehicles and its effect can be detected as deep as 1 metre. This all lead to the decreasing number of earthworms in the area.

We should also not forget about the great quantity of poorly aired cattle and pig manure which has a negative affect on earthworms leading to a drop in their numbers. Pesticides and herbicides poison earthworms which may end up in the birds and mammals feeding on them.

An area inhabited by earthworms may be an excellent location for organic farming. In order to increase their number it is advised to provide them with food source. Actions increasing the organic matter of soil have a positive impact on earthworms just like planting clovers in crop rotation. Farmers must remember not to exploit their land and to replace the organic matter in their garden. There are various techniques to achieve this like crop rotation, green manure etc.

6. Composting and vermicompost

Composting was already known in ancient times, however, in the age of the industrial revolution technology started to bloom and agriculture became increasingly chemical, which led to the replacement of compost. Composting has made a big comeback due to several reasons.

On one hand it has been proved that intensive farming significantly reduces soil fertility on the long run and damages soil structure. On the other hand the increasing amount of waste has become a grave cause for concern. By composting the organic waste it is possible to reduce the waste disposed in the landfill sites. What's more we gain a humuslike substance by the end of the process. Compost is a dark brown, soil like material which is really rich in organic matter providing plants with fundamental nutrients.

Pic. 8: Tiger worm (*Eisenia fetida)* (Photo: Otto Ehrmann)

A massive amount of waste produced in households (almost 30%) is biologically degradable organic matter. This usually ends up in the dumpsite where it starts to decompose emitting a significant amount of metane and carbon dioxide in the air. Meanwhile all this could be utilized through composting. By returning this material to nature and with a little care we could make use of its organic matter content and energy. There are different versions of composting such as vermicomposting at home or communal composting but could be introduced on an institutional level like in school, school gardens.

With the help of tigerworms we can turn organic waste into vermicompost rich in nutrients thus helping the growth of plants. We need only organic waste. Composting can be done anywhere, all we need is a container where worms can do their job. Plants provided with vermicompost do not need further fertilizer so we can save water, energy and landfill.

7. Protection of earthworms in the school garden

Soils are fundamental for life, they provide the medium for plant growth, habitat for many insects and other organisms, act as a filtration system for surface water and also fulfills several other roles. As long as the soil for us is not just the base onto which we build our roads and houses, but also the ground which helps us to grow our crops , vegetables and fruit then it easier to understand why it is our job to keep the soil healthy and balanced to gain healthy food.

Earthworms are the perfect indicators of the soil fertility, where it is able to reproduce plants will also bloom. Low or absent earthworm populations are a sign of little or no organic residues in the soil and/or high soil temperature and low soil moisture that are stressful not only to earthworms, but also for sustainable crop production. So it is our task to ensure the protection of the earthworm population in our school garden just like in our garden at home. Organic farming follows principles that try to minimize the disturbance in the Earth's natural balance, aiming to preserve the natural cycles of the soil along with its fertility. While working in our garden we must not forget that we need to give nature a home in our land so it is our responsibility to provide the animals living in the soil , like earthworms, with the required living conditions so they can also help us to give our plants the ideal conditions . So what can we do to reach and maintain the earthworms' optimal living conditions in our school garden?

Pic. 9: : Children applying mulches
(Photo: Iskolakertekért Alapítvány)

7.1. Mulches

Provided that we cover the beds with the necessary layer (5-10 cm) of mulches (grass clippings, field hay, straw) then we can :

- continuously supply the decomposers with nutrients
- retain soil moisture
- regulate soil temperature
- protect the surface of the soil from direct exposure to the sun thus reducing evaporation

This way we can provide favourable conditions for the earthworm population in our garden , and their beneficial effects stimulate root growth and proliferation deep into the soil to satisfy nutrient and water requirements. Mulches can help us to conserve moisture even in dry seasons when it is difficult to water , helping plants in their uptake of soil resources through their fine roots. This way we can improve soil structure, providing improved habitat for earthworms. According to experiments in soil where mulches are applied the number of earthworms is much higher in the topsoil (20 cm) than in uncovered areas.

„The positive effects of straw mulches has been confirmed by the observations in tomato cultivations where 10 cm of straw mulches were applied twice as much earthworms were to be found by the end of the season than in areas covered by plastic mulch (SCHONBECK and EVANYLO, 1998).(Pusztai Péter Phd dissertation)

The ideal materials for mulches are grass clippings, compost, spinach, field hay but do not use pine woodchip mulch because earthworms do not like it.

7.2. Farming with care

Soil management practices have an impact on the activities of the earthworms. Digging and turning of the soil can cut the channels that the earthworms carefully burrow so most of them will either die in the upper part of the soil or move deeper down in the ground. If we reduce the frequency of soil digging to 2 or 5 years then we do not disturb the burrows of the earthworms so they stay in the topsoil where they contribute to the modification of the physical structure of soils by producing new aggregates and pores, which improves soil tilth, aeration, infiltration, and drainage. To losen your garden soil it is recommended to use forks and other soil loosening tools instead of digging.

Pic. 10: Soil loosener tools in the Mozikert, Budapest (Photo : Iskolakert Alapítvány)

7.3. Cover crops and green manure

When one creates beds in a garden their aim is to meet their own needs so they control the growths of their plants in a preferably weed free land. However it will defintely lead to times in the season when there are no seeds planted in the soil , for instance tomatoes are usually planted at the end of May or it is already the end of the cucumber season in August. These are times when we should not leave the land empty because it can easily get dry, heat up and earthworms will move somewhere else where the conditions are more favourable for them. So the best is to plant some cover crops which do not only cover the surface of the soil but also will be able to help the healthy growth of our plants, just by cutting them on a field they serve as a mulch and soil amendment.

Why is cover cropping beneficial?

• reduction of evaporation: by keeping the planted beds moist they can provide favourable living conditions to the earthworms

• improved water infiltration and retention, aeration, and other soil characteristics: the soil is more easily turned or tilled than non-aggregated soil. Further aeration of the soil results from the ability of the root systems of many green manure crops to efficiently penetrate compact soils. These conditions are ideal for the earthworms and for other soil dweller organisms

• nitrogen fixation: leguminous green manures such as clover , lupins, vetch contain nitrogen-fixing symbiotic bacteria in root nodules that fix atmospheric nitrogen in a form that plants can use and also an appropriate resource of organic matter for the earthworms.

• Insect pests reduction: some types of cover crops encourage beneficial insect populations, often minimizing or eliminating the need for other insect control measure (e.g. mustard, oilseed radish)

7.4. Crop rotation

Growing the same crop in the same place for many years disproportionately drains the soil of certain nutrients. However crop rotation helps us to ensure the preservation of soil fertility thus optimizing the living conditions of the earthworms. What it means is that we grow a series of dissimilar types of crops in the same area in sequenced seasons. One kind of crop that leaches the soil of one kind of nutrient is followed during the next growing season by a dissimilar crop that returns that nutrient to the soil or draws a different ratio of nutrients. Crop rotation does not only give various nutrients to the soil but also can improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants.

7.5. Construction of vermiculture in the school garden (see in the activities)

8. Connection to curriculum in Hungary

The National Core Curriculum defines those key competences that will help learners find personal fulfilment and, later in life, find work and take part in society. ELENA projec offers the teachers such hands on activties which comply with the core curriculum and the key competences defined in it.

- basic competences in science and technology
- learning to learn
- entrepreneurship and sense of initiative
- social and civic competences
- communication in the mother tongue
- mathematical competence
- digital competence

ELENA activties support the following development goals:

- enhancing nature awareness
- environmental sustainabilty
- development of learning skills
- organisation and application of knowledge and information
- problem solving
- self reflection, self evaluation, self image
- gaining experience: collection, recording, communicating, understanding of experiences
- critical thinking
- communication
- economics
- preparation for the adult role in society

From the common, defined goals of the content areas ELENA supports:

- the development of social skills
- focusing on active participation, observation, experiments
- diverse development of social skills
- building the grounds for healthy lifestyle
- ensuring the development of creativity and self-sufficiency
-creative use of different media

General objectives that are met while doing ELENA activities:

- grounding such life style and behaviour which ensures the protection of the environment onboth individual and social level
- making students aware of the biological diversity, its beauty so that students become dedicated protectors of it
- developing ecological approach in students
- making students aware of the impact of human actions on nature and its consequences
- active participation in the protection and conservation of nature
- developing responsibility in students towards sustainable developmnet while learning about the natural resources
- helping students to be able to adapt to each other and cooperate
- development of the students' creativity and logical thinking
- ability to use various ways of gaining information
- ability to see themselves in a positive way
- development of personal competences, skills and creative skills
- development of fast adaptation to new circumstances
- get familiar with different problem solving methods
- appreciation of value creating work
- use of knowledge and information gained in other classes or from other sources
- openness towards the world of economy, eagerness to be creative, innovative and open minded

The activities rely on the students' ability to learn in an independent way based on experiential learning, which is always paired with some ativities performed by students. The process is always built on the students' own experiences.

9. Literature

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10. Internet addresses

General information about earthworms for kids -http://kids.nationalgeographic.com/animals/earthworm/#earthworm_1_closeup.jpg

Everything you need to know about earthworms: - http://earthwormsinfo.com/

The adventures of Herman - http://extension.illinois.edu/worms/

Guide to British earthworms - https://www.opalexplorenature.org/Earthwormguide

Vermiculture - http://www.wormpoop.com/composting/composting.htm

11. Contact person for further advice on earthworms (Hungarian)

Dr. Barbara Simon

Szent István University, Hungary

Email: simon.barbara@mkk.szie.hu

12. Contact people to maintain a school garden as an enterprise

Garden Organic

Address: Ryton Gardens

Wolston Lane

Coventry

Warwickshire

United Kingdom

CV8 3LG

Web: https://www.gardenorganic.org.uk/education

Email: enquiry@gardenorganic.org.uk

Schulgarten und Schulgeländegestaltung

Web: http://www.schulgarten.sachsen.de/

Email: sonnenblume.sachsen@gmx.de

In Hungary:
Iskolakertekért Alapítvány
Postal address: 1172 Budapest, Petri u. 2.
Web: www.iskolakertekert.hu
E-mail: info@iskolakertekert.hu
Contact person:
Izolda Mátyás, Nóra Pauliczky

Junior Achievement Hungary
Address: 6724 Szeged, Eszperantó utca 5.
Web: www.ejam.hu
E-mail: junior@ejam.hu
Contact person: Szilágyi Orsolya: 00 36 30 996 0359

13. NGOs doing composting

On an international level:

The European Compost Network
Address: Im Dohlenbruch 11
44795 Bochum (Germany)
Web: http://www.compostnetwork.info/
Tel: +49 (0) 234-4389447
Email: info@compostnetwork.info

In Hungary:

CSEMETE Természet- és Környezetvédelmi Egyesület
Address: CSEMETE Iroda, Szeged, Arany János utca 1. 6720
Web: www.csemete.com
Tel: 3 36 62 / 424-392
Email: csemete@csemete.com

Galgamenti Népfőiskola
Address: Galgahévíz, Fő út 106
Web: www.galga-nfi.info.hu
Tel: 06-70-3819287
Email: galgaokoinfo@gmail.com

Humusz Szövetség
Address: 1111 Budapest, Saru u. 11.
Tel: (06) 1/386-26-48
Email: humusz(kukac)humusz.hu

14. Legal information and handling of earthworms

In the EU Community legislation concerning the welfare conditions of farm animals lays down minimum standards which reflect the so called 5 freedoms:

- Freedom from hunger and thirst
- Freedom from discomfort
- Freedom from pain, injury and disease
- Freedom to express normal behaviour
- Freedom from fear and distress

15. Living animals in education

It is important to set the rules before making oobservations about the earthworms.

Key points to consider:

- remove earthworms from their natural habitat if it is really necessary
- make sure your fingers are moist when handling earthworms (erathworms' skin is moist)
- handle earthworms with care and do not cause them any harm. The shorter time it spends in the hands the better as it is really stressful for them.
- never expose them to direct sunlight because UV rays may be fatal for them.
- return earthworms to the same spot from where it was removed

Note: Provided that the earthworm does not react to external stimuli do not continue the observations with it in order to avoid damages.

In order to reduce disgust or negative feelings towards them it is best to let children have enough time. If children work in teams it is recommended to have at least one person who is not afraid to touch earthworms, so the children can slowly get accustomed to them and their curiosity gets dominant.

Always make sure that children wash their hands after working with the earthworms. Never consume earthworms (some students may want to impress others). There are numerous parazites living in earthworms so it is important to remember hygienic regulations.

In classroom observations it is better to use larger earthworms like common earthworms (Lumbricus terrestris). To present different habitats it is ideal to compare it with redworms (Eisenia fetida).

Transport of earthworms: never expose earthworms to direct sunlight. It is best to transport them in humus, moist soil or in peat. Pay attention to the tempretaure since too high temperature may be harmful to them and around 0°C they get frozen. (Frühwald, 1986).

Activities

Fundamental aims of the activities

- to get to know more about the lifestyle of earthworms
- to reduce prejudices and the feeling of disgust
- to recognise the role and usefulness of earthworms in the ecosystem
- to awaken interest in earthworms
- to learn about composting and recycling

Activities

A1 Creative writing

A2 Sizzling earthworm
simple experiment

A3 Building an earthworm habitat - How the earthworms work in the soil?

A4 School garden as a classroom
A4.1 School garden as a student company
A4.2 Searching for an earthworm habitat in the school garden
A4.3 Productive earthworms in the school garden

Appendix

App. 1 A_1 Creative writing
App. 2 Frequent earthworm species I
App. 3 Frequent earthworm species II
App. 4 Earthworm tracks in nature

A1 Creative writing

Sep Oct Nov Dec Jan Feb Marc Apr May June July Aug

Earthworms are not particularly popular animals among young people, so it is time to get familiar with them a bit more and to place ourselves in their shoes. The students' task is to write a short story, poem or a novel extract about one aspect of the life of earthworms. We can make it even more exciting by asking students to select one from the given genres. Obviuosly this list is just for orientation , can be changed in any way. It can be helpful to use the story map in Appendix 1. which gives bulletpoints to follow such as parts of the story, characters, plot, events etc. (see Appendix 1).

Grade level: any

Curriculum connection: literature, writing, ethics

Season: anytime

Competence: creativity, writing, language competency

Type of work: individual

Time: 45 minutes

Aim of the activities:

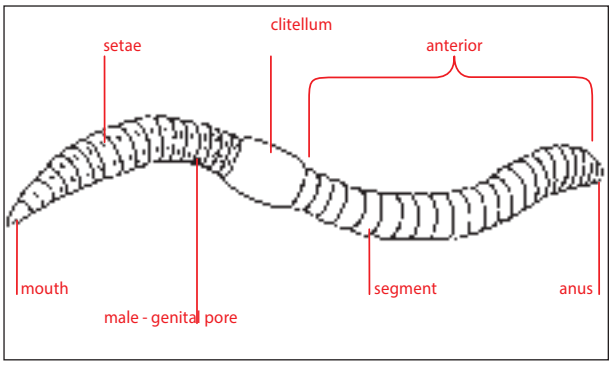
- to reduce negative feelings towards earthworms,
- to evoke empathy

Props:

- Appendix 1: Creative writing story map

Topics	**Styles**	**Point of view**
being in love	Russian classics	a chef of a restaurant
staring worm school	sci - fi	a little bird
going to a party	a young boy's diary	a Buddhist
In a restaurant	of Romeo and Juliet	an other worm
After rain	folk tales	a liar
.....	...	....

The sizzling earthworm



Pic. 11: Morphology of an earthworm (Otto Ehrmann)

4 pairs of bristles can be found on the body of a common erathworm, so when placed on a piece of paper it produces a specific sound while moving. (tigerworms are not suitable for this type of observation as they do not make that sound).

Preparation:

- place the earthworms in petri cups which are lined with wet paper towel

- to observe the earthworms making the sizzling sound place the erathworms only for a short time on the paper, then return it to the petri cup

Questions:

How do we know which is the anterior (head) and posterior (tail) of the earthworm? Observe it with a magnifier. (It moves ahead with its head - the head is always the one closer to the clitellum)

What are the most important body parts of the earthworm? How can you identify them?

What helps its movement?

(The setae help them to grasp while the muscles allow them to move in the soil. It is important to keep the animals moist!)

Sep	Oct	Nov	Dec	Jan	Feb	Marc	Apr	May	June	July	Aug

Grade level: 3-10

Curriculum connection: science, biology

Season: anytime except December, January and February

Competence: communication, science, observation, analytical

Type of work: individual

Time: 10 minutes

Aim of the activities:

- to observe the movement of earthworms

Props:

- sheet of paper
- earthworm
- Petri cup
- paper towel
- magnifier

Building an earthworm habitat
How do earthworms work in the soil?

Sep Oct Nov Dec Jan Feb Marc Apr May June July Aug

Grades: 5-10

Curriculum connection: biology, science, useful arts

Competences: communication, science, digital competence

Type of work: individual or pairwork

Time: construction 45 min, observation 3-4 weeks

Aim of the activities:

- to observe the movement of earthworms, drawing conclusions
- to learn the anatomy of earthworms
- to observe bioturbation
- to observe decomposition

It is best to have a revision about earthworms before starting to build an earthworm habitat, to review their life style, feeding habits, movement to have the necessary background information. As the activity involves a lot of props and tools it is recommended to include students in the preparation. It might be a good idea to write a list of props before the lesson and split the tasks of purchasing. It is also helpful to make an inventory before the lesson so we can make sure everything is set

Please follow the instructions and call the students' attention to them as well:

- Don't forget that you are working with living animals!
- Handle them with care!
- Use only the recommended organic material !
- Be aware of the hygienic precautions while working with earthworms !
- Don't touch your mouth or your eyes during the activity.
- Wash your hands with soap when ready!

It is recommended to follow these steps during the activity but of course these can be adapted to the actual needs and interest of the children

- Searching for earthworms: It is best to find them after a heavy rainfall in our garden or in the field. This is an optimal time to discuss the living conditions of earthworms and their needs.

Tip: Imitating earthquake. Try it in your own garden or in the school yard. The soil must be moist and loosened. Break the surface with a shovel vertically and start moving the shovel with its handle forth and back giving the impression as if there was an earthquake. Based on observations the earthworms come to the surface believing there is earthquake.

Observations: it may be good to start with the following steps in pairs or in small groups:

- observe the body parts of the earthworm with the help of a magnifier. Students can make some sketches and notes. Points to observe: anterior and posterior part of the body, number of sections, body weight, length
- observe the movement of the earthworms: muscles, movement forth and back, measure the speed
- observe what conditions earthworms prefer (dry or moist), use dry and wet paper towel
- observe if it is sensitive to light. Possible experiment: make a small paper tent and place it on a wet surface. Place the earthworm on the wet surface and observe what it does. We can see that the earthworms always move to the dark.

Optional idea: place the anterior part closer to the tent then the other way around.

- Tip: Prepare a wet glass surface where you put different obstacles. Observe their movement and how they touch and feel their surrounding.
- Collect some information about earthworms and the phases of their development. Students can even make a poster about it.

Building an earthworm habitat:

Now that the students know a lot about earthworms it is time to start building the habitat. Students can work in pairs, in small groups or individually depending on the supplies.

Preparation: move the desks and chairs in a way that students can work on the habitats. It is a good idea to cover these desks with newspapers so they do not get dirty or damaged.

Steps:

- Cut the top of the bottle, so there is a large opening at the top.
- Make holes on the bottom of the larger bottle so that excess water doesn't get locked inside.
- Place the smaller bottle in the larger one.
- Fill the gap between the two bottles with pebbles, stones and different types of soil in layers.
- Spray it with water but avoid overwatering it.
- Count the earthworms and place them on the soil.
- Place some leaves on the surface of the soil.
- Cover the top of the bottle with a net or piece of tights and a rubber band.
- Cover the side of the bottle with black cardboard so it won't be exposed to direct light.

Placement:

- Do not expose it to extreme temperature (neither cold nor hot)
- Choose a shady location.

Tasks to be performed after the construction:

- observe how the earthworms move and adapt to the different spaces
- observe how earthworms move and air the soil
- feed the earthworms (e.g with leaves) what happens with the leaves?
- spray the soil with water, but don't make it too wet
- observe the changes in the soil layers
- discuss the process of bioturbation and decomposition
- observe the habitat for some weeks
- after the observation return the soil and the earthworms to nature preferably where they were collected
- discuss the earthworms' role in the ecosystem and the impact on soil

Recommended task: After the contrsuction it may be more challenging to keep the students' attention. One solution may be the creation of a photo documentary. While making it the students appoint persons to take photos of the habitat from the same angle. This way they can follow the changes taking place there. At the end of the process they can present the pictures and discuss their observations.

Activity 4.1
School garden as a student company

Sep Oct Nov Dec Jan Feb Marc Apr May June July Aug

Grades: 4-10

Subjects: biology, science, useful crafts, geography, maths

Competences: application of knowledge in real life, communication, mathematics, digital and social competences, competences in science, learning to learn, sense of initative and entrepreneurship

Work type: in small groups

Time: between February and June or February and November

Aim of the activities:

• gain experience in managing a school garden as a student enterprise

Location: school garden and classroom

Tools:

• garden tools

• documentation for the student company program

School gardens are a wonderful way to use the schoolyard as a classroom, reconnect students with the natural world. Through gardening, we become aware how we ourselves are part of the web of life, how we are embedded in an ecosystem; in a landscape with a particular flora and fauna. Learning in the school garden is beneficial for the development of the individual student and the school community, and it is one of the best ways for children to become ecologically literate and thus able to contribute to building a sustainable future. Growing a school garden is an ideal project for experiencing systems thinking and to see how the principle of ecology operate in reality. It teaches them valuable skills such as personal responsibility, teamwork, cooperation and problem solving and it support important educational goals.

School garden as a student company is a school year long complex educational program where teachers have the opportunity to enhance environmental attitude and increase nature wareness but also to support the development of entrepreneurial skills and sense of initiative. Students are usually forced into the role of a customer where they buy and use products and services, but in this program they can become the producers and sellers themselves, which helps them to prepare for their future emlployment. In a student company students become young entrepreneurs who actually run their own business, which is the school garden here. The students have to make decisions, take responsibility and face the consequences. They do not only take care of the school garden but also manage the business. There is a long road from turning ideas to reality which requires students to fulfill various tasks applying what they learnt during the lessons thus creating real intercurricular connections.

The aim of the program is the development of the student's whole personality where students and teachers are partners and the location of education is not exclusively the school but the scope is extended.

Pic. 12: School garden stalls (Iskolakertekért Alapítvány)

Partners in the implementation (Hungary):

Iskolakertekért Alapítvány: providing the know-how of planning, creating and maintaining a school garden for the schools and teachers. The foundation supplies the teachers with methodology, the sharing of good practices and the opportunity of participation in professional workshops.

Junior Achievement Hungary: provides the teachers with the know how of the Student Company Program. Teachers can attend to a free accredited training course and remain in the network of teachers and institutes who run mini companies. The mini companies are entitled for legal financial activity for the proper management of their business.

Activity 4.2.
Searching for an earthworm habitat in the school garden

1. Create groups of four people

Assign the following areas in the school garden:

- walking path (e.g. between the beds for walking)
- bed covered with mulches in the garden
- beds not covered with mulches in the garden

2. Assign the groups to each area and ask them to measure and mark a half square meter place (use the measuring tape, rope and sticks)

3. Loosen the soil in these areas in about the depth of 15 centimeters. Look for earthworms and place them in a bowl with a little soil.

4. After 20 minutes compare how many earthworms the groups managed to find in the given area.

5. Look for correlations: where and why they found more or fewer. e.g. they are expected to find more in the area covered with mulches and find fewer on the walking path (because of the composition of the soil and the moisture in it).

6. Sum up together how the mulches help the earthworms and improve their living conditions.

7. Return the earthworms to the place you found them and and cover them with soil.

Grades: 4-10

Subjects: biology, science, useful crafts, geography, maths

Competences: application of knowledge in real life, communication, mathematics, digital and social competences, competences in science, learning to learn, sense of initative and entrepreneurship

Work type: in small groups

Time: continuous application of mulches, observation 45 min/occasion

Aim of the activities:

- to gain first hand experience regarding the living conditions of earthworms

Location: school garden

Tools:

- hand tool: cultivator/fork (1 for each group)
- hand tool: spade (1 for each group)
- small bowl (1 for each group)
- measuring tape, rope, stick (to measure and mark the area)

Activity 4.3
Productive earthworms in the school garden

School garden is a perfect place to breed and raise earthworms, so students apart from observing them can also gain fluid, good quality organic manure. In a shadier part of the garden, using a container with a hole at the bottom (even a bathtub is suitable for this) we can create our first vermi-culture. In the container we place the mixture of organic manure and soil where the earthworms can move in. It is important to avoid direct sunlight and exposure to heavy rain because these can destroy our vermiculture. Later on we can place all garden and household green waste into the container. It is important to cut them up into smaller pieces which the worms can pull down into the deeper layers. Once they consume it there, they speed up the process of decomposition, in other words composting itself. We must always keep the container moist, the best is to wet our compost bin while we water the plants in the garden. During decomposition we gain a dark brownish fluid at the bottom of the container which we should collect in a bowl or tray, it is the vermicompost. This is a concentrate so the best is to steep it with water and use it as a fertilizer or spray the plants. If we have too many earthworms during the season we can move them to other compost bins. During winter they have to be released on the compost heap well before the first frost arrives.

Grades: 3-10

Subjects: biology, science, useful crafts, geography, maths

Competences: application of knowledge in real life, communication, mathematics, digital and social competences, competences in science, learning to learn, sense of initative and entrepreneurship

Work type: in small groups

Time: continuously in the vegetation phase

Aim of the activities:

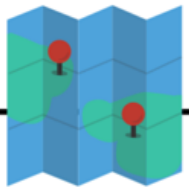
- to breed and raise earthworms in the school garden
- to make the school garden soil more fertile
- to observe the work of earthworms

Location: school garden

Tools, equipment:

- manure
- container with a hole at the bottom
- tray to hold the liquid coming from the manure
- tigerworm wiggler (can be bought in an angler shop or collected from a manure or compost heap)

Creative Writing: Story Map



Introduction

setting the time,
the place and
the environment

Characters

appearance
personality
features

Conflict

define the central conflict
smaller diturbances

Plot

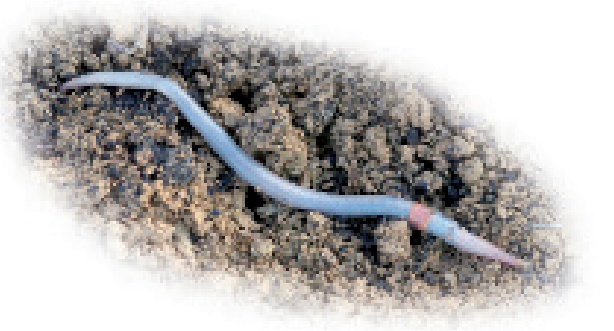
list what happens
beginning
middle
end

Solution

Frequent earthworm species I

Common earthworm (Photo: Johannes Bauchhenß)

9 – 21 – 30 cm



Octolasium lacteum (Photo: Otto Ehrmann)

~ 8,5 cm

Black- headed worm (Photo: Johannes Bauchhenß)

12 – 14 – 16 cm

Grey worm (Photo: Otto Ehrmann)

6 – 10 – 15 cm

Octolasium cyaneum(Photo: Johannes Bauchhenß)

7 – 9 – 24 cm

smallest - average- largest

observed animals

Supplementary Information for the species in the pictures

General information on earthworms with fully developed clitellum with minimum and maximum values in brackets. Below there are some details on life forms by DUNGER 1983. The same type can vary depending on its age.

Species	Life form types	Length (mature earthworms with clitellum)	Colour	Clitellum - Beginning/End of segment Nr.
Common earthworm *Lumbricus terrestris*	Subsoil dwellers ***	(9)-21 (-30) cm	dark brown, violet, ventrally yellowish	32/37
Black headed worm Aporrectodea longa	Subsoil dwellers ***	(12-)14 (-16) cm	dark brown, with a grey hue	28/35
Red earthworm *Lumbricus rebellus*	surface dweller *	(7-)11(-15) cm	reddish brown, violet	27/32
Grey worm *Aperrectodea caliginosa*	topsoil dweller**	(6-) 10 (-15) cm	grey, flesh colour, brown, yellow	28/34
Octolasium cyaneum	topsoil dweller **	(7-)9 (-12)	dirty white, light clay coloured	29/34
Octolasium lacteum	topsoil dweller**	~8,5 cm	bluish gray	30/35
Tiger worm *Eisenia foetida*	surface dweller in the compost	(5-) 8 (-12) cm	rings bright/red, characteristic stripes	26/32
Eisenia andrei (no picture!)	surface dweller in the compost	(5-)8 (-12) cm	rings dark red/violet, characteristic stripes less pronounced	26/32
Green earthworm *Allolobophora chlorotica*	topsoil dweller **	(4-)5(-7)	yellowish, greenish, flesh colour	29
the rosy tipped worm *Aporrectodea rosea*	topsoil dweller **	~4,5 cm	flesh colour	26
Chestnut worm *Lumbricus castaneus*	surface dweller*	(3-)4 (-5) cm	maroon, brownish violet, iridescent	28

* Surface dwellers: They live in areas containing high amounts of organic matter. Relatively small, agile, tend to have dark skin colour (pigmentation) (it acts as camouflage and also helps to protect them from UV rays.)They live at or near the soil surface and feed on leaf litter, decaying plant roots and bacteria, fungi and algae living on it. These earthworms do not form permanent burrows. They burrow in the ground only in case of extreme drought or cold

** Topsoil dwellers: their niche is the top 20 cm depth of soil. They form shallow burrows in the mineral soil below the surface, They have only some pigmentation and are more and less transparent. They eat large amounts of soil and the organic matter in it (bacteria, fungi and algae), although species sometimes come to the surface to search for food.

***Subsoil dwellers: „Lift worms" live in between the bottom layers of mineral soil and the top soil. They dig permanent burrows as deep as 3 m below the soil surface. They collect food from the soil surface and ingest organic matter from the soil, forming extensive burrows that extend laterally and vertically through the subsoil. They leave their burrows at night, they are relatively strongly built at least on the back. Mostly pigmented red (UV rays). They feed on leaves and residues scattered on the botom surface drwaing them into their tunnels where they eat and digest them. Following that they leave their casting on the surface of the soil.

Frequent earthworm species II

Red earthworm (Photo: Otto Ehrmann)

7 – 11 – 15 cm

Tiger worm (compost worm) (Photo: Peter Sturm)

5 – 8 – 12 cm

Allolobophora chlorotica (Photo: Johannes Bauchhenß)

4 – 5 – 7 cm

The rosy tipped worm (Photo: Johannes Bauchhenß)

~ 4,5 cm

Chestnut worm (Photo: Otto Ehrmann)

3 – 4 – 6 cm

Green earthworm (Photo: Johannes Bauchhenß)
(sehr selten)

smallest - average- largest

observed animals

Earthworm tracks in nature

Earthworm castings in a park (Photo: Otto Ehrmann)

Earthworm castings on the lawn (Photo: Otto Ehrmann)

Leaves collected by earthworms (Photo: Otto Ehrmann)

(Photo: Johannes Bauchhenß) Earthworm castings

Contsruction of straw by earthworms (Photo: Otto Ehrmann)

Earthworm constructions with open tunnels (Photo: Otto Ehrmann)