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BioBio indicator factsheet

Earthworms (Earthworms)

Refers to Chapter 6 ‘Species diversity indicators’ of the Guidebook ‘Biodiversity Indicators for European Farming Systems’

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Earthworms (Earthworms)

Description

Earthworms contribute to physical, chemical and biological soil processes, thus affecting the productivity of farms. They are key soil detritivores, essential for composting and recycling soil nutrients. They thus enhance soil fertility and contribute to soil structure (formation of stable aggregates) as well as to soil aeration and water infiltration (soil pore formation through their burrowing activities). Earthworms can be divided into three ecophysiological categories: (1) leaf litter/compost dwelling worms (epigeic), (2) topsoil or subsoil dwelling worms (endogeics) and (3) worms that construct permanent deep stable burrows through which they visit the surface to obtain plant material for food, such as leaves (anecic).

Earthworm abundance and diversity is a **state indicator** and over time it can be used as a **change indicator**. Earthworms respond sensitively to land management practices, correlate with beneficial soil functions and are frequently used to assess soil quality. They can allow comparison across spatial scales, both between habitats within farm, and between farms of a region. Wider comparisons could, however, be less efficient given the lack of pan-European surveys, database and distribution maps.

Surveyor skills

Surveyors do not need any specific expertise for field sampling but they must know how to use a handheld GPS. They must also have good eyesight and be in good physical condition, especially for the transport of water tanks across fields and for soil digging (see below). Given that reliable species identification is mostly based on internal anatomy, this has to be undertaken in the lab by taxonomic experts. Adults can be specified at species level, for juveniles this is generally impossible. It would only be possible to identify earthworms in the field at morphospecies level after intensive surveyor training.

Data collection method

A combined method should be used to extract earthworms, namely extraction with an expellant solution and hand-sorting from a soil core[1].

Equipment: 30-L tank, 2-L bottle, labelled sample containers (~ 100 ml), metal frame (30 cm x 30 cm x ~20 cm height), scissors, tweezers, expellant solution (AITC: allyl-isothiocyanate), spade, graduated rulers, white plastic sheets, household rubber gloves, small trays, alcohol (ethanol), plastic tool box (~60L).

Sampling location: Sampling is undertaken in each of the habitat types identified on the farm during the habitat mapping, i.e. one habitat/field plot per habitat type. In habitat/field plots of areal elements, 3 samples are haphazardly located 20 meters apart from the border of the habitat/field plot and 10 meters apart from each other. In linear elements, the 3 samples are taken along a line in the middle of the habitat and 10 meters apart from each other.

Sampling procedure: After cutting the vegetation with scissors at ground level (avoid too much tremor if possible), a 2-litre AITC solution (0.1 g/l) is poured twice at 5 minute intervals into the metal frame (driven into the ground to a depth of approximately 1-2 cm to prevent the chemical from running off the sampling site). Earthworms appearing on the surface

Allolobophora chlorotica(top left), Octolasion cyaneum (top right), Lumbricus friendi (left)

during a 10-minute period are collected. Then a soil core of 30 cm x 30 cm x 20 cm deep is extracted and placed on a white plastic sheet, where earthworms are hand sorted from the soil for 20 minutes by one person (time could be increased for clay-textured soils, and reduced for sand-textured soils).

Notes: Prepare AITC solution shortly (not more than 4 hours) before fieldwork to prevent loss of irritating activity. First dilute AITC with ethanol 70% to give a 5 g/l solution; then dilute this solution with water to reach a concentration of 0.1 g/l. If lower than 20 cm, soil depth is noted.

Specimen preparation and identification: Collected specimens are put in containers with cold water to carefully clean from dirt and AITC solution. Within one week of sampling each sample should be processed; meanwhile samples will be kept wet in the fridge at 3-5 C°. If earthworms are going to be identified by an external taxonomist, fixation is needed either with 70-80% ethanol (and fridge) or 4% formalin solution. In the latter case, because of the toxic hazard of formalin, earthworms should be transferred to ethanol for further manipulation during identification.

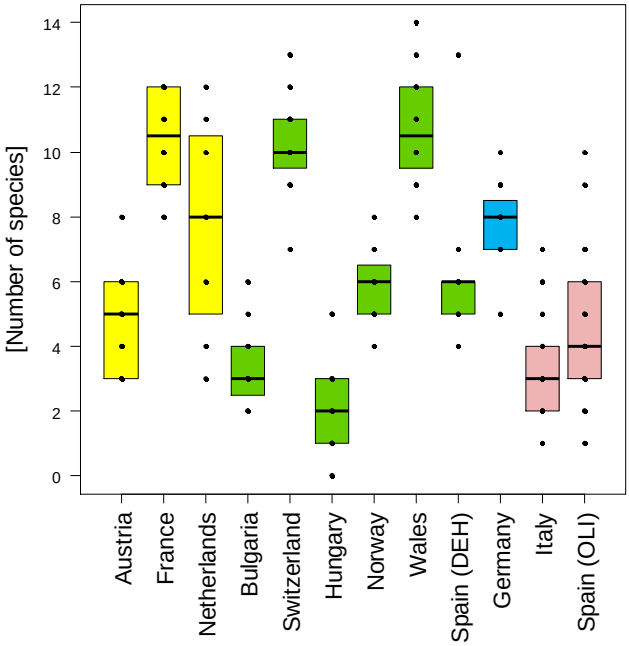
Sampling date: One sampling time during cool and wet seasons (e.g., spring and/or autumn).

Calculation method

The basic comparator is the total number of species per habitat. This can be used to represent the number of species per farm or geographic region for general comparisons at each of these spatial scales and over time by aggregation of the number of species found in habitats. Estimates of the species richness of farms can be calculated from the species lists obtained for habitats (gamma, alpha, area weighted, rarefied and Chao estimated richness). In addition, earthworm individuals can be weighed and counted to be expressed per square meter, which can also be used as an indicator of soil health. In this case juveniles should be included.

[1] Dennis P. et al. 2012. Biodiversity in organic and low-input farming systems ALTERRA Report 2308.

Process of sampling earthworms by chemical extraction and further hand-sorting of dug soil



Distribution of indicator 'Earthworms'
Each point displays the indicator value of a farm. Farms are grouped in the respective case studies. Yellow: field crops & horticulture in Austria, France and the Netherlands, green: specialist grazing livestock in Bulgaria, Switzerland, Hungary, Norway, Wales and Dehesa in Spain, blue: mixed crops & livestock in Germany, pink: permanent crops in Italy and olives in Spain. The colored box contains the values of 50 % of the farms of a case study. The line marks the median.

Synergies with other indicators

There is a relationship with the indicator farm gamma species richness of 'Vascular Plants' (in 3 of 12 case studies), of 'Spiders'(in 4 of 12 case studies) and of 'Wild Bees and Bumblebees' (3 of 12 case studies). In most of the farms, earthworm species richness was not significantly correlated to indirect management indicators recorded at farm level except for the indicators 'Field Operations' in Germany and the olive plantations of Spain, and 'Pesticide Use' in the olive plantations of Spain. Remarkably, the earthworms species richness was positively correlated to the sub-indicator 'Diversity of Linear Habitats' in 4 case studies.

Estimated effort and costs (labour effort required, analysis)

Earthworms are a rather time-consuming indicator, although skilled staff are not necessary for sampling. Overall, the earthworm indicator was the second most expensive (after spiders). Sampling took 3.8 hours per habitat/field plot, ranging from 12 to 70 hours per farm (depending on farm complexity, soil texture and in-farm car mobility), and cost around 100 € per habitat and 900 € per farm (a wide range for European countries, from 200 to 2600 € per farm in Bulgaria and Holland, respectively). Costs for taxonomic identification by external specialist can be considerable.

Earthworms change as an indicator

About 430 species of earthworms (Annelida, Oligochaeta) have been described in Europe. Earthworm populations depend on both physical and chemical properties of the soil, such as soil temperature, moisture, pH, salts, aeration and texture, as well as available food, and the ability of the species to reproduce and disperse. Earthworms are sensitive to most soil management practices (from machinery operation that cause soil compaction to ploughing), crop patterns (these affect soil cover, soil water content, soil structure and organic matter content), application of chemicals (fertilizers and pesticides), manure/compost/green manure applications etc. Indeed, most of the larger species (over 18-25 cm long) have disappeared from cultivated areas and to a high percentage are only found in woodland and unimproved grassland. This is mainly due to high predation rates occurring after tillage operations and due to decreased leaf litter and soil organic matter.

Consequently, earthworm abundance and species richness are considered suitable indicators for farm practices (e.g. tillage practice, pesticides) and derived consequences (e.g. soil structure or compaction, heavy metals). Moreover, earthworms can live in litter, soil, wet mud, submerged mud, organic manure, composts, dung, under bark and on rotten wood, and most earthworm species are adapted to a particular habitat. Finally, earthworms form the base of many food chains (e.g. ground beetles, snails and slugs, birds, mammals), and the activity performed by earthworms allows the soil to reach a condition that hosts many other sorts of organisms. This, in turn, means the supply of a greater amount of resources for higher above soil trophic levels, thus contributing directly to the enhancement of overall biodiversity of agroecosystems.

Interpretation

A change in indicator value (change in state) can reflect (i) reduced soil litter and soil organic matter caused by soil ploughing, application of pesticides and herbicide, loss of soil biological fertility (microorganism abundance) etc.; (ii) increased soil compaction caused by machinery use and/or high stocking densities of livestock. Favourable changes in this state indicator may indicate an increase of the organic matter content and recycling, soil health and overall soil biodiversity caused by the shift from mineral to organic fertilisation, maintenance of non-ploughed and/or non-productive habitats (e.g., linear elements, grasslands in arable farms), conservation of wet areas.

Strengths and weaknesses

The use of earthworms as an indicator is straightforward, repeatable and easy to carry out. It can be performed without special expertise. It gives few opportunities for sampling biases caused by human error. Simple tools are required and each plot has to be visited only once. Double sampling (expellant + hand sorting) allows a good approximation of the whole earthworm population. Apart from information about biodiversity, it gives information on soil health, and earthworms are a highly appreciated animal group by stakeholders.

However, the need to handle AITC in the field calls for attention and poses personal safety issues. Carrying water to more remote sites is a disadvantage due to the weight. Finally, AITC solution infiltration is difficult on steep terrain, and in clayish and/or very wet soils. AITC is also ineffective where a thick litter layer is present.

Additional weaknesses of earthworms as an indicator are: (i) earthworms are generally not present in stony and sandy soils; (ii) in Mediterranean countries, communities are very fragmented and only locally present; (iii) earthworm classification and nomenclature is still under discussion and more taxonomists are needed; (iv) poor knowledge of distribution at national level; (v) non-existence of earthworm species in red list or national/regional catalogues of protected species.

This factsheet is part of the Guidelines **Biodiversity Indicators for European Farming Systems**.
More detailed information on the set of indicators developed in the EU FP7 research project BIOBIO (Biodiversity indicators for organic and low input farming systems, KBBE-227161) is given in a printed report, published as ART Publication Series Nr. 17. The report can be downloaded from the BIOBIO website.
Printed versions can be ordered at www.agroscope.admin.ch or at Agroscope, Reckenholzstrasse 191, 8046 Zurich, Switzerland

BIOBIO Indicator Factsheets

Genetic diversity	
Breeds:	Number and amount of different breeds
CultDiv:	Number and amount of different varieties
CropOrig:	Origin of crops

Species diversity	
Plants:	Vascular plants
Bees:	Wild bees and bumblebees
Spiders:	Spiders
Earthworms:	Earthworms

Habitat diversity	
HabRich:	Habitat richness
HabDiv:	Habitat diversity
PatchS:	Average size of habitat patches
LinHab:	Length of linear habitats
CropR:	Crop richness
ShrubHab:	Percentage of farmland with shrubs
TreeHab:	Tree habitats
SemiNat:	Percentage of semi-natural habitats

Indirect management indicators / parameters	
EnerIn:	Total direct and indirect energy input
IntExt:	Intensification/Extensification - Expenditure on inputs
MinFert:	Area with use of mineral nitrogen fertiliser
NitroIn:	Total nitrogen input
FieldOp:	Field operations
PestUse:	Pesticide use
AvStock:	Average stocking rate
Graze:	Grazing intensity