

The importance of earthworms in agricultural systems

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Overview

- Earthworm species and ecological groups
- Factors controlling earthworm distribution
- How do earthworms improve soils?
- Results from recent studies
- Q & A

How many species of native earthworms are there in the UK?

- 27 species
- All in family Lumbricidae
- All re-colonised from continental Europe after the last glaciation
- Molecular evidence suggests there are some “cryptic” species but these are morphologically indistinguishable
- A few non-native introduced species but not widespread

Ecological groups (1)

- Topsoil dwellers (Endogeics)
 - Live in top 10 – 15 cm of the mineral soil
 - Feed on soil
 - Non-permanent horizontal burrows
 - Most usually cast in the soil
 - Pale grey, pink, yellowy/greenish in colour
 - Length = approx. 3 cm to 10cm
 - 12 species
 - Occur in grasslands and woodlands

Green worm (green form)
Allolobophora chlorotica



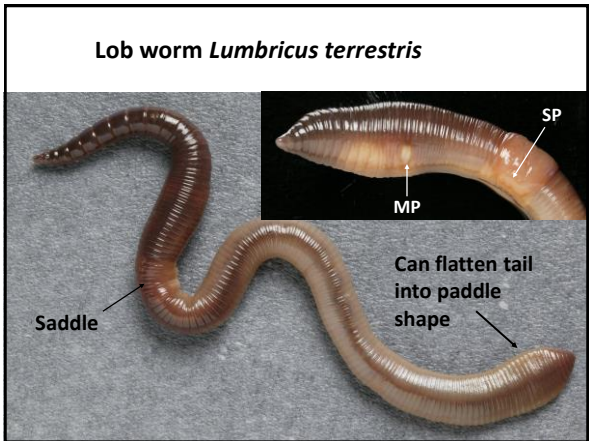
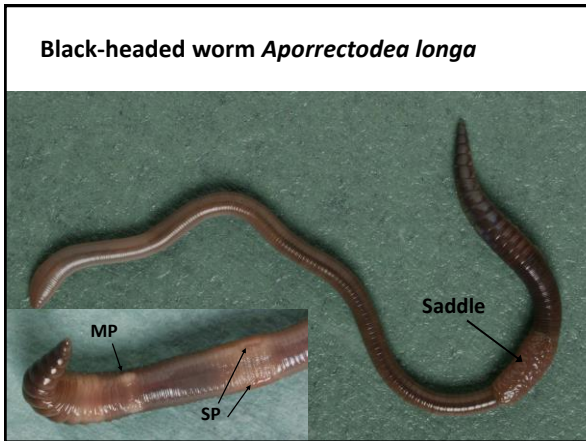
Green worm (pale form)
Allolobophora chlorotica





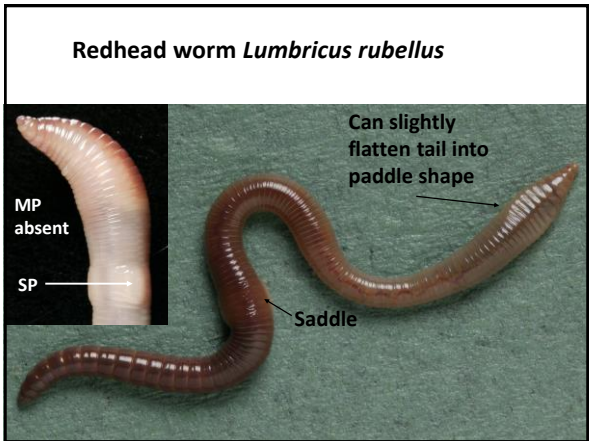
Ecological groups (2)

- Deep-burrowers (Anecics)
 - Permanent vertical burrows (up to 2 m depth)
 - Feed on leaf litter at the surface
 - Cast on the surface
 - Dark red or purple in colour on upper surface
 - Length = approx. 10 cm to 14 cm
 - 2 species
 - Occur mainly in grasslands



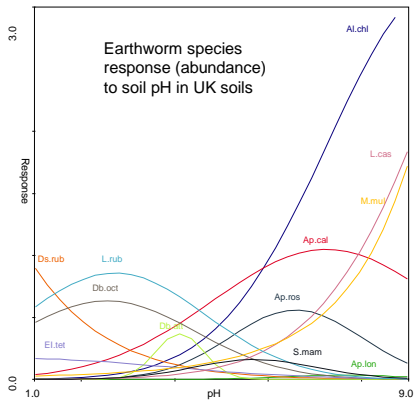
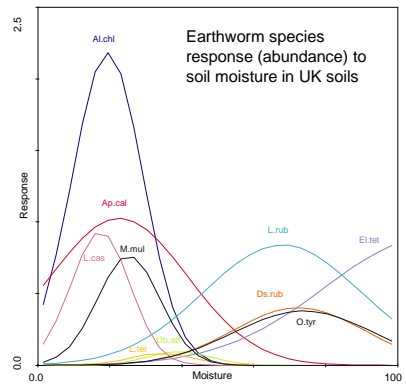
Ecological groups (3)

- Leaf litter dwellers (Epigeics)
 - Live in leaf litter and humus layer at soil surface
 - Do not enter the mineral soil
 - Feed on leaf litter
 - Cast in leaf litter and humus layer
 - Dark red in colour on upper surface
 - Length = approx. 3 cm to 8cm
 - 12 species
 - Occur predominantly in woodlands



The three main factors controlling earthworm distribution

- Vegetation cover
 - grassland vs. woodland + leaf litter
- Soil moisture
- Soil pH



Why are earthworms important?

- The most abundant animal biomass in temperate soils
- Ecosystem engineers
 - not all species are equal: “drivers and passengers” hypothesis
 - moving earth changes 3D soil architecture
 - earthworms are drivers of some key ecosystem functions and services
- Support biodiversity
 - create niches for other organisms
 - food source for many other animals

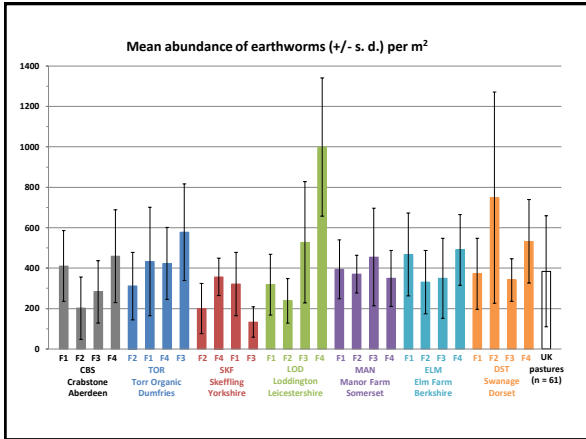
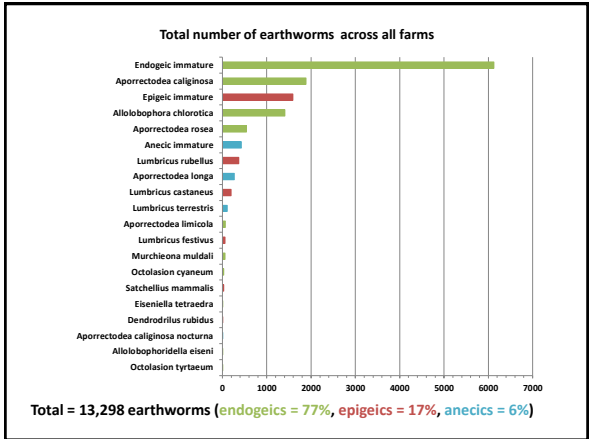
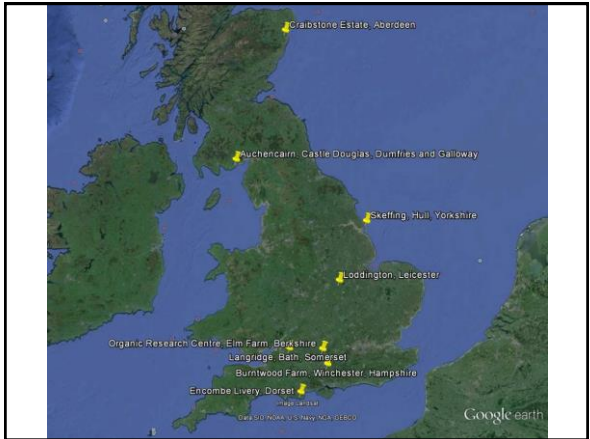
Catalyst of major ecosystem services

- Soil formation
 - casting brings soil to the surface at a rate of about 40 t ha⁻¹ year⁻¹
 - adding about 0.4 mm soil depth year⁻¹
- Soil structure
 - earthworm burrowing, feeding and casting improves soil structure, porosity, aeration and water infiltration, and decrease soil bulk density
 - earthworm abundance is positively correlated with infiltration rate and soil moisture levels
 - earthworm abundance is negatively correlated with surface runoff and soil erosion
- Nutrient cycling (via decomposition)
 - earthworms eat dead leaves, decayed vegetation or soil containing tiny plant fragments
 - increase surface area of dead plants on which microbes can act
 - earthworm casts are rich in nutrients (nitrogen, phosphorous, potassium, calcium and magnesium) – more easily absorbed by plants

How do earthworms stimulate plant production?

- Increasing nutrient availability
- Improving soil structure
- Production of plant-growth regulating substances
- Stimulation of microbial plant symbionts
- Bio-control of pests and diseases

Research findings



van Groenigen et al, *Scientific Reports*, vol. 4, article No. 6365, published 15 Sept 2014

OPEN Earthworms increase plant production: a meta-analysis

SUBJECT AREAS: ECOSYSTEM SERVICES, AGRICULTURE

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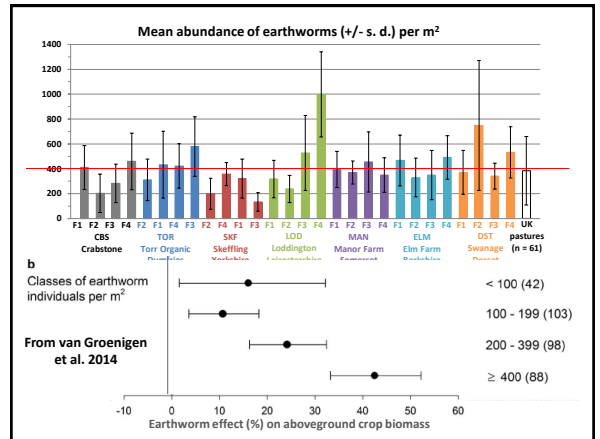
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To meet the challenge of feeding a growing world population with minimal environmental impact, we need comprehensive and quantitative knowledge of ecological factors affecting crop production. Earthworms are among the most important soil dwelling invertebrates. Their activity affects both biotic and abiotic soil properties, in turn affecting plant growth. Yet, studies on the effect of earthworm presence on crop yields have not been quantitatively synthesised. Here we show, using meta-analysis, that on average earthworm presence in agroecosystems leads to a 20% increase in crop yield and a 23% increase in aboveground biomass. The magnitude of these effects depends on presence of crop residues, earthworm density and type and rate of fertilisation. The positive effects of earthworms become larger when more residue is returned to the soil, but disappear when soil nitrogen availability is high. This suggests that earthworms stimulate plant growth predominantly through releasing nitrogen locked away in residue and soil organic matter. Our results therefore imply that earthworms are of crucial importance to decrease the yield gap of farmers who can't or won't use nitrogen fertiliser.

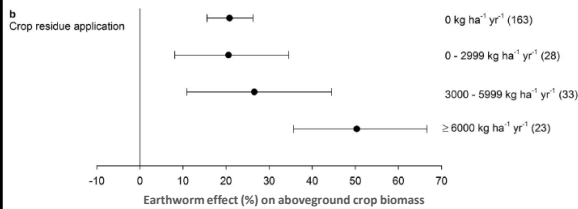
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Earthworms and plant production (meta-analysis by van Groenigen et al. 2014)

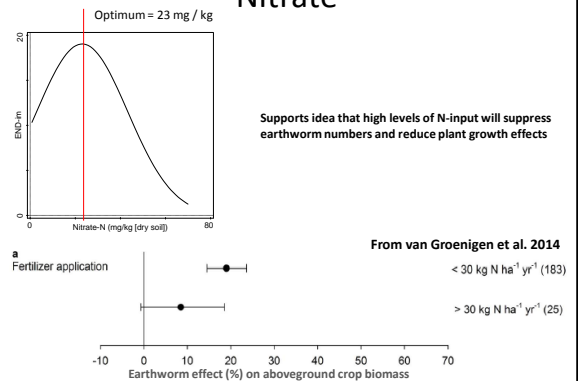
- Earthworm presence leads to:
 - 25% increase in crop yield
 - 23% increase in aboveground biomass
 - 20% increase in belowground biomass
- This positive effect of earthworms:
 - is across all grain crops
 - is across all pasture grasses
 - occurs for all three earthworm ecological groups
 - is generally dependent on earthworm abundance
 - but the effect is less in legume crops



Crop residue application From van Groenigen et al. 2014



Nitrate



Summary

- Earthworms can greatly improve crop yield
- Earthworms most effective with >400 individuals / m²
- Earthworms respond +ve to Phosphorus, pH, Calcium, % clay
- Humped response to Nitrate, total carbon, temperature, soil moisture
- Negative response to Ammonium, % sand
- Probably biggest effect of earthworms on plant production is due to improving N-availability to crops
- However, too much N-fertiliser probably causes earthworm decline (but we don't yet know what that critical amount is)
- The N that earthworms release comes mostly from dead plant residues
- Find best balance between N-fertiliser and plant residues

How to increase your earthworm populations

- Lots of plant residues and organic matter
- Reduce deep ploughing (zero till is best)
- Keep N-levels low to moderate but not too high
- Higher pH
- Soil moisture: not too wet, not too dry
- Clay soils better than sandy soils
- FYM better than inorganic N