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The role of earthworms in

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Earthworms have a reputation as soil builders and renovators, particularly among ‘organic’ farmers and gardeners. They improve soil fertility through increased aeration, aggregation, water infiltration and release of nutrients from organic matter. However, the benefits of earthworms in the wheatbelt have been doubted for many years because of their poor survival in cultivated soils.

Native and introduced earthworms

There are both native and introduced earthworms in the Western Australian wheatbelt. Since cropping began in the Western Australian wheatbelt over 100 years ago, the physical condition of many soils has deteriorated. The primary causes of soil degradation were the European cultivation practices used by farmers and the trampling effect of introduced animals, in particular, sheep.

There are also earthworms that only live in composts, leaf litter and animal dung, for example, Eisenia fetida also known as the tiger or common compost earthworm. Unlike the other types of earthworm, these earthworms have little potential for persisting in wheatbelt soils.

Native species

Species of native earthworms are adapted to their native vegetation and are rarely found in soils used for agriculture.

Earthworm species

Of the 3000 species of earthworms in the world, there are species adapted to all soils types. Each species usually conforms to one of three basic lifestyles.

• Some species form permanent vertical burrows several metres deep and come to the surface to feed on decaying litter. These species provide deep soil aeration and quick water drainage if there is heavy rain. Over many years, they mix the subsoil with the topsoil and they also increase the breakdown of soil organic matter and the release of nutrients for plant use.

• Other species move throughout the soil, eating it and decomposing organic matter, and rarely come to the surface. These species usually fill the burrow behind them with their excrement (called casts), so they improve soil aggregation but create fewer macropores than the first type of earthworms.

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Earthworms in the wheatbelt

Native worms have been found in the soil beneath native woodland in the Dragon Rocks Nature Reserve, south-east of Hyden. Up to 416 earthworms per square metre have been measured in areas that receive water run-off from surrounding granite outcrops, however, under normal rainfall conditions the populations are much smaller (20 to 60 per square metre). These...
An extensive survey of the wheatbelt in 1979 found that the most common species were *Aporrectodea trapezoides* and *Microscolex dubius*, with the latter more common in the fine sandy surface soils of the southern wheatbelt. *Aporrectodea trapezoides* originates from Europe, and when mature is 9 to 11 cm long and dark brown. *Microscolex dubius* is native to up to 19 g. This earthworm forms burrows to a depth of 2 m. These burrows branch in the topsoil, enabling the earthworm to explore a large surface area of soil without venturing too far from the safety of its deep vertical burrow. Unlike most native earthworms, numbers of *M. imparicystis* are largest in established pastures.

**Introduced species**

Exotic earthworms have colonised large areas of the wheatbelt since European settlement. These earthworms could have been accidentally introduced around homesteads from the soil of introduced pot plants.
In experiments conducted between 1987 and 1990 on a grey sandy loam near Quairading, introductions of *A. trapezoides* and *M. dubius* greatly improved the soil surface structure; in one case, the yield of wheat was increased by 62 per cent. Significant increases in macroporosity and water infiltration were also measured in clusters where *A. trapezoides* occurred without recent introduction.

Earthworm numbers

The more earthworms there are in a soil the greater the improvement of soil fertility. Earthworms are not evenly distributed throughout a paddock.

The average density of earthworms in a brown sandy loam soil beneath a seven-year-old clover pasture near Quairading was between 14 and 51 per square metre. The worms were in small clusters of up to eight worms in an area with a diameter of about 30 cm. This density, 113 per square metre, probably represents the maximum for earthworms in this and similar wheatbelt soils.

The numbers of *M. dubius* can change rapidly because of its high reproductive potential. At the Department of Agriculture's Newdegate Research Station for example, only a few native earthworms were found in the winter of 1986 in a sandy soil next to a fence. The soil was resampled in the following winter, a few months after the weeds had been killed with herbicide. As before, a few native earthworms were found but the density of *M. dubius* was 114 per square metre. Some unidentified juveniles of *M. dubius* were present at the previous sampling and after feeding on the decaying weeds, they multiplied rapidly.

Effects on soil structure

Earthworms can make dramatic improvements to soil structure.

In experiments conducted between 1987 and 1990 on a grey sandy loam near Quairading, introductions of *A. trapezoides* and *M. dubius* greatly improved the soil surface structure; in one case, the yield of wheat was increased by 62 per cent. Significant increases in macroporosity and water infiltration were also measured in clusters where *A. trapezoides* occurred without recent introduction.
In a brown sandy loam beneath a wheat crop, also near Quairading *A. trapezoides* increased the macroporosity of the topsoil 37 times within one winter season; consequently, the water flow into soil was greatly improved (see photos on page 161). These effects were limited to small areas where the earthworms had been active, but if managed correctly, the worms could spread to the whole paddock with time.

**Survival and spread**

Many factors influence earthworm survival and spread.

*Soil density and moisture*

The ability of earthworms to colonise a soil can be limited by high soil density and/or low soil moisture. An experiment was conducted on a medic pasture near Quairading, to assess the growth of adult and juvenile earthworms of *A. trapezoides* and *M. dubius* introduced at the beginning of winter, 1989.

At the end of the second winter after introduction, eggs of both species were recovered but no earthworms were found. Each adult *A. trapezoides* produced up to eight eggs, of which three-quarters failed to hatch in the second winter. Only a few *M. dubius* juveniles grew to maturity and produced eggs in the first winter. The poor persistence of the worms in this experiment may be related to the high soil density, which limits the earthworm's ability to burrow down to the subsoil. It seemed the earthworms and eggs did not survive in the topsoil during summer, where soil temperatures were high and moisture content was low.

The rate of earthworm population growth will be slow if there is a succession of short or intermittently dry growing seasons. Short seasons reduce the time favourable for earthworm feeding and reproduction.

*Food*

The quality and quantity of food in the soil can also influence the growth and survival of *A. trapezoides* and *M. dubius*. In laboratory studies, these species preferred activated sewage sludge to composts containing sheep
manure, wheat or lucerne straw. Poor earthworm persistence can be expected in soils with low organic matter contents.

Fungicides and insecticides
Some fungicides and insecticides kill earthworms. Herbicides and fertilisers are often blamed for earthworm decline, but both can improve their survival. Herbicides reduce the need to cultivate soils for weed control and fertilisers increase plant growth and soil organic matter content.

Reproductive rate
The earthworms *A. trapezoides* and *M. dubius* produce eggs without mating. This is an advantage for colonising new soils because earthworm numbers in wheatbelt soils are low and mating is not likely. *Aporrectodea caliginosa* is a close relative of *A. trapezoides*, but is not found in wheatbelt soils, probably because it must mate to produce eggs.

The rapid growth rate, high fecundity and egg capsule viability of *M. dubius* explain the population explosions that can occur with this species. Under ideal conditions, hatched juveniles of *M. dubius* reach maturity and produce eggs within four weeks, while juveniles of *A. trapezoides* take about twice as long to produce eggs.

Ecotypes
Earthworm populations from different areas of the wheatbelt (ecotypes) differ in their reproductive potential and their ability to colonise soils. Laboratory studies have demonstrated differences between *A. trapezoides* ecotypes in their rates of growth, egg production and egg viability, and the proportions of normal juveniles to deformed juveniles. Up to 13 per cent of juveniles are deformed, often with two tails or heads, and do not survive to become adults.

At present, we do not know which ecotypes are most suitable for specific soils, however, those with high reproductive rates are likely to colonise a soil quickly. In long season areas, such as the south coast, the reproductive differences between ecotypes are probably less important.

It is possible that ecotypes may also be adapted, such as winter temperature, soil pH or salinity level, to other factors that may limit worm growth and survival.

Maximising earthworm benefits
If undisturbed, earthworm burrows can persist for many years in the soil. For the benefits of earthworms to extend beyond the small areas of a paddock where their numbers are high, minimal soil disturbance is critical. Tillage and excessive sheep trampling destroy the macropores created by worms and limit the spread and survival of earthworms.

Some tillage may encourage earthworm populations. Minimum tillage is compatible with *A. trapezoides*, whose eggs are usually found 10 to 12 cm below the soil surface. Observations on a brown sandy loam near Quairading showed that *A. trapezoides* activity was associated with areas where wheat straw had been tilled into the top 5 cm of soil. Tillage to this depth incorporates organic matter that can decompose in a moist environment, thus making it a suitable food for earthworms.

*Microscolex dubius* is particularly well suited to exploit organic matter recently incorporated into the soil because of its fast reproductive rate. Unfortunately, the eggs of *M. dubius* are found mostly in the top 5 cm of soil and tillage may reduce its survival.

Low stocking rates and the retention of a mulch layer help protect the soil surface from animal damage.

Planned introductions of earthworms
Given that *A. trapezoides* and *M. dubius* were introduced and spread by chance, there is potential for introducing other species that have a high capacity for improving soil fertility. However, much more research is needed to locate and assess these species.

Undoubtedly, planned introductions of *A. trapezoides* will accelerate its spread and benefits, especially because its reproductive rate seems slow. *Aporrectodea trapezoides* and *M. dubius* have been successfully bred in the laboratory on sewage sludge in soil. If this food source could be safely applied to a field, then breeding and introduction may be possible on a large scale.

There is a need to develop methods for introducing earthworms on a paddock scale. In other countries, clods of soil containing earthworms are removed, usually from a pasture, and placed on the soil surface where the earthworms are required. Important considerations for this method are:
• ensuring that earthworms are not exposed to dry conditions during introduction and for as long as possible after introduction

• minimising damage to earthworms caused by crushing in the soil clod

• ensuring that the paddock into which earthworms are introduced has an adequate supply of nutritious debris such as leguminous straw.

The best ecotypes for introduction are probably those near the site of introduction, because they have had the most time to adapt to local conditions.

Conclusions
In general, the cultivation of soils for agriculture has drastically reduced the distribution of native earthworms.

Introduced earthworms improve the fertility of many wheatbelt soils, however, they tend to cluster in small patches in paddocks.

High soil density, high stocking rates, low soil moisture, low soil organic matter content, and tillage limit earthworm growth and reproduction.

The adoption of low stocking rates, stubble retention and minimum or zero-tillage can encourage the spread of earthworms.

There is potential for introducing other exotic earthworms to further improve soil fertility. However, further research is needed to understand the ecology of these species and to develop methods for their large scale production and introduction.

Further reading


