A Preliminary Survey of Earthworms in the Varteg Soils

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This is an account of a preliminary survey for earthworms, carried out over 2 days (26/27 July 2010) by volunteers. The soils of some compartments of the tree planting scheme on the Varteg Hill, Torfaen, Monmouthshire South Wales were tested in an attempt to monitor the effects of the tree planting on soil fertility and soil formation from coal mine slag.

Apparatus List

2 L plastic drinks bottles (minimum 4 per sample)
Water carrier (10 L is probable maximum size that can safely be carried up the steep hillside to the sample areas)
Colmans mustard powder
Measure for mustard powder (30 ml or16g in each 2 L plastic bottle). We used the plastic container for measuring soap powder for a washing machine.
Spatula for transfer of mustard powder to 2 L bottle
Measuring tape
Mattock/trowel/hand fork/Stanley knife
Plastic sheeting
Plastic containers for earthworms
Paper towel
Blunt-ended forceps
Hand lens/Binocular microscope
Earthworm key

Optional but Useful Extras

Soil thermometer
Soil pH meter
GPS
Soil nitrate kit
Rain gauge

Sample Method

A vermifuge solution of mustard powder in water was made up to the approximate recommendations of Joji Muramoto and Matthew R Werner. (http://rms1.agsearch.agropedia.affrc.go.jp/contents/JASI/pdf/society/66-1295.pdf Accessed 15.07.2010)
30 ml (16g) Colmans mustard powder were mixed with 2 l water in a plastic drinks bottle. The mustard powder was measured using the plastic container for measuring washing powder into a washing machine and transferred to the drinks bottle using the spatula-like end of a plastic fork. The 2l bottle was then filled with water and shaken vigorously to produce a suspension. 4 x 2 l bottles of mustard powder suspension in water were used for each assay.

A square of side 0.5m was measured on the ground using a metal tape and the surface vegetation was removed either using a mattock or by cutting around the square with a Stanley knife then removal by hand using a small trowel and fork. The

surface vegetation was carefully placed onto a sheet of plastic and was checked by hand to remove any earthworms in the root systems. This process allowed greater infiltration of mustard water into the ground. A layer of closely-rooted vegetation was found to prevent the vermifuge from soaking into the earth.

2 x 2l bottles of vermifuge mustard solution were poured over the cleared sample area. The tines of the garden fork were used to make holes in the cleared ground to assist the vermifuge to soak into the soil. All earthworms which came to the surface were collected and placed into a plastic container with a little water in it to rinse away the vermifuge. It was found to be best practice to allow the worms to exit their holes completely before being handled. Earthworms anchor themselves in the ground using their tails and if handled while they are still partly in their holes will retreat and be very difficult to capture.

10 minutes after the first application of vermifuge had soaked into the soil, a second application was made using a further 2 x 2l bottles. As with the first application, all the earthworms which came to the surface were collected and rinsed in clean water. A time period of 10 minutes was again allowed, after the second application had soaked into the soil, before the assay was concluded.

All earthworms were transported in a plastic container containing a damp paper napkin. They were then counted and weighed and the total biomass of each assay was noted. Identification to species was attempted using the Field Studies Council "Soil and Earthworm Field Guide" downloaded from the Opal Explore Nature website. (http://www.opalexplorenature.org/sites/default/files/7/file/Field-guide-OPAL-online.pdf accessed 15/07/2010). Unfortunately, success in identification was limited in the 2 days available for the survey. Soil temperatures and Grid references at the sample sites were also noted. After counting, weighing and attempted identification, all earthworms were released.

Sample Sites

The sample sites in each compartment were carried out on areas of relatively flat, stone-free ground, close to an alder (*Alnus glutinosa/incana*). The alder was chosen as they are of large size, common in most compartments, easily identified and increase soil fertility by nitrogen fixation. Soil temperature was noted using a soil thermometer and a 5 figure grid reference was taken using a portable Garmin GPS receiver.

Samples were taken in the following compartments:

1. Pan
2. Titania
3. Svetla
4. Sheila
5. Cariad

Control samples were also taken in unplanted areas . One sample was taken in an ungrazed, fenced area and two samples were taken in a grazed area outside the

north west corner of the Twilight Zone. These would correlate with the soil of the compartments before the tree planting took place.

Results

Table 1 showing the details of all the sample sites:

Sample Site	Grid Ref.	Site Marker and Description
Control 1 (Ungrazed)	SO 25659 05823	Marked by stones and car head-rest
Control 2 (Grazed)	SO 25488 05665	Between path and Twilight Zone
Control 3 (Grazed)	SO 25462 05664	Further down slope from Control 2
Pan	SO 25568 05707	North of tree 1209. Between 2 alders.
Titania	SO 25590 05622	5 rows from Northerly row. 8 rows from row closest to Pan. Beneath alder.
Sheila	SO 25677 05725	Between trees 7625(alder) and 7626(alder)
Svetla	SO 25637 05703	North of trees 299 (rowan) and 286 (alder) Steep slope.
Cariad	SO 25523 05765	Between trees 229 (oak) and 231 (alder)

Table 2 showing soil data in relation to numbers and biomass of earthworms

Site	Date of Planting	Soil Temp °C	No of Worms	Mass of Worms g
Control 1 (Ungrazed)	None	18.0	4	0.44
Control 2 (Grazed)	None	20.0	0	0
Control 3 (Grazed)	None	19.5	1	0.07
Pan	1993	18.5	54	38.5
Titania	1994		68	28.4
Sheila	1997	16.5	13	21.0
Svetla	1991	18.0	46	21.2
Cariad	2003	20.0	12	1.6

Species

Lack of time and expertise made the identification of the earthworm species rather tentative. All plantation compartments contained some very large worms which came to the surface late in the assay, suggesting that they inhabited the deeper layers of soil. These were thought to be specimens of the Lob Worm *Lumbricus terrestris.* A number of smaller earthworms were also found in the planted compartments. These surfaced more rapidly than the large species and were therefore felt to be surface-dwellers. They were thought to be the Black-headed or Long Worm *Aporrectodea longa* with possibly some individuals of *Satchellius mammalis* the Little Tree Worm. It must be stressed that this identification is not definitive. A very small number of earthworms were found outside the planted compartments in the control areas and only one definite identification was made. Of the 4 earthworms found in Control Area 1 (Ungrazed), one curled up in the hand and exuded a yellow fluid when handled. It was therefore considered to be a Green Worm *Allolobophora chlorotica.*

Graph 1

Graph 1 shows an interesting correlation between the dates of planting of the compartments and the biomass of earthworms found in these compartments. If the points from Pan; Titania; Sheila and Cariad are considered, a negative correlation is shown with the obvious conclusion that the older the plantation, the greater the biomass of earthworms in the newly forming soil. The correlation could be a straight line, representing a direct increase in earthworm biomass with time. There is also a possibility of a curve connecting these 4 points. This would suggest that for the first few years after planting (15 years?), earthworm biomass increases directly with time but after a critical time period, as good soil is formed, the increase in earthworm biomass becomes exponential.

Svetla provides an outlier result with a lower biomass of earthworms than expected. An explanation for this could be that Svetla was the only compartment in this group where pit planting took place. Pan, Titania, Sheila and Cariad were all trench planted i.e. a trench was dug in the ground using a mechanical digger, the trees were planted and the disturbed material was replaced. This method would have resulted in major break-up of the compacted ground and easier access for earthworms. In Svetla, small pits were dug by hand for the tree planting with little effect on the ground compaction. This planting method could be expected to result in a less “earthworm-friendly” habitat.

Graph 2

When numbers of earthworms are plotted against year of planting, (Graph 2) the results are more difficult to explain. Both Sheila and Cariad have relatively small numbers of earthworms in the ground. This would be expected in Cariad as it is the

most recently planted. The trees have not had enough time to establish themselves and little soil formation has occurred. The low count in Sheila is surprising. It was noted when sampling that the soil in Sheila was very thin with many large stones. The soil temperature also appears to be markedly lower than in other compartments though the reason for this is unclear. Earthworms were few in number but the majority were of a large size, probably *Lumbricus terrestris,* which is a deep burrower. It is possible that where the surface ground was very stony it could not support a large population of surface dwellers. The presence of large numbers of stones may also have affected the capacity of the soil to absorb and retain heat. The presence of the trees seems to have allowed a large biomass of earthworms to inhabit the area but only the larger, deeper burrowing species can cope with the inhospitable terrain.
The other three compartments, Svetla, Pan and Titania, support relatively large numbers of earthworms but the pattern is difficult to explain. It is unclear why Titania should have larger numbers of earthworms in the soil than either Pan or Svetla, both of which were planted before Titania.

Control Plots

Three control plots were tested for comparison with the tree-planted areas. All three were chosen to represent the type of earth found on the Varteg Hill prior to tree planting. None of the control areas contained any trees. One of these (Control 1) was inside a fenced area and therefore ungrazed. The other two controls were in an unfenced area where sheep were free to graze. Control 2 was close to an unmarked path with the possibility of further soil compaction. Control 3 was approximately 16m down the hillside from Control 2 and therefore well away from the path.
All the control areas gave very poor results with no earthworms at all found from Control 2 and at best, Control 1 provided 4 worms with a biomass of 0.44g. These results show clearly that the tree planting is having a direct and beneficial effect on the soil, increasing organic material and fertility and encouraging a healthy soil fauna as indicated by the presence of the earthworms.

Sources of Error

As a preliminary survey carried out in a short time period, without access to a laboratory, there were a number of sources of error.

1) The size of the sample area was not exact. An area of approximately 0.25 sq m was cleared, using a mattock and this area was sampled. A more exact sample might be taken by measuring a square using a tape, cutting around it using a Stanley knife, then clearing the surface vegetation using hand held trowels and forks.
2) Many of the samples were taken on sloping ground. There was run-off of the vermifuge solution to adjacent ground and occasionally this brought worms to the surface from outside the sample area. These worms were often included in the sample.
3) The quantities of mustard and water in the vermifuge solution were approximately constant but could have been made more accurate by weighing the mustard before use.
4) Biomass of earthworms was determined as accurately as possible using a Sartorius balance. Of necessity, it included the gut contents of the earthworms. A more accurate result would have been obtained if the worms

could have been kept overnight to allow them time to void the material in their guts.

5) The vermifuge solution of mustard in water irritates the earthworms and causes them to move away. Some come to the surface to avoid the vermifuge and can then be caught. It is not known what proportion of the earthworm population in the sample area come to the surface. It seems likely that some individuals will burrow deeper, and some may escape sideways.
6) Samples in plantations were taken close to an alder tree as far as possible. The alder is known to fix nitrogen and therefore to increase levels of nitrate in the soil. Nitrogen is considered to be a critical factor in limiting earthworm populations. (Satchell, J. (1967) Lumbricidae in Soil Biology. Academic Press, London UK. Quoted by Sharratt, M. (2006) "The Loss of Earthworms by the Reinstatement of Land and its Effect on Wildlife" Thesis for M.Sc. in Environmental Conservation and Management. Swansea Institute of Higher Education). Sampling close to alder may have artificially increased the results.

Future Work

Although this work was only done as a preliminary survey, results have been positive and exciting suggesting that further surveys would be worthwhile.

1) The major problem was the difficulty in identification of earthworms experienced by all the volunteers. While it is gratifying to be able to monitor an increase in earthworm numbers and biomass due to tree planting, biodiversity is also important. To determine if the tree planting has resulted in an increase in biodiversity it is vital to speciate the captured earthworms.
2) All plantation compartments need to be included in the survey and different planting conditions need to be noted. For example, areas where fairy dust or fertiliser have been used should be sampled separately.
3) Each plantation should be sampled more than once to ensure consistency of results.
4) The nitrogen content of the soil is likely to be an important factor in earthworm populations. Further samples should be taken in areas away from the influence of the alders. It would also be useful if soil nitrogen could be directly measured.
5) Rainfall and soil moisture are likely to be important factors in the capture of earthworms. Under dry conditions, earthworms are likely to burrow deeper and be more difficult to reach with the vermifuge. Further samples should be taken at the same points, under different weather conditions and monitoring of soil moisture should be carried out.
6) Monitoring of soil pH was not possible in this preliminary survey. pH is a factor which may influence earthworm populations and should be considered in any future work.
7) More accurate weighing of mustard powder would standardise the vermifuge solution.
8) A more accurate biomass result could be obtained by weighing the earthworms after they have been kept overnight to allow them to void the contents of their guts.