ISLE OF RUM EARTHWORM CONFERENCE

University of Central Lancashire, UK;
University of Rzeszow, Poland

MAY 2014

Contents

1.0 ISLE OF RUM EARTHWORM CONFERENCE 2014

Dates: 26th – 28th May 2014

Location: Kinloch, Isle of Rum, Inner Hebrides, Scotland

INTRODUCTION

The Isle of Rum is the largest element of the "Small Isles" in the Inner Hebrides. It lies 30 km off the west coast of mainland Scotland. Rum is unique as almost the whole island is a National Nature Reserve (since 1957). The 10,650 ha managed by Scottish Natural Heritage (SNH) comprise mountains, to 812 m, and surrounding moorland. Only 20-30 people live on Rum in one major settlement (Kinloch). Natural sciences of the island are of major interest (geology, geomorphology, ecology and conservation) and Rum is often viewed as an "outdoor laboratory". For example the red deer on Rum have been the focus of research for over 40 years. The Earthworm Research Group (ERG) from the University of Central Lancashire (UCLan) has been active on Rum since 1995 (see Butt and Lowe, 2004; Callaham *et al*, 2012; Gilbert and Butt, 2012).

Due to natural processes, previous subsistence farming (crofting) and the importation of 250,000 tons of soil to a small location around Kinloch castle over a hundred years ago, earthworms on the island have a remarkable distribution (Butt and Lowe, 2004). Much has been learned of this on numerous visits in the past, but there is still much more to be investigated. A move to develop a greater tree cover on this relatively barren island, to regenerate the crofting systems, plus a need for a greater sustainable existence of all residents, means that there is scope for a variety of research projects with a focus on earthworms.

By bringing together researchers from UClan and the University of Rzeszow (U of R), a synergy will be provided. The soil building attributes of earthworms can be married with their organic waste processing characteristics to explore the full range of possibilities for utilisation. Residents are well aware of their island status and have to take care with all aspects of waste management (Lowe *et al*, 2005). However, practices could be improved upon and organic waste management with earthworms has the potential to be grown substantially with the use of appropriate expertise (e.g. Kostecka and Pączka, 2011). Equally there is still much to be learned of basic earthworm ecology, with one species (*Dendrobaena attemsi*), recently collected by Butt and Lowe from Rum, described by Sims and Gerard (1999) as previously recorded in Britain only from "a single record (in)… Cumbria".

This Conference will bring the two research groups closer together to exchange ideas and permit future collaborative projects to be discussed and developed (on Rum and further afield).

Thanks are offered to Scottish Natural Heritage (SNH) on Rum for hosting this conference and Lesley Watt in particular, for assistance with logistics.

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2.0 CONFERENCE PROGRAMME

27.05. Day I
Field trip 1: Rum as a National Nature Reserve – an outdoor laboratory (led by KRB/CNL).

28.05. Day II (Chaired by KRB and JK) Introduced by a representative from SNH
A Generic Presentations
Kevin R. Butt:
THE EARTHWORM RESEARCH GROUP (ERG) AND INVESTIGATIONS ON THE ISLE OF RUM: 1995-2014

Joanna Kostecka:
POLISH EARTHWORM RESEARCH GROUP (PERG) - CHOSEN ACTIVITY FOR SUSTAINABLE DEVELOPMENT AND SUSTAINABLE WASTE MANAGEMENT

B Specific Project Presentations:
1/ Mariola Garczyńska: CHEMICAL AND BIOLOGICAL WAYS FOR LIMITING FLIES IN EARTHWORM ECOLOGICAL BOXES

2/ Grzegorz Pączka: CHOSEN ASPECTS OF VERMICOMPSTING OF LITTORAL PLANT BIOMASS

3/ Anna Mazur-Pączka: LUMBRICIDAE CONCENTRATIONS AT SELECTED SITES OF A FORMER SULPHUR MINE IN JEZIÓRKO

4/ Agnieszka Podolak-Machowska: LIFE CYCLE COMPARISON OF *EISENIA FETIDA* (*SAV*.) AND *DENDROBAENA VENETA* (ROSA) IN LABORATORY CONDITIONS

5/ Chris Lowe: NOVEL DEVELOPMENTS FOR *IN SITU* ASSESSMENT OF SOIL CONTAMINANTS USING EARTHWORMS *(Poster)*

6/ Frank Ashwood: THE INFLUENCE OF EARTHWORM ACTIVITY ON RECLAIMED SOIL AND WOODLAND ECOSYSTEM SERVICES DELIVERY

7/ Janet Cooper: AN ASSESSMENT OF GROUND BEETLE PREDATION ON EARTHWORMS IN AGRO-ECOSYSTEMS – CONFLICTING ROLES OF ECOSYSTEM SERVICE PROVIDERS IN AGRICULTURAL ENVIRONMENTS *(Poster)*

8/ Pete Bentley: EARTHWORMS AS ECOSYSTEM SERVICE PROVIDERS IN SUSTAINABLE AGRO-ECOSYSTEMS (*Poster*)

9/ Nalika Rajapaksha: PREFERENCE TESTING OF EARTHWORMS FOR SHORT ROTATION FORESTRY LITTER (*Poster*)

10/ Kevin Butt and Visa Nuutinen: EARTHWORMS FROM THE OUTER HEBRIDES – A LITTLE FURTHER WEST FROM RUM

C Discussion Session:
General points arising from all presentations:-
Potential avenues for future joint research:-

29. 05. Day III
Field trip 2 - to Harris/Kilmory.

3.0 Abstracts of Presentations:-

The Earthworm Research Group (ERG) and investigations on the Isle of Rum: 1995-2014

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The ERG has existed for just over a decade, but research on earthworms has been occurring in Preston since 1994. This work, to name a few areas, has investigated general ecology; use of earthworms in soil restoration; inter and intra-specific interactions; mating behaviours; ecotoxicology; earthworm-tree interactions and research technique development. Kevin and Chris Lowe have been the ever-present members, with numerous research students obtaining PhDs over the given period. In addition, the wider ERG has associate members from across the world with long term research relationships in Poland (University of Rzeszow), Finland, Spain and the USA.

Research on Rum began with a visit in 1995 and has seen more than 30 visits since. An historical document located in the Reserve Office, produced by John Morton Boyd, gave some basic findings from the time when National Nature Reserve status on Rum was conferred. General survey work by the ERG led to a picture of earthworm distribution, followed by more specific investigations. A number of publications have resulted (see Appendix 1) with others still in preparation. To date, these have looked at species distribution on Rum and the influence of human habitation, specific investigations with *Lumbricus terrestris* middens, (the largest recorded individual earthworm in the UK was discovered at Papadil), influence of Manx shearwater (*Puffinus puffinus*) marine inputs to terrestrial soil systems and soil development under afforested plots.

Some long term monitoring continues, but there is still scope for further research as the geology, soils, historical and current management on Rum allow for an array of earthworm-related research questions to be formulated.

Polish Earthworm Research Group (PERG) - chosen activity for sustainable development and sustainable waste management

Joanna Kostecka

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Research on earthworms began in Rzeszow in the last century. Most of our research and publication deal with the issues related to the Lumbricidae family in soils of natural and anthropogenic ecosystems (also their protection) and applications of the earthworm *Eisenia fetida* (Sav.) (also now *Dendrobaena veneta* Rosa) in biotechnology of vermiculture (with determination of technology of organic waste vermicomposting and using vermicomposts in agriculture and horticulture).

In the 1980s research focused on the ecology of earthworms in the natural ecosystems of the Bieszczady Mountains [e.g. 1, 2, 3, 4]. In the early 1990s experiments on using *E. fetida* for vermicomposting organic waste started. In a farm belonging to the Regional Development Fund for Rzeszow Area run by Agricultural Secondary School in Miłocin, near Rzeszow, about 30 m^2 of vermiculture was set up. At first this was in a bed limited by wooden walls and the base covered with wire netting. Then the walls were made of hollow bricks and the base of concrete [5, 6]. The farm specialised in breeding cattle and horses, hence the first waste given to the earthworms was cow and horse manure. Testing the principles and technology of vermicomposting, a lot of cow manure vermicompost was produced with high quality parameters [7]. This allowed for numerous experiments which compared fertilising vegetables with vermicompost with balanced doses of mineral fertilisers. The research showed a positive influence of the manure vermicompost on the size and quality of carrots, tomatoes, cucumbers, potatoes, celeries, leeks and cabbages [e.g. 8]. The high quality of the crops was defined by a lower content of some heavy metals (Pb, Cd) and nitrates in vegetables grown on vermicomposts as compared to those grown on mineral fertilisers. Studies on the use of the second product of vermiculture, i.e. earthworm's biomass were also carried out [e.g. 9].

The research conducted by us in this field, gradually attracted other scholars of the Faculty, mainly from the Department of Agroecology. The research results were also known of and used in the educational area (in contact with teachers, pupils, farmers, students and local government representatives).

Vermicomposting was also conducted on a large scale in selected sewage treatment plants [e.g. 10, 11, 12, 13]. In 1996 the first tests took place aiming to use earthworms for utilising kitchen organic waste on the spot, in "ecological earthworm boxes" [14,15]. During those tests, a number of educational projects were realised including promoting zooedaphone biodiversity [e.g. 16].

Some research of PERG (also in cooperation with ERG from UCLan) still consists of further study for Lumbricidae populations in various ecosystems [e.g. 17,18,19] and using them in biotesting [20]. PERG and ERG from UCLan are now starting to be connected further, also by publications in the field of education for sustainable development [21].

Promoting the importance of Lumbricidae for soil fertility and organic waste management, conferences entitled "Ecological and economic significance of earthworms" were organized in Rzeszów. They played a remarkable role for the exchange of information and expanding research in Poland. So far, five such conferences have been held [Conference "Ecological and economic significance of earthworms" 1994, 1996, 1998, 2001 and 2003- published at Zeszyty Naukowe AR w Krakowie *no 292/41* /1994- 150 pp; *no 310/47* /1996- 180 pp; *no 334/58* / 1998- 202 pp; *no 372/75* / 2001- 292 pp; Zeszyty Problemowe Postępów Nauk Rolniczych *no 498*/ 2004- 230 pp].

As part of the European Union, Poland has to follow European law and directives concerning municipal waste. By the year 2020 our country is supposed to retrieve up to 75%

from the municipal waste dumped in landfills. The proper use of *E. fetida* populations might help to achieve that goal.

With sustainable development and sustainable organic waste management, there should be more than enough space for protection of such important soil animals [16] and a use of such versatile biotechnology [13, 22].

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Chemical and Biological ways for limiting Flies in Earthworm Ecological Boxes

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A fundamental problem in Poland, and across the world, related to development of turbocivilization is the growing mass of wastes, including the organic fraction. According to principles of sustained economy of waste management, organic wastes should be subjected to recycling, for instance, by methane fermentation or composting. An alternative method of managing the segregated organic fraction may be its neutalization by vermicomposting on-site in so called “earthworm ecological boxes” (with the use of earthworms). However, vermicomposting in small containers may be uncomfortable owing to the presence of *Diptera Sciaridae,* which compete with earthworms for organic wastes.

To fight *Diptera* larvae in ecological boxes, natural insecticides and xenobiotics were used, in doses recommended by the producers. Owinema biopreparation (containing living Nematoda *Steinernema feltiae* larvae) (50mln larvae·m^{-2}), aliofilic preparation (2% infusion of garlic) and insecticides: Dimilin 25 WP (4g·m^{-2}) and Dar 2.5GR (400g·m^{-2}) were added to the boxes. Their influence on size of the population, biomass and reproduction of the earthworm *Eisenia fetida* (Sav.) were tested.

The experiment was conducted in 5 repetitions by introducing 2 dm^3 of typical garden soil and in doses of 150 ml of kitchen wastes: potato and apple peelings, leftover bread and leftover cooked pasta. To improve the effectiveness of vermicomposting, the wastes were mixed with cellulose (Kostecka, 2000). 50 earthworms were introduced into each container. The population dynamics in control boxes and those with insecticides was checked regularly by manual segregation of the substratum tested and the individuals and cocoons found were counted and weighed.

The tests showed that the composted earthworms, in response, to the (chemical) agents applied, showed differentiated life strategies. Owinema biopreparation stimulated the average sum of numbers and biomass of all earthworm populations ($p<0.0002$). Similar results were obtained for the number and biomass of the representatives of the individual age classes: adult individuals and immatures ($p<0.0002$) and cocoons (size number $p<0.0004$; biomass $p<0.01$). However, the other natural insecticide, aliofilic preparation, reduced the number ($p<0.01$), the biomass sum ($p<0.01$) and the average biomass of immature individuals ($p<0.00001$). The Dimilin 25 WP and Dar 2.5GR xenobiotics, in the dose indicated by the producers did not influence the number and biomass of the whole populations of earthworms and the representatives of individual age classes but they significantly lowered the number and biomass of the cocoons produced by earthworms (Dimilin 25 WP – the number ($p<0.001$) and cocoons biomass ($p<0.01$); Dar 2.5GR – the number and biomass of cocoons ($p<0.01$)).

Key words: earthworm *Lumbricidae*, scarid flies *Sciaridae*, Owinema, Aliofilic preparation, Dimilin 25WP, Dar 2.5GR, ecological boxes

Reference

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Chosen Aspects of Vermicomposting of Littoral Plant Biomass

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During recent decades, numerous bodies of water have been affected by increased fertility, which has further led to their eutrophication. Various methods are used to prevent excessive fertilization of standing water (lakes, ponds, wetlands). Plants growing in the proximity and in the littoral zone of water reservoirs are known to play an important protective function, as a barrier capturing excess of biogenic substances, they promote processes of water self-purification and provide habitat for numerous organisms. Yet, excessive growth of such plants as bulrush (*Typha latifolia*) and yellow flag (*Iris pseudacorus*) within shore zones leads to gradual decrease in depth and successive coverage of the reservoirs, which reduces their recreational value (for fishing, sailing and other water sports). After these are mechanically removed it is necessary to adequately dispose of large quantity of biomass originating from the plants.

An attempt has been made to neutralize this type of waste in the process of vermicomposting. The experiment was repeated four times for each type of waste, in boxes with capacity of 2.5 dm^3. Refined plant biomass in plastic nets, at constant weight (*Typha* – 110g, *Iris* – 130g), was placed in boxes with potting soil of known parameters. The experiment used *Eisenia fetida* Sav. with balanced biomass of 14.42±0.15 g and number of 23.6 ± 1.1. The vermicomposting process occurred in a climate box at 20±0.5°C.

The findings showed significantly faster neutralization of biomass originating from *Iris pseudacorus* (I) (70 days) as compared to *Typha latifolia* (T) processing for which earthworms needed approx. 180 days. There was an increase ($p<0.05$) in the mean number of earthworms (by 550% for (I) and 360% for (T)) (Fig. 1), which coincided with a decrease ($p<0.05$) in their mean total biomass (by 59% (T) and 31% (I)) (Fig. 2); the latter may have resulted from the decreasing amount of available nutrients.

The mean number of young worms in group I (112±31.3) was higher than in group T (62.5±25.5) (Fig. 3). No significant differences were found in the number of cocoons ($p>0.05$) (Fig. 4).

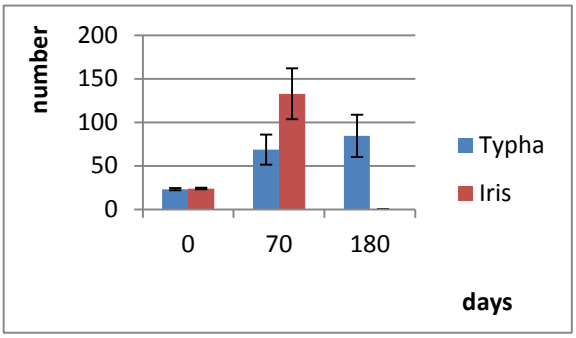

Figure 1. Mean number of *E. fetida*

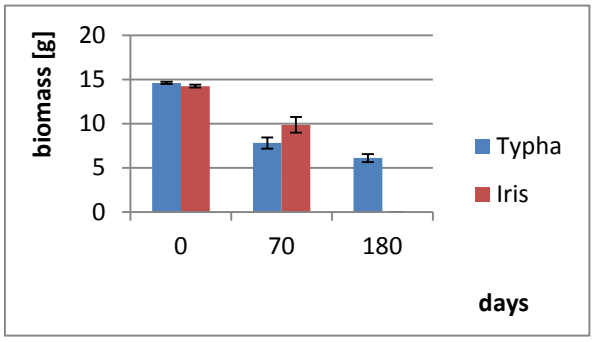

Figure 2. Mean total biomass of *E. fetida*

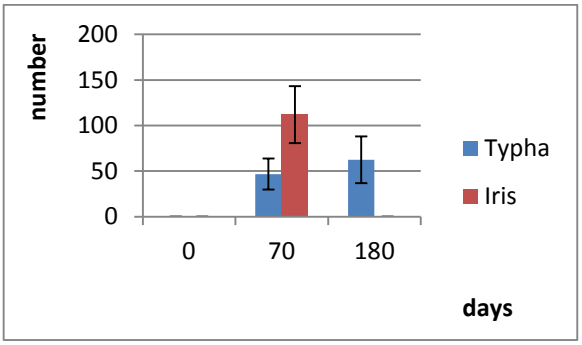

Figure 3. Mean number of young worms

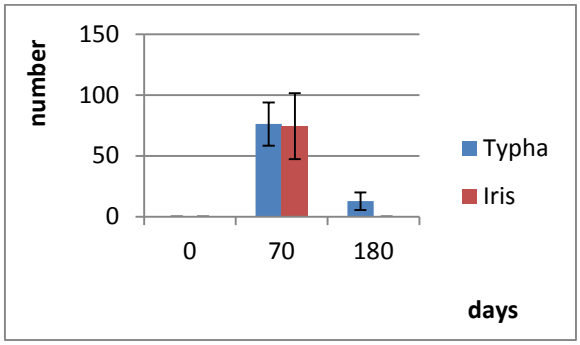

Figure 4. Mean number of cocoons

It has been demonstrated that *E. fetida* earthworms may be useful for neutralizing this type of waste, but in order to optimize the process the research should be continued.

Lumbricidae concentrations at selected sites formerly supporting a sulphur mine in Jeziórko

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Lumbricidae are used as bioindicators for soil contamination, with applications in biomonitoring, ecotoxicology and soil reclamation.

This study aimed at assessing progress in the land reclamation process at selected sites formerly comprising Machów S.A. sulphur mine in the area of Jeziórko (Poland, Podkarpackie Province), based on qualitative and quantitative composition of earthworm populations.

The study was conducted at four sites (Table 1).

Table 1. Diversity in the sites designed for the search of earthworms.

Site	II	X	XX	XXI
Reclamation design towards	forest	forest	meadow	meadow
Year of reclamation	1992	1997	2012	2012

Earthworms were collected using a mixed method (manual sorting of soil and flushing out with a weak 0.4% formalin solution). They were preserved in 30% ethanol, kept in 4% formalin solution and identified in accordance with appropriate keys. Seven species were identified (Table 2).

Table 2. Proportional rates of earthworm species identified at site II, X, XX, XXI within the reclaimed areas formerly comprising Machów S.A. sulphur mine in Jeziórko, during May 2012 to November 2013 [%].

Site	Species	Ecomorphology group	Domination	Proportional rates of ecomorphology groups
II	*D. rubidus, D. octaedra* *L. rubellus* *A. caliginosa, A.rosea,* *O. lacteum* *L. terrestris*	epigees transitory endogees aneciques	(7,55), (5,73) (6,15) (22,66), (46,15), (7,55) (4,12)	13,29 6,15 76,36 4,2
X	*D. rubidus, D. octaedra* *A. caliginosa, A.rosea,* *O. lacteum*	epigees endogees	(9,96), (12,45) (26,35), (39,63, (11,62)	22,41 77,59
XX	*			
XXI	*			

* earthworms () were only found in clusters, around isolated preserved trees.

Mean quantity and biomass of earthworms identified in the former mining areas were varied, depending on the reclamation design and advancement of the process.

Affiliation of the specimens with ecomorphology groups: *epigees, endogees* and *aneciques* reflected the progress in land rehabilitation in the relevant areas.

Life Cycle Comparison of *Eisenia fetida* (Sav.) and *Dendrobaena veneta* (Rosa) in laboratory conditions

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With respect to intensive economic development the amount of generated waste should be limited the most efficient way and incapacitated as close to the source of its formation as possible. Vermicomposting is a good example of easy and effective method of recycling of organic waste and can be provided with 2 species of earthworms: *E. fetida* and *D. veneta*.

The aim of the study was to compare selected features of activity of earthworms *Eisenia fetida* (*Sav.*) and *Dendrobaena veneta* (Rosa) in the annual cycle as practical importance in the selection of species for vermiculture.

10 adult (*clitellate*) earthworms *E. fetida* (*Sav.*) or *D. veneta* (Rosa) were used to form experimental groups. The groups were kept in plastic containers filled with 8 dm^3 of soil. Earthworms were collected by hand-sorting method every 4 or 6 weeks (last four controls) and they were then divided into mature (*clitellum*), preclitellate (*tubercula pubertalis*), immature and cocoons. Checking of humidity and feeding (organic household waste and cellulose – 4:1) was performed at every control of the containers. The activity of populations was measured by increments of number of individual age classes, biomass growth, and numbers of cocoons produced. The results were expressed as means (□) and standard deviations (SD). Significant differences between two species in numbers, body weight and the cocoons production rate were checked by means of unpaired samples *t*-test ($\alpha \leq 0.05$).

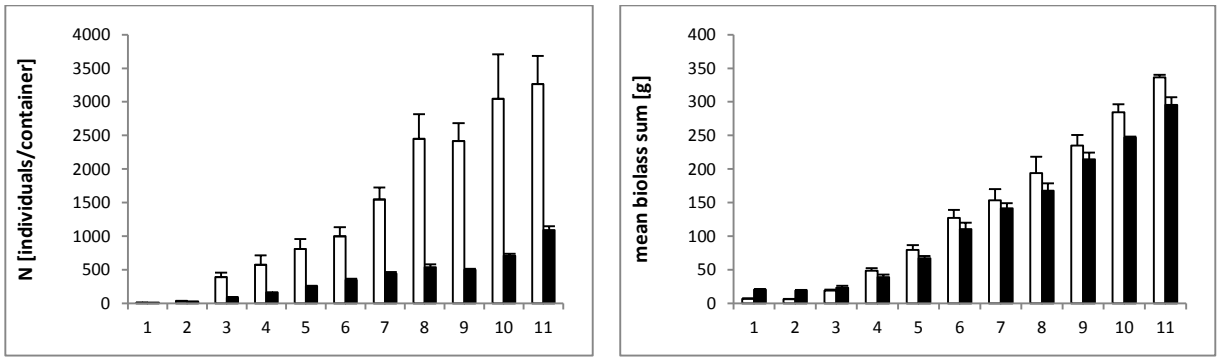

Fig. 1. Number of earthworms annual dynamic (left). Mean biomass sum in annual cycle (right). *E. fetida* (empty bars) and *D. veneta* (solid bars) throughout a one year experiment

Conclusions:

1. The study showed differences in the life cycle of the two compared species of earthworms.
2. *E. fetida* demonstrated a significantly more numerous annual population.
3. Despite the much higher total biomass of the *D. veneta* population (numerically balanced with the population of *E. fetida*) at the start of experiment, after 12 months, a higher growth rate of biomass of *E. fetida* resulted in the significantly lower total biomass of *D. veneta*.

Novel developments for in situ assessment of soil contaminants using earthworms

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The potential of earthworms as bio-indicators in field-based Ecological Risk Assessment (ERA) and in particular bio-accumulation studies is widely recognised as earthworms are both resistant and sensitive to pollutants and are capable of accumulating chemicals at concentrations higher than the surrounding substrate. Earthworms are also present in the majority of soils and are relatively sedentary. However, realising the potential use of earthworms in field-based assessment has been restricted by logistical and technical issues including inherent heterogeneity of field sites, earthworm collection and identification, lack of information about exposure history of earthworms and genetic heterogeneity of specimens.

Research conducted by the Earthworm Research Group has sought to develop a practical *in situ* method for mark, release and recapture of earthworms for use in ERA, by utilising techniques for earthworm culture and tagging developed by the ERG. A range of field-based experiments have been conducted investigating the use of PVC tubes to enclose, and recover experimental earthworms in contaminated and non-contaminated soils and silicone-based (visible implant elastomer) tags to aid identification of individual earthworms. Results have suggested that earthworms could not be efficiently retrieved without containment. PVC tubes (0.2 m diam., 0.3 m length) inserted to a depth of 0.1m were suitable to prevent movement of earthworms, however the visibility of these tubes in public-accessible sites was an issue. To address this, PVC tubes (0.2 m diam, 0.1 m length) inserted flush with the ground were employed and while this design prevented movement of earthworms in unpolluted conditions, it did not prevent surface movement unless the tubes were covered with a 0.5 mm nylon mesh.

It has been suggested that the use of laboratory-reared earthworm cohorts in field-based ERA may increase the efficacy and reliability of results. Therefore experiments were also undertaken to compare the response (in terms of pollutant uptake and survival) of field-collected and laboratory-reared cohorts of a specific earthworm species (*Octolasion cyaneum*) introduced into a heavy metal-polluted and an unpolluted field site. Results have suggested that the use of laboratory-reared earthworms did not significantly influence experimental results, however further work is required to confirm these findings.

The influence of earthworm activity on reclaimed soil and woodland ecosystem service delivery

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The use of a suitable soil resource is essential to provide the necessary chemical, physical and biological conditions for sustainable woodland establishment on reclaimed land. There is an increasing industrial and scientific interest in improving the soil resource for reclamation projects, particularly through the addition of organic matter from waste streams. Additionally, whilst it is recognised that earthworms play a crucial role in soil development and the cycling of essential plant nutrients and organic carbon, much is still unknown about their potential for improving the delivery of ecosystem services by soil and trees on reclaimed land.

This work describes the early stages of a research project, and presents the methodologies and preliminary results of experiments employed to date. These include a field experiment at a reclaimed woodland site, a pot-based field experiment, and a lab-based microcosm experiment. This research will contribute knowledge regarding the effects on tree growth, soil biodiversity, and soil quality on reclaimed land through the activity of earthworms and organic waste addition; and improve our understanding of the dynamics of naturally and artificially colonised earthworm populations in brownfield land reclaimed to woodland.

An assessment of ground beetle predation on earthworms in agro-ecosystems – conflicting roles of ecosystem service providers in agricultural environments

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Contemporary agricultural practice is moving toward an approach which emphasises sustainable intensification. This approach emphasises an increase in production without the consequential negative effects on the social, environmental and economic factors which farming can affect. Davies et al. (2009) stress the importance of an increased understanding in practices which might augment farm production without it affecting economic sustainability or ecosystem services. This approach seeks to optimise the use of ecosystem services such as soil nutrient cycling, pollination and pest predators. Naturally occurring invertebrate predators such as ground beetles and spiders are cited as providing significant ecosystem services through predation of crop pests such as aphids and slugs.

These predators are polyphagous however, and can predate upon other invertebrates which are deemed to provide other ecosystem services. This intra-guild predation can have a negative impact on pest control exerted by natural enemies. Laboratory studies of gut samples from beetles using multiplex-PCR and fluorescent-labelled primers have highlighted that diets consisting of only earthworms significantly improve the fitness parameters of selected ground beetles and produce heavier beetles, greater egg production and shorter egg development times than slug and aphid diets.

The aim of this PhD is to assess the behavioural and predatory reactions of the ground beetle *Pterostichus melanarius* in response to earthworms and to establish whether the sex of *P. melanarius* is a reason for a change in earthworm predation. A combination of methods will be used including field surveys in agricultural landscapes, laboratory choice feeding trials and the use of PCR to ascertain gut content.

Reference

Davies, B., Baulcombe, D., Crute, I., Dunwell, J., Gale, M., Jones, J., Pretty, J., Sutherland, W. and Toulmin, C. (2009) *Reaping the Benefits: Science and the sustainable intensification of global agriculture.* Royal Society, London.

Earthworms as Ecosystem Service Providers in Sustainable Agro-ecosystems

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The overarching theme of this project is Earthworms and Ecosystem Services, as reviewed recently by Blouin et al (2013), but with a focus on sustainable agro-ecosystems. Much has been written on the role of earthworms in agriculture, but much more is still to be learned, particularly in relation to the value of ecosystem services attributable to non-conventional agricultural practices. A focal point of this research will be the use of biostimulation (the modification of an environment to stimulate organisms capable of bioremediation) and its effect on earthworm populations and plant communities.

Earthworms and their role within ecosystems may have been reviewed, but long term analysis of the functioning of earthworms in sustainable agro-ecosystems has not been well documented and there are gaps in research on transition between aboveground and belowground processes. The current study will seek to bridge such gaps through an increase in the understanding of a range of factors including, for example, the facilitation of water movement through soil and uptake by plants. It will also contribute to knowledge by linking earthworm physical, biological and chemical processes with organic matter in soil for use as a tool for future land management methods. This may improve conditions for agricultural land, mitigate for climate change, enhance biodiversity in degraded habitats, and utilise waste.

This PhD is a joint project with input from UCLan, Myerscough College and MTT Agrifood Research Finland. This means that the part time project over 6 years will have the opportunity to integrate investigations alongside existing field research projects.

Reference

Blouin, M., Hodson, M. E., Aranda Delgado, E., Baker, G., Brussaard, L., Butt, K.R., Dai, J., Dendooven, L., Pérès, G., Tondoh, J., Cluzeau, J. and Brun, J-J (2013) A review of earthworm impact on soil function and ecosystem services. *European Journal of Soil Science* **64**, 161-182.

Preference testing of earthworms for Short Rotation Forestry litter

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Short Rotation Forestry (SRF) which includes planting of rapidly growing native and non-native tree species has been introduced to the UK as a method to increase woody biomass production. Expansion of SRF planting in the UK is increasingly seen as important to provide quality feedstock for heat and power sectors. However, a largely unknown aspect of SRF is the quality of leaf litter, and its palatability to the soil decomposer community of which earthworms are a major component in temperate systems.

The aim of the present study was to examine the preference of common British earthworms for six designated SRF species litter; alder (*Alnus glutinosa*), ash (*Fraxinus excelsior*), birch (*Betula pendula*), eucalyptus (*Eucalyptus nitens*), sweet chestnut (*Castanea sativa*) and sycamore (*Acer pseudoplatanus*). This was investigated through a series of laboratory-controlled behavioural experiments. Choice chamber technique was used to quantify litter removal by *Allolobophora chlorotica, Aporrectodea caliginosa, Aporrectodea longa* and *Lumbricus terrestris* over a period of up to five weeks. In addition, an infrared webcam recording technique was used to directly observe night litter selection behaviour of *L. terrestris*.

Both choice chamber and webcam observation results revealed that earthworms had clear SRF leaf litter selection behaviour and that this was not a random activity. This series of experiments concluded the earthworm preferential sequence for selected SRF species litter as; alder, ash, birch > eucalyptus > sycamore > sweet chestnut. It was remarkable that native British earthworm preferred non-native eucalyptus over naturalised sycamore and sweet chestnut.

For a more detailed description of this work see:
Rajapaksha, N. S. S., Butt, K. R., Vanguelova, E. and Moffat, A. J. (2013) Earthworm selection of Short Rotation Forestry leaf litter assessed through preference testing and direct observation. *Soil Biology and Biochemistry* **67**, 12-19.

Earthworms from the Outer Hebrides – A little further west from Rum

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Recent (spring 2014) ERG Investigations have begun relating to the earthworm fauna of the Outer Hebrides: - in particular North and South Uist. Part of this research is looking specifically at the effects of traditional agricultural practices on the organic-rich soils of "Blacklands" to the east of these islands. Over time these have been enriched by addition of marine algae and shell sand, but are now largely abandoned. Another aspect of this research is on the shell sand-derived machair soils to the west (Atlantic) side of the islands. Once again, the types of management of these soils and their effects on soil fauna are under scrutiny. Investigations looked at distribution and abundance across the managed machair with particular emphasis on long term, direct kelp additions and short term dung additions.

Data has yet to be fully analysed but results so far show that 11 species of earthworm have been located, with the distribution of some severely restricted by soil conditions or soil management. Addition of organic matter in a variety of forms appears to enhance earthworm abundance and diversity. As shown previously at the Sefton coast in NW England (Chamberlain and Butt, 2008), some species of earthworm are able to exist in soils with a surprisingly high sand content.

Within a relatively small area, some extremely different soil conditions were encountered. Data from N. and S. Uist may provide scope for comparisons with similar abandoned areas of cultivation on Rum.

Reference

Chamberlain, E. J. and Butt, K. R. (2008) Distribution of earthworms and influence of soil properties across a successional sand dune ecosystem in NW England. *European Journal of Soil Biology* **44**, 554-558.

Appendix 1: Published papers

Butt, K. R. and Lowe, C. N. (2004) Anthropic influences on earthworm distribution, Rum National Nature Reserve, Scotland. *European Journal of Soil Biology* **40**, 63-72.

Butt, K. R., Lowe, C. N. (2007) Presence of earthworm species within and beneath *Lumbricus terrestris* (L.) middens. *European Journal of Soil Biology***43,** S57-S60.

Gilbert , J.and Butt, K. R. (2012) Effects of fertilisers on vegetation of ultrabasic terraces (1965-2010): isle of Rum, Scotland*. Glasgow Naturalist* **25** (4), 105-110.

Callaham, M. A. Jr., Butt, K. R. and Lowe, C. N. (2012) Stable isotope evidence for marine-derived avian inputs of nitrogen into detrital foodwebs on the Isle of Rum, Scotland, UK. *European Journal of Soil Biology* **52**, 78-83.

Lowe, C.N**.,** Butt, K.R. & Hough, F. (2005) Waste Management in Isolated Communities: The Isle of Rum Scotland. Proceedings Sardinia 2005, Tenth Int. Waste Manag. and Landfill Symp.

Papers in Preparation:

Butt, K.R., Lowe, C. N., Callaham, M. A. Jr. and Nuutinen V. (In prep) An oasis of fertility on a barren island: Earthworms from Papadil, Isle of Rum.

Callaham, M. A. Jr., Butt, K. R. (in prep.) Effects of afforestation and landscape position on C and N, and stable isotopic signatures of soils, vegetation, and earthworms on the Isle of Rum, Scotland, UK.