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Monitoring earthworm communities in translocated grasslands affected by the construction of Runway 2 at Manchester Airport

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Abstract:

This work assesses earthworm communities in translocated turf/soil at Manchester Airport that provide food for legally protected vertebrate species. Earthworms were sampled by digging and hand sorting of soil, followed by vermifuge application. Monitoring produced nine species of earthworm. Areas supplied with turf contained significantly more earthworms than areas supplied with soil only. Density and mass of earthworms have generally increased or remained relatively stable, suggesting translocation to be successful after the first 5 of 15 years monitoring.

Key words:

Earthworms, Manchester Airport, Mitigation, Translocated Grassland.

Introduction

The construction of a second runway at Manchester Airport took place from 1997 to 2000 (Figure 1). This development encompassed 210 ha of prime wildlife habitat, including woodland and grassland, within the River Bollin valley. In mitigation of this development, a £17M scheme was put together to assist the replacement of lost habitats, transfer of biota, and to minimise effects of habitat fragmentation (Marshall *et al*. 1997). A significant part of the mitigation proposal involved translocation of colonies of European badger (*Meles meles* L.) and Great Crested Newt (*Triturus cristatus* L.), protected by British legislation (HMSO 1981, 1992). To ensure that food supply for these two species was not adversely affected, monitoring for earthworms, a key dietary component of badgers and newts was included within the mitigation (MacDonald 1983, Griffiths 1996). The aims of this work were to assess density, biomass and species composition of earthworm communities within translocated grasslands. Records of this nature have not been reported from similarly created sites.

Figure 1: An aerial view of Runway 2 looking north east.

Materials and Methods

Study Areas

Translocation of grassland turf (0.1 - 0.15 m deep) took place in February 1998. Grassland was mechanically cut from areas where the new runway was due to be constructed and transported less than 1km to receptor sites, where topsoil had been stripped away prior to translocation of turf/soil. Four specific grassland areas (GT1–4) were identified by the Airport for monitoring (GT: Grassland Translocations). The soils forming GT1–3, came from a previously disturbed site and contained traces of brick-derived materials with a pH of 7.8. Those forming GT4 were from an undisturbed site with a pH of 7.1.

GT1 (National Grid Reference SJ 814831). Located on a 30^o sloping bank between Runway 2 and a road, this site consists of two parts, one where turves were translocated intact and a second where soil alone was transferred.

Provision of soil from the same donor site has allowed direct comparisons to be made of the two sub-units of GT1 on an annual basis.

GT2 and GT3 (SJ 824838). Close to constructed ponds and existing woodland, this site was created in two parts. GT2 consists of "hummocks", raised to 3m above the surrounding area and containing voids to act as potential hibernacula (over-wintering spaces) for Great Crested Newts. These were covered with a layer of translocated grass turves (Figure 2). The adjacent GT3 site is lower lying and subject to inundation by water. These wet "hollows" were created with turves of similar origin to those used at GT2 and were designed to assist newt breeding, as ponding sometimes occurs here. Comparisons were made here between earthworms present in the hummocks and hollows.

GT4 (SJ 812823). This site, adjacent to pasture land grazed by dairy cattle and a wooded part of the Bollin Valley was constructed using floristically species-rich turves (of different origin to GT1-3). During the monitoring period this grassland was also used occasionally for grazing cattle.

Data Collection

A single method of sampling was used that involved digging and hand sorting of soil plus the addition of a vermifuge (a liquid such as mustard powder in water which acts as a skin irritant and is used to drive deep burrowing worms to the soil surface). In each year, from 1998 to 2002, sampling took place during the third week of October. Ten 0.1 m^2 quadrats were randomly located within each of the sampling sites. Each area delineated by the quadrat was dug to 0.15 m and the soil sorted for earthworms in the field (Figure 3). Those collected were preserved in 4% formaldehyde. A suspension of mustard powder (50g in 10 litres of water) was used as a vermifuge in the holes created

Figure 2: Grassland Translocations 2 and 3 (Hummocks and Hollows).

Figure 3: Sampling for earthworms using a quadrat and mustard vermifuge beside Runway 2 at Manchester Airport.

by soil removal (Butt 2000). Following earthworm collection the sample site was, as far as possible, returned to its original condition.

Specimens were examined and identified to species level, using the nomenclature of Sims & Gerard (1999). Earthworm biomasses were also recorded and individuals allocated as adult (i.e. fully clitellate = with saddle = reproductively active) or juvenile. The total number and mass of earthworms collected were compared during each year of sampling using a Mann Whitney statistical test at sub-sites of GT1 where different methods of translocation had occurred and also at GT2/3 where hummock and hollow areas had been created. Comparisons using Mann Whitney were also made between the most recent monitoring (2002) and initial sampling (1998) at each GT site.

Results

Table 1 lists the nine species recorded and their presence (as a percentage of the community by number), at each of the sites over the sampling years. The majority of earthworms (>95 %) were located by hand sorting of soil, the vermifuge extracted only individuals of the deep burrowing (anecic) species *Lumbricus terrestris*. The majority of earthworms were represented by two shallow working (endogeic) species, *Aporrectodea caliginosa* and *Aporrectodea rosea*. In GT3, *Allolobophora chlorotica* (endogeic) also accounted for more than 10% of every sample and also had a significant presence at GT4. Of the anecic species, *L. terrestris* was low in number overall whereas *Aporrectodea longa* was well represented. The surface dwelling (epigeic) *Eiseniella tetraedra* was only found at GT3, and here in only two sampling years, although in 1999 this species accounted for just over one fifth of earthworms found.

Table 1: Earthworm species, ecological grouping and percentage of community composition from Grassland Translocation (GT) sites at Runway 2, Manchester Airport, 1998 - 2002.

Earthworm Species	Ecological Grouping	GT1 (Turf)					GT1 (Soil only)					GT2 (Hummock)					GT3 (Hollow)					GT4 (Pasture)				
		98	**99**	**00**	**01**	**02**	**98**	**99**	**00**	**01**	**02**	**98**	**99**	**00**	**01**	**02**	**98**	**99**	**00**	**01**	**02**	**98**	**99**	**00**	**01**	**02**
Allolobophora chlorotica	endogeic	0	0	2	1	1	0	0	0	4	18	0	6	0	6	4	18	10	29	22	12	8	15	4	13	18
Aporrectodea caliginosa	endogeic	26	32	27	12	40	66	42	5	16	27	58	34	33	41	43	48	18	15	42	45	41	37	41	39	48
Aporrectodea longa	anecic	2	5	7	9	0	6	25	16	12	9	9	21	18	14	17	15	12	17	11	14	0	0	1	3	2
Aporrectodea rosea	endogeic	62	46	51	67	55	22	25	76	48	38	20	15	6	20	11	0	0	11	10	18	38	30	36	37	26
Eiseniella tetraedra	epigeic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	5	0	0	0	0	0	0	0
Lumbricus castaneus	epigeic	0	0	2	1	0	0	0	0	0	0	0	1	4	3	0	0	12	0	0	0	0	0	0	0	0
Lumbricus rubellus	epigeic	2	8	4	1	0	6	0	0	0	0	1	8	1	5	6	8	5	5	10	3	0	1	1	3	0
Lumbricus terrestris	anecic	2	0	0	0	2	0	8	0	0	4	11	2	4	4	7	0	1	0	0	4	6	5	1	1	1
Octolasion cyaneum	endogeic	0	0	4	5	3	0	0	2	4	2	0	0	5	0	1	0	0	8	0	0	5	0	5	1	1
Juv. *Aporrectodea* spp.	endogeic	6	8	7	4	1	0	0	0	16	2	1	13	29	6	8	11	20	9	5	5	2	13	13	5	4
Total Species Count		**5**	**4**	**7**	**7**	**6**	**4**	**4**	**4**	**5**	**6**	**5**	**7**	**7**	**7**	**7**	**4**	**7**	**7**	**5**	**6**	**5**	**5**	**7**	**7**	**6**

Figures 4 and 5 represent records of earthworm community density and biomass respectively, over the 5-year sampling period at all of the monitored translocated grassland sites. The highest recorded density was 427 m^{-2} at GT4 in 2001, and the largest biomass (140g m^{-2}) was at GT2 in 2000.

In GT1, areas supplied with turf contained significantly more earthworms with a significantly greater mass than those supplied with soil only, at every sampling date. Lowest earthworm mass and density were both recorded in GT1, where soil only, rather than intact turves, had been translocated. In GT1, results from 2002 (for both types of translocation) were not significantly different to results from initial sampling in 1998, with respect to both earthworm number and biomass. [Throughout this section 'significant(ly)' means $p>0.05$]

Results from comparisons of earthworm density and biomass at GT2 and GT3 over the monitoring period revealed significant differences during the period 2000–2001. This difference was greatest in 2000 when 140g m^{-2} was recorded at GT2. Initially, and in 2002 earthworm number and mass have not differed markedly. The greatest significant increase in density was at GT2 between 1999 and 2000.

In GT4, results from 2002 were not significantly different to results from sampling in 1998 with respect to earthworm density and biomass. However a significant increase in numbers was recorded in 2000–2001, and there was an equally significant decrease over the following year. This trend was mirrored in biomass records.

Overall, trend lines for GT2 and GT4 have been positive over the monitored period, however slight declines have been recorded at GT1 (turf transfer) and GT3 for both number and mass and at GT1 (soil only) for mass only. Similarly the species count for each site (Table 1) has shown generally increasing trends, with up to seven of the recorded nine species at any one site.

The proportion of juvenile (non-clitellate) earthworms was recorded in the range of 40–80% for each site over the period of monitoring. A steady increase from 44–76% at GT1 (soil only) and a steady decrease from 57-45% at GT4 have been the only clear trends. Evidence that *T. cristatus* makes use of the hummocks as hibernacula was found in 2001 when a juvenile newt was uncovered during the digging of one sample hole at GT2.

Discussion

All species of earthworm recorded from these sites represent those that normally occur in grassland habitats (Sims and Gerard 1999) with all three ecological groups (Bouché 1977) represented. The failure of a vermifuge application to extract many animals would seem to be a function of the number of anecic species present rather than the technique employed (Butt *et al*, 1999). As a representative of this group, *L. terrestris* may require further time for population development and only a long-term presence would indicate that the translocation process has been fully successful. The deep burrowing requirement of this species requires that the translocated turf becomes a fully functioning part of the soil profile.

The comparison of methods used for translocation of earthworms at GT1 strongly suggests that use of turves is the better ecological option. However, further comparisons of the two subunits of GT1 are required for a long-term view. Community composition in GT2 and GT3 (on adjacent areas) is markedly different and reflected in significantly different earthworm densities and biomasses. This is certainly a function of their topography. Results from

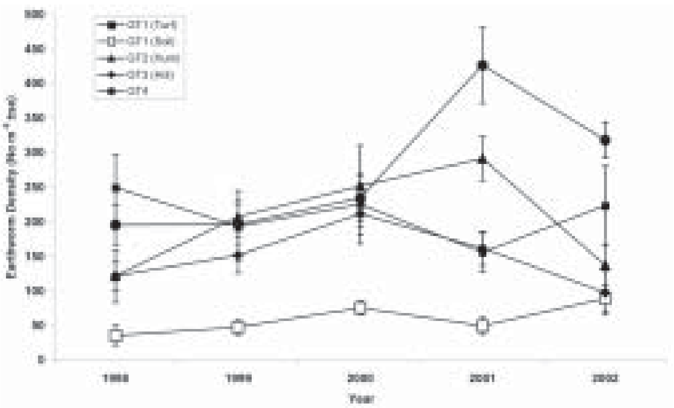

Figure 4: Development of earthworm community numbers in grassland translocation sites at Manchester Airport (Runway 2).

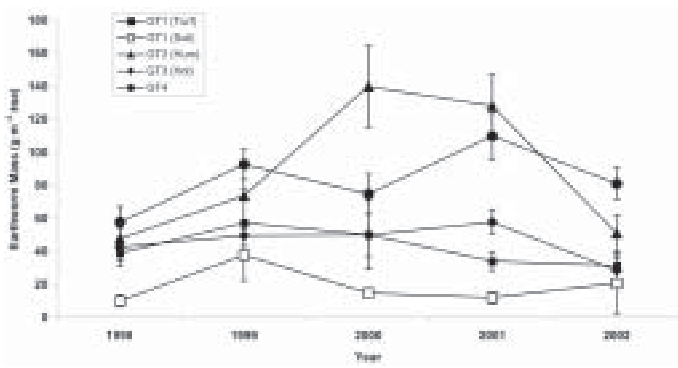

Figure 5: Development of earthworm community masses in grassland translocation sites at Manchester Airport (Runway 2).

GT3 may reflect the changing nature of this habitat, which has become drier over the monitoring period. Although the ponds are still present, the wet grassland once dominated by rushes (*Juncus* spp) is no longer present. Such a change is reflected in the recent recorded absence of *E. tetraedra* (a semi-aquatic species) and a reduced representation of the green morph of *A. chlorotica*, a species also associated with wet habitats (Sims & Gerard 1999).

The highest density and biomass records for earthworms in these translocated grasslands fall within the range of reported figures from pastures in temperate systems using similar collection methods (Edwards & Bohlen 1996). However, only after a period of several years will it be possible to determine if an equilibrium state has been reached. Community development may encompass both changes in number, mass and species composition over time, which has to some degree already been seen (Figs. 4 & 5 and Table 1).

At GT4 cattle grazing from 1999 led to an input of dung that has been accompanied by the highest recorded increase in earthworm numbers. *A. longa*, not initially recorded here appears to have entered the area from adjacent pasture where this species is present in large numbers (evidenced from surface casting). *L. rubellus*, another colonist of this area, may have also been attracted by the surface application of organic matter, as reported by several authors (e.g. Hendrikson, 1991).

In terms of a food supply for badgers, the density of *L. terrestris*, their primary earthworm prey item, is very low in the translocated areas, and could not meet the 130-200 required per animal per night (Kruuk 1978). However the large number of smaller earthworms (represented by the endogeic and epigeic species) may well be of value to the sustenance of Great Crested Newts during part of their amphibious annual cycle.

Overall results from this monitoring programme suggest that after five years the mitigation scheme has been a success in terms of translocating sustainable earthworm communities in grassland turves. As a part of this programme, monitoring of earthworm communities at Runway 2 will continue for a further ten years. This strategy should permit a more complete evaluation of the outcome from this part of the larger translocation programme.

Conclusions

- All the areas sampled contained dynamic earthworm communities.
- Some dramatic decreases have occurred; this may be due to a decrease in dung addition (e.g. at GT4), or may possibly be "moisture-related" (e.g. at GT2/3). In future, relationships with recorded precipitation on site may prove useful (Butt *et al*, 1999).
- Results presented must still be considered preliminary as time since translocation is still relatively short (less than six full years).

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