Continuing the research into the cultural control of earthworm activity, Dr Stephen Baker & Daniel Binns of the STRI, conclude their studies with their most recent findings...

Worm food

In the February 1999 issue of Greenkeeper International we reviewed recent research work at the STRI on the effectiveness of chemical control in tackling earthworm casting. To an extent chemical treatments are a last resort and the number of materials that can be used has been substantially reduced, a trend which is likely to continue as pesticide legislation becomes more restrictive.

An alternative to the use of wormkillers or lumbricides is cultural control. Environmental manipulation to reduce earthworm activity has of course been carried out for many years and is well documented in early STRI publications from the 1920's, 1930's and 1940's. As lumbricides become less persistent and increased application frequency makes earthworm control more costly, our research (funded by the R&A) has increasingly looked at the ecology of earthworm populations and cultural control methods.

Earthworm Populations

Knowledge of the distribution of earthworm species on golf courses is important if we are to gain an understanding of how environmental factors and management practices affect earthworm populations. Table 1 shows species identified from over 8000 earthworms collected from 59 sites at 32 golf courses throughout Britain in a joint study carried out by the STRI and the University of Lancaster. It is an unfortunate fact that the three earthworm species that are most closely associated with casting activity are by far the most abundant species on UK golf courses. Aporrectodea longa is a large, lightly pigmented earthworm, with adults 90-170 mm in length. It constructs permanent burrow systems to a depth of about 0.5 m and is common in gardens, pastures and cultivated soils.

Lumbricus terrestris is another large earthworm, brown to purplish red above but pale beneath with a flattened, paddle-shaped tail. This is the species that is regularly seen on the surface on mild, moist nights when it emerges either to forage for plant material or for reproduction.

Aporrectodea caliginosa can be both variable in colouration and size. Small individuals are common in the upper 70 mm of the soil from where they can produce some casting, but it is the larger, deeper burrowing "nocturna" form that is associated with large surface casts.

In our survey, significantly higher rates of casting were recorded on areas with higher soil pH, higher soil moisture content and more vigorous grass growth.

These relationships suggest that manipulation of pH, food supply and soil moisture content can all be used as mechanisms to reduce earthworm populations, particularly of casting species.

Soil Acidity

Two of the main casting species, A. longa and A. caliginosa are intolerant of acid conditions and the use of acidifying fertilisers has long been known to reduce casting activity. On some courses it may be appropriate to reduce soil pH using

FIG 1. Rates of casting in relation to mowing treatments with return and removal of clippings (the vertical bars show the least significant difference).

Earthworm species found on UK golf courses

Species	Percentage of all earthworms collected	Percentage of samples containing species
Aporrectodea longa	39	98
Lumbricus terrestris	22	98
Aporrectodea caliginosa	26	88
Allolobophora chlorotica	3	56
Aporrectodea rosea	3	54
Octolasion cyaneum	3	42
Lumbricus rubellus	2	27
Lumbricus festivus	2	24
Lumbricus castaneus	<1	10
Dendrodrilus rubidus	<1	5
Aporrectodea icterica	<1	3
Octolasion tyrtaeum tyrtaeum	<1	2
Satchellius mammalis	<1	2

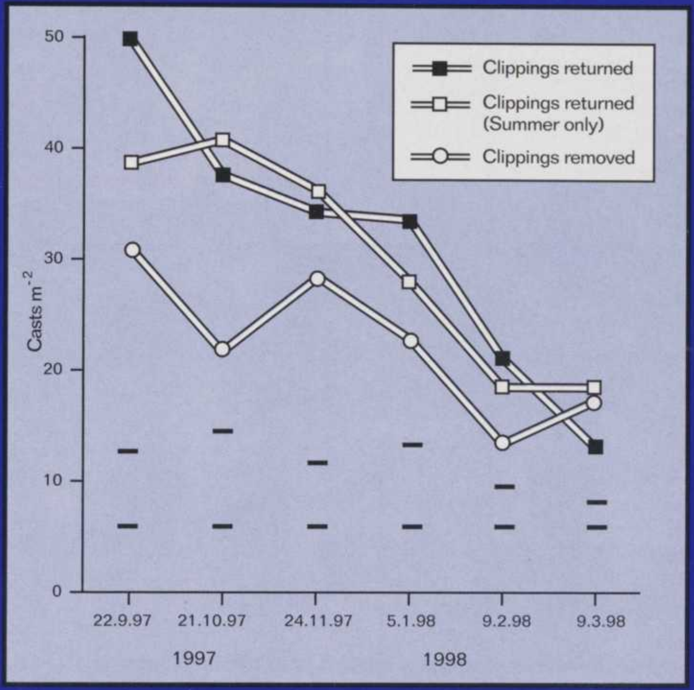
sulphur based compounds and in a previous article in Greenkeeper International initial trials with sulphur and aluminium sulphate were discussed. In this work (on a sandy clay loam soil with an initial pH of 5.7) a total application of 65 g/m2 of sulphur and 360 g/m2 Of aluminium sulphate applied in up to four dressings was sufficient to reduce casting by 50%. In our most recently reported work, carried out on a clay loam soil, 40 g/m2 Of sulphur, applied as an aqueous suspension, reduced the pH of the surface 25 mm from 5.8 to 5.2 and the pH at the 25-75 mm depth fell from 6.7 to 6.4. Casting was substantially reduced by sulphur and one year after the initial application, rates of casting relative to the untreated turf were 48% and 36% respectively for total sulphur applications of 20 g/m2 and 40 g/m2.

The use of sulphur is not without its risks and problems of scorch were recorded when sulphur was applied as two dressings of 20 g/m2. In addition over acidity may in the long term impair healthy grass growth. In consequence a series of trials have been established this autumn at eight separate sites to help us predict with greater certainty, the effects of sulphur on a wide range of soil types.

Mowing Practices

All animals need food and earthworms are no different, with the organic matter produced by golf course grasses seemingly providing delicious fare. If the food supply is reduced the size of the earthworm community that can be supported is also reduced and in management terms this can be achieved by collecting clippings and disposal away from the main playing areas on the course.

Organic matter production, even on relatively infertile golf course soils, may amount to 0.5-1.0 tonnes per hectare dry weight per year and this is a considerable amount of material to be collected and disposed of. We have therefore been looking at the timing of clipping removal to see how this affects



casting rates. We have considered three possibilities; (a) letting clippings fly all year; (b) boxing off all clippings; (c) an intermediate treatment whereby clippings are removed during the spring and autumn, when earthworms are most active, but allowed to fly in the summer when earthworms are dormant, especially in very dry conditions. This latter strategy would in theory substantially reduce the amount of clippings needing disposal but still allow some nutrient recycling associated with the breakdown of mown leaf tissue.

This trial started in October 1996 on fairway type turf mown at 13 mm growing on a sandy clay loam soil with a pH of 5.7. Results for the main period of casting from September 1997 to March 1998 are shown in Fig. 1. Apart from March 1998, when casting activity had already slowed down, the boxing off of clippings consistently reduced the rate of casting, by an average of nearly 30% over the whole year. Selective removal of clippings in the spring and autumn only brought about a significant reduction in casting on one occasion.

Unfortunately, it would therefore appear that the overall productivity of organic material is more important than the time when clippings are added or removed from the surface.

Removal of clippings means that nutrient cycling is reduced so we included light fertiliser dressings of 25 and 50 kilogrammes per hectare per year of nitrogen in the experiment (applied as two dressing in the spring and summer). This compensated for an estimated loss of about 30-45 kg/ha per year of nitrogen through clipping removal. Ammonium sulphate was used because of its acidifying effect, which as we have seen earlier can help reduce earthworm activity. The use of ammonium sulphate at 50 kg/ha per year reduced casting by 26% when averaged over all mowing regimes. However when comparison is made of the use of 50 kg/ha per year of ammonium sulphate on turf where the clippings are removed against turf with no acidifying fertiliser and clippings returned the reduction in casting was 48%. Some care is needed in this policy as acidification can go too far, but adjustment of mowing regimes and fertiliser practices will certainly influence casting actively. It may not be practical to remove clippings on all parts of the course but it should be considered where possible for more sensitive areas such as landing zones and approaches, as well as tees and greens.

Soil moisture content

Earthworm casting falls rapidly in dry conditions but at the same time earthworms have considerable ability to survive drought, either moving into moister soil lower in the profile, by curling up in a mucus lined chamber or by ceasing feeding and existing in a dormant state. Our work has shown that wet areas on a golf course have higher earthworm populations.

Furthermore, the effects of casting are probably more severe in wet areas because the cast soil is more easily smeared. In consequence improved drainage may reduce the effects of casting problems.

Turf needs at least moderate rainfall or supplementary irrigation for its survival and it is unlikely that moisture content is one of the main factors limiting the presence of earthworms on golf courses.

However the consequence of factors such as fairway irrigation in areas with potentially high earthworm populations must be considered because of the twin effects of higher moisture contents and greater organic matter production. Both properties are associated with increased earthworm populations and casting. More research work in this area is required.

The outlook

In the absence of persistent pesticide materials such as chlordane (now withdrawn from use) no single factor is going to bring about total control of earthworm casting. Indeed it is highly unlikely that even in combination the good management practices discussed above can bring about a complete cessation of casting. However it should be possible to bring about reasonable suppression of casting using cultural control techniques, so that only the worst areas on the course need pesticide applications for casting control.