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THE IMPACT OF A LUMBRICIDE TREATMENT ON THE FAUNA OF AIRFIELD GRASSLAND

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SUMMARY

This paper presents data from trials of a lumbricide (worm-killing) chemical to reduce bird numbers on an airfield by reducing the available food supply.

Numbers of feeding birds, worms and other invertebrates were monitored in adjacent 1 ha treated and untreated areas from 1 November 1989 to 2 April 1990.

Data for bird numbers were inconclusive due to low numbers being present on either area for most of the winter. Results for worm numbers showed no significant reduction in the sprayed areas, possibly due to long grass preventing penetration to the soil itself. Soil surface invertebrates showed significant long-term reduction in numbers as a result of spraying. Typical examples of data for the various species groups identified are given.

The potential for the use of lumbricides in airfield bird control is discussed, along with the possible problems which could result from the continued disruption of the grassland ecosystem by chemical treatment. The most profitable use of lumbricides is likely to be for small scale treatment of short grass strips alongside runways and around other installations. Airfield-wide application is not currently recommended. Further work is planned for 1990-91.

1. INTRODUCTION

The data presented in this paper form part of a series of investigations being carried out by the Aviation Bird Unit (ABU) under contract to the UK Civil Aviation Authority into possible new techniques for managing the airfield environment to deter birds.

At present, reduction of bird numbers on airfields is usually achieved by scaring using pyrotechnics and taped distress calls (CAA 1981), and by growing long grass swards to make the grassland areas less attractive to birds (Brough & Bridgman 1980). Both of these techniques are labour intensive if carried out effectively and, as staff costs rise, will become increasingly expensive.

The logical starting point for the study was to concentrate on those species which are recognised as the most hazardous on UK airfields, ie lapwing (*Vanellus vanellus*), golden plover (*Pluvialis apricaria*), black-headed gull (*Larus ridibundus*) and starling (*Sturnus vulgaris*) and to attempt to remove the features which attract them to airfelds. It is generally recognised that food, in the form of grassland invertebrates, and the security afforded by good all round visibility in large open spaces are the two main attractive features of airfields to these species. The removal of some or all of the food supply should, therefore make dispersal by scaring easier since the attractiveness of the airfield would be reduced and birds, once dispersed, would be less likely to return. Other studies have shown that worm numbers can be effectively reduced around runway margins using benomyl (Tomlin & Spencer, 1976) and that bird numbers can be reduced by removing worms using granulated endosulfan (Caithness, 1986). Neither of these chemicals is approved for use as a lumbricidein the UK however. Earthworms (Lumbricidae) are known to form a significant part of the diet of all of the species listed above, the remainder consisting largely of other grassland invertebrates (Cramp & Simmons, 1983, Barnard & Thompson, 1985). A lumbricide chemical approved for use on amenity grassland and sports turf was chosen (Ministry of Agriculture, Fisheries and Food, Health and Safety Executive, 1988), the active ingredient of which (gamma HCH) is also effective against a wide range of insects, spiders and other invertebrate species.

As well as investigating the effectiveness of the lumbricide in terms of reducing bird numbers, consideration must be given to the impact of the chemcial on the grassland ecosystem. Little information is available on how a grassland invertebrate population responds in the long term to the application of what is a relatively persistent pesticide. The desirability of large scale pesticide use needs to be carefully considered in the light of increasing concern about the environment and the public relations implications should not be diregarded. The data gathered from this project will allow the ABU to offer detailed advice to aerodromes contemplating the use of lumbricides as a bird deterrent.

2. METHODS

The study was conducted at British Aerospace's airfield at Salmesbury, Lancashire UK from 1 November 1989 to 2 April 1990.

Three experimental areas, each 200m x 100m in extent were marked out on the airfield and each divided in half to produce three pairs of plots each 100m x 100m. One plot from each pair was selected to be treated with the chemical, otherwise they were managed identically. The chemical was applied in November 1989 at the manufacturers recommended dosage. At the time of application the grass sward was approximately 10cm high. The bird and invertebrate populations present on the plots both before and after treatment were monitored by the following methods.

2.1 Birds: The numbers and species of birds present on the three pairs of plots were determined by counting the number of birds feeding on each plot at half-hourly intervals from 0700 to 1100 hrs (the period of maximum feeding activity) daily for two weeks before and after spraying.

2.2 Worms: Worm populations were estimated by taking a total of 40 randomly dispersed soil samples (20 from each plot) from each experimental area. The soil samples measured 20cm x 20cm x 10cm deep. Each sample was hand sorted and the worms present measured and counted. Hand sorting is recognised as the most effective technique for removing worms from soil samples, particularly the larger burrowing species (Edwards & Lofty, 1972). One set of samples was taken before spraying, and two further sets at 6 and 30 days after spraying respectively.

2.3 Soil surface invertebrates: A series of 25 pitfall traps (plastic cups set into the ground containing a preservative solution into which the invertebrates fall (Southwood, 1978)) was laid out in a grid pattern on each each plot. The traps were approximately 25m apart. Traps were emptied at approximately two-weekly intervals, once before spraying and for a total of 5 months afterwards. All invertebrates trapped were classified into broad taxonomic groupings (Table 3) and in some instances separated arbitrarily by size in order to emphasise those likely to be of importance in the diet of the birds being studied. The number of individuals present in each group was determined, and the treated and untreated areas compared using t-tests.

3. RESULTS

Monitoring of the three pairs of plots before spraying showed some significant differences between the different areas, eg. pair A had a significantly lower worm population than pairs B and C and also held significantly fewer feeding birds (t test $P<.05$). The effect of the chemical treatment was, however, uniform across all three pairs of plots. Data are, therefore, not pooled across the three areas, but are presented for one pair of plots only (area C) for the sake of brevity. A full account will be published elsewhere.

3.1 Bird numbers and behaviour: Table 1 gives the data pooled over all bird species for the number of individuals observed feeding on the treated and and untreated plots both before and after spraying. Before spraying significantly more birds fed on the plot which was subsequently treated. After treatment there were still more birds feeding on the treated plot, but the difference was no longer statistically significant.

3.2 Worm numbers: Table 2 shows the data for the mean number of earthworms recovered from the 20 turf samples taken from each half of the experimental plot before, 6 days after and 30 days after spraying. The spray had no discernable effect upon worm numbers. The mean number per sample did not differ significantly at any stage of the experiment. There are several possible reasons for the lack of effectiveness against worms which are discussed later.

Table 1. Mean numbers of birds observed feeding on treated and untreated areas before and after application of the treatment. Figures in brackets are standard errors of the means.

a) PRE-TREATMENT (42 observations)

	Plot Ci	Plot Cii	t	P
Mean No. Per observation	24.1 (6.5)	42.3 (7.9)	2.84	0.007

b) POST-TREATMENT (27 observations)

	Plot Ci (unsprayed)	Plot Cii (sprayed)	t	P
Mean No. Per observation	6.9 (1.9)	20.8 (9.1)	1.61	0.12

Table 2. The mean numbers of earthworms present in 20 soil samples taken from each experimental plot before, 6 days after and 30 days after treatment with a lumbricide. Figures in brackets are standard errors.

a) PRE-TREATMENT

	Plot Ci	Plot Cii	t	P
Mean No. per sample	14.5 (2.5)	9.6 (1.6)	1.63	0.11

b) 6 DAYS AFTER TREATMENT

	Plot Ci (unsprayed)	Plot Cii (sprayed)	t	P
Mean No. per sample	14.3 (2.5)	9.0 (1.8)	1.68	0.10

c) 30 DAYS AFTER TREATMENT

	Plot Ci (unsprayed)	Plot Cii (sprayed)	t	P
Mean No. per sample	12.6 (2.2)	9.4 (1.8)	1.15	0.26

Table 3. The groups into which invertebrates were divided from the pitfall trap samples and the species, genera or families which constituted the majority of individuals in each group (where no particular species dominated 'various species' are indicated).

Invertebrate Group	Constituent Taxa
Coleopteran larvae > 5mm length	(Hydrophilidae, Dytiscidae)
Coleopteran larvae < 5mm length	(" ")
Adult coleopterans	(Helophorus sp, Carabidae, Staphalinidae)
Collembolans	(Various species)
Arachnids	(Various species)
Adult Diptera > 3 mm length	(Scathophagidae)
Adult Diptera < 3 mm length	(Nematocera)
Dipteran larvae	(Tipulidae)
Lumbricidae	(Various species)
Homopterans	(Phrophaidae)
Heteropterans	(Various species)
Hymenopterans	(Various species)
Acarina	(Various species)

3.3 **Soil surface invertebrates**: Table 3 lists the groups into which the contents of the pitfall traps were divided, and gives the species, genera or family which constituted the majority of individuals in each group. Identification was carried out on a pragmatic basis since this study is concerned with invertebrates as the food supply of birds rather than with the effect of chemical treatment on insect species *per se*.

It must be emphasised that pitfall trapping does not give a complete picture of the invertebrate fauna in a grassland. The number of individuals trapped will vary depending on activity levels, and hence temperature, and on the susceptibility of particular species to pitfall trapping (some species may be able to avoid or escape from the traps). The technique is, however, useful for giving a measure of relative abundance of species or groups of species in comparable areas. It is not unreasonable to assume that particular species are equally susceptible to pitfall trapping in two adjacent 1 ha plots and that the effects of temperature on activity levels will be similar. Other studies have shown that the number of beetles caught in pitfall traps is proportional to their total abundance (Baars 1979). Pitfall trapping can, therefore, be used to give a measure of the relative abundance of some species groups in the treated and untreated areas, but gives no indication of total species composition or absolute numbers in the invertebrate population. For this reason data on the actual numbers captured are given for only one species group (coleopteran larvae > 5mm long) in order to illustrate how variation in trapping efficiency ran in parallel in both plots (Fig. 1) presumably due to changes in weather conditions. The remainder of the data are expressed as plots of the t statistic against time. The t test measures the magnitude of the difference between the mean values for the numbers of individuals captured in the two plots relative to the variance of the mean. Since pitfall trapping gives a measure of relative abundance only, the t statistic is a more useful measure of the impact of the chemical treatment on invertebrates relative to those in the untreated areas.

factors such as variation in temperature, rainfall etc can be assumed to be uniform across the two plots, leaving the t statistic as a measure of the effectiveness of the pesticide treatment alone. Figs. 2, 3, 4, 5 and 6 show the data for coleopteran larvae over 5 mm, adult Coleoptera, Collembola Arachnida and Diptera over 3 mm respectively. These groups have been chosed to show typical patterns in the data and to illustrate some of the potential problems that may result from the use of lumbricide chemicals. Other groups which were trapped in sufficient numbers to allow meaningful analysis show similar patterns to those illustrated.

3.4 Coleopteran larvae over 5 mm in length (Fig. 1): There was no difference between the two plots before spraying, and numbers trapped fell in both plots immediately after spray application due to cold weather. Numbers remained very low in the sprayed area for over 50 days before recovery commenced. The recovery coincided with an increase in numbers trapped in the unpsrayed plot which coincided with a mild spell of weather. This indicates that the long term effectiveness of chemical treatments will depend on how weather conditions govern the growth and reproduction, and hence the recovery time, of the invertebrate populations concerned. Fig. 2 shows the value of the t statistic for the data plotted in Fig. 1. Significant differences in population took about 20 days to occur, and the maximum differential occurred after 75 days. 150 days elapsed before the treated population recovered to the level of the untreated one. The times taken to respond to, and recover from, pesticide treatment will not only vary with weather conditions but with the life history and hence reproductive state of the animal concerned. Species which overwinter as larvae, reproducing only in the summer months must rely solely on immigration to restore a population, whilst those able to reproduce all year round may be able to recover more quickly if weather permits.

3.5 Adult coleopterans (Fig. 3): Significant differences were detected almost immediately, but it should be noted that there were differences between plots which neared statistical significance before the treatment was applied. As with coleopteran larvae, the maximum effect was not immediate but occurred after 55 days, again coinciding with mild weather. The population had recovered after 140 days.

3.6 Collembola (Fig. 4): Although these are too small to feature in the diet of the important bird species, they are prey to many other grassland invertebrates and hence form an important part of the food chain. The maximum impact on collembolans was achieved after 100 days, followed by a rapid recovery. The difference between populations had disappeared after 120 days. This rapid population recovery is achieved by the collembolan's capacity for very rapid reproduction in suitable conditions. The warmer spring weather enabled a rapid population recovery to take place, indicating that chemical treatments applied in summer may have shorter term impacts as populations can recover more quickly.

3.7 Arachnida (Fig. 5): There was already a significant difference between the plots before treatment. The application of the chemical increased the size of the difference between plots, and no recovery had taken place by the end of the experimental period at 150 days. Spiders are recognised as one of the major predators in grassland ecosystems (Curry, 1987) and their removal may allow other species to increase their population sizes beyond normal levels (see below).

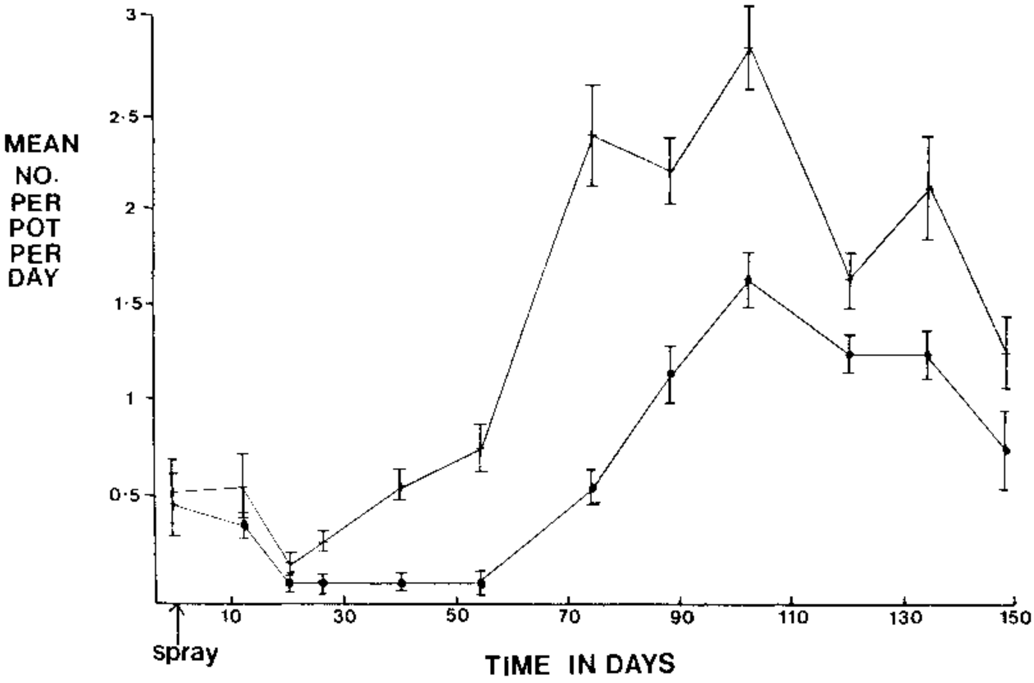

Figure 1. The mean number of coleopteran larvae over 5 mm in length captured per pitfall trap per day for treated (●) and untreated (+) plots. Vertical bars are standard errors of the means. The timescale is from 9 November 1989 to 2 April 1990.

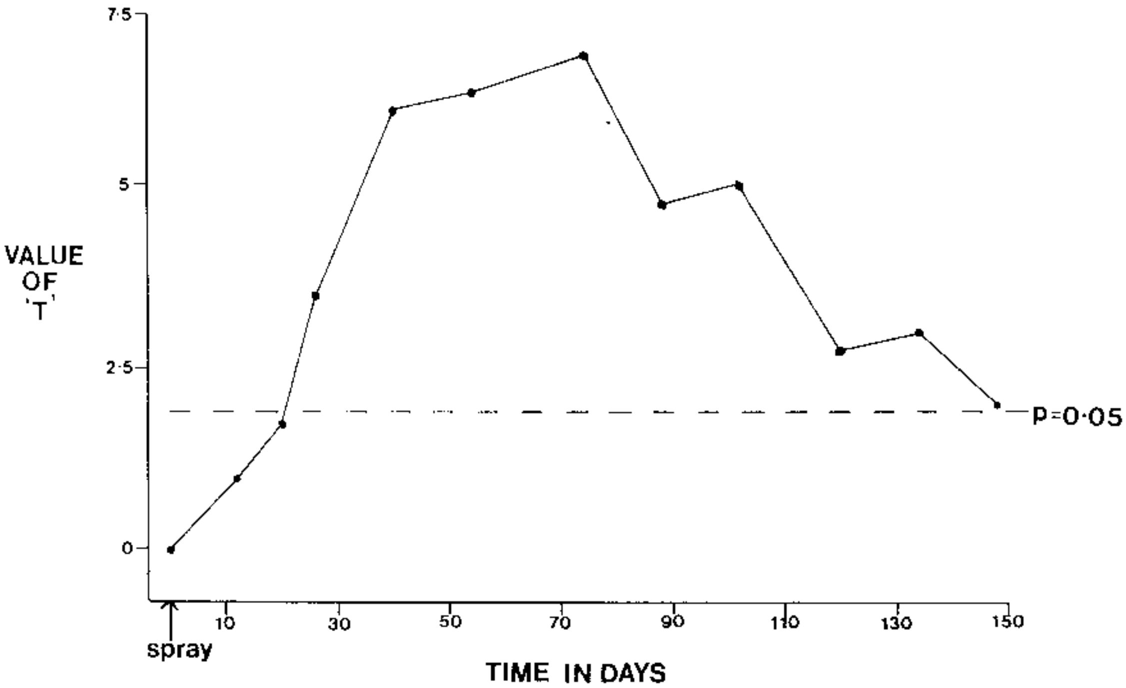

Figure 2. The value of the 't' statistic comparing the mean number of coleopteran larvae over 5 mm in length caught in the treated and untreated plots. The 5% threshold of statistical significance is indicated by the dashed line. Timescale as for figure 1.

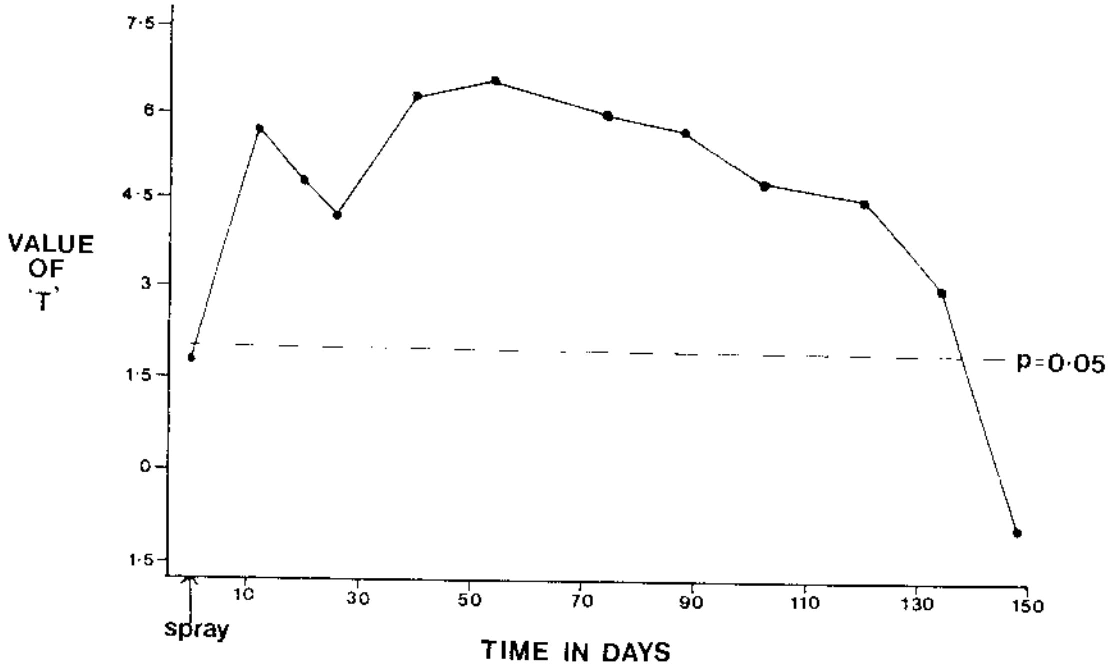

Figure 3. The value of the 't' statistic comparing the mean number of adult Coleoptera caught in the treated and untreated plots. The 5% threshold of statistical significance is indicated by the dashed line. Timescale as for figure 1.

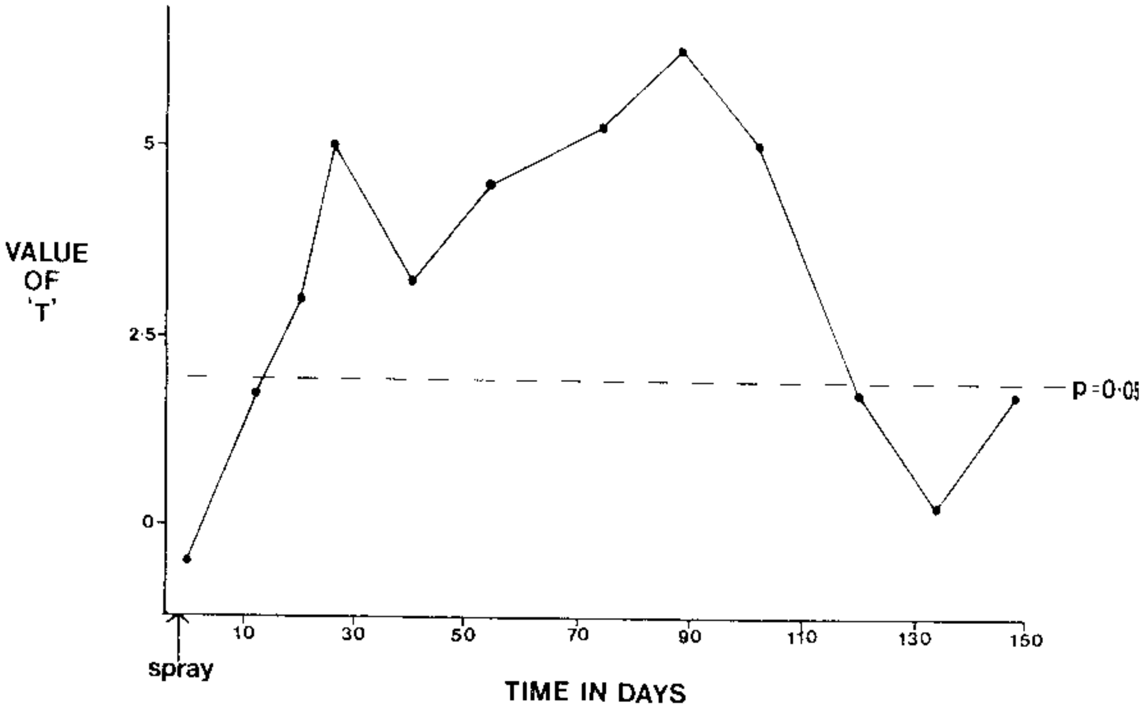

Figure 4. The value of the 't' statistic comparing the mean number of Collembola caught in the treated and untreated plots. The 5% threshold of statistical significance is indicated by the dashed line. Timescale as for figure 1.

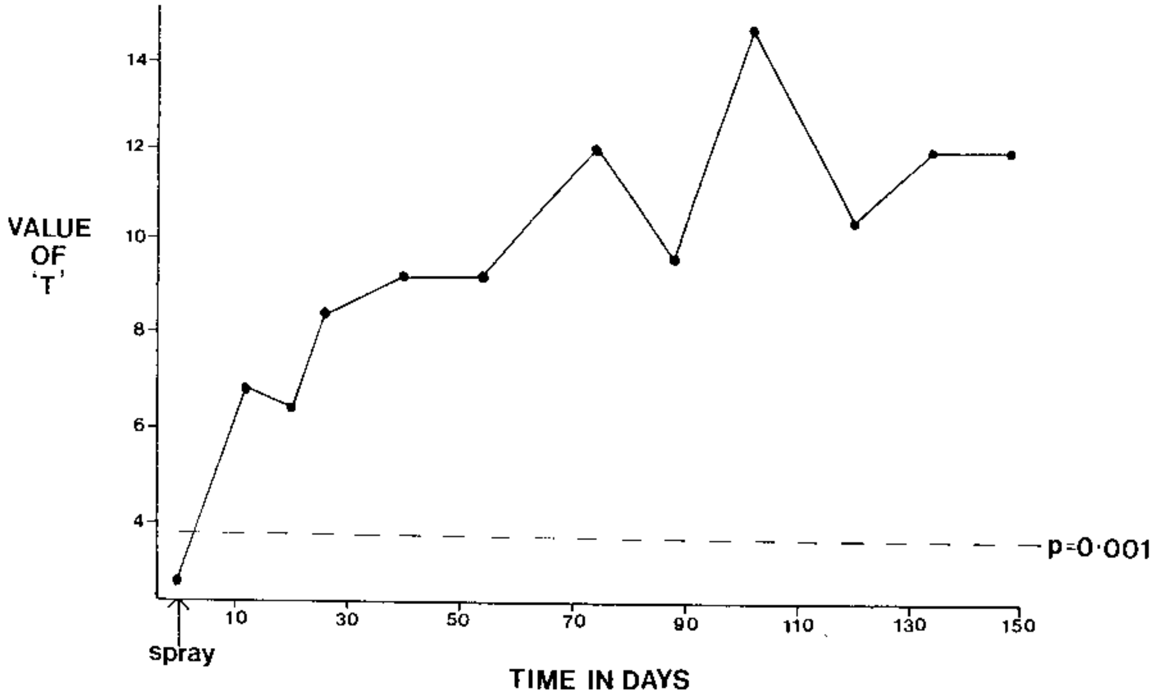

Figure 5. The value of the 't' statistic comparing the mean number of Arachnida caught in the treated and untreated plots. The 0.1% threshold of statistical significance is indicated by the dashed line. Timescale as for figure 1.

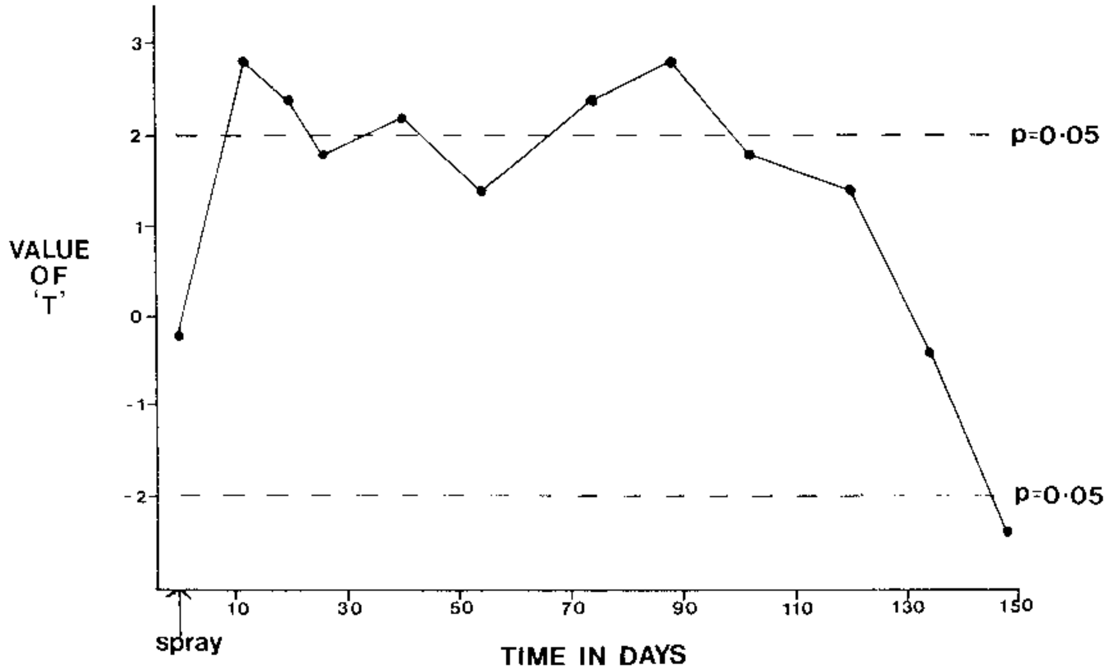

Figure 6. The value of the 't' statistic comparing the mean number of Diptera caught in the treated and untreated plots. The 5% threshold of statistical significance is indicated by the dashed line. Timescale as for figure 1.

3.8 Diptera over 3 mm length (Fig. 6): As with other groups, a significant effect was achieved after about 10 days. The difference remained at around the 5% significance level until about 120 days. At this point a very rapid population recovery took place which resulted in a significant <u>increase</u> in the dipteran population of the treated plot compared to the untreated one after 150 days. This increase is indicated by a negative value of the t statistic in Fig. 6. The population recovery coincided with that of the collembolan population and may have resulted from the emergence of adults from pupae under the soil surface in response to warmer weather or from immigration of winged individuals. The large reduction in the numbers of spiders, said to consume up to 30-50% of emerging dipterans in some situations (Curry, 1987) may have allowed the population in the treated area to overshoot its normal levels.

4. DISCUSSION

4.1 Bird numbers: The data on the birds themselves are inconclusive. Despite the fact that the airfield frequently held in excess of 2000 lapwings, gulls and golden plovers and usually several hundred starlings, the birds moved around the airfield whilst feeding and were on the plots quite infrequently. This fact, combined with the gradual reduction in numbers as birds moved out in response to colder weather resulted in a sparse data set, especially in the midwinter period when the effect of the chemical was at its maximum. The lack of significant differences between the numbers of birds feeding on treated and untreated areas should not, at this stage, be taken as an indication that the candidate lumbricide has no potential as a bird control agent. Further work, during periods of higher bird numbers, is planned for 1990-91.

4.2 Worm numbers: No significant differences were detected betwen the two plots either before or after the application of the lumbricide. There are three possible explanations for this result. Firstly, that the chemical itself was ineffective or improperly applied. This seems unlikely in the light of the highly significant effect on the soil surface invertebrates. Secondly, the sampling technique used may not have been sensitive enough to detect small changes in worm populations relative to the variability in their distribution. This also appears unlikely, as the constant values of mean and standard error for all three samples taken from the unsprayed section indicate that the technique copes with the variability to give a repeatable measure of abundance. The third possible explanation is that the chemical may have failed to penetrate below the soil surface in sufficient quantity to be effective due to the long grass (15-20cms) on the experimental plots. This seems the most likely explanation since the chemical formulation is usually employed on golf greens or other amenity turf which is normally kept short. Caithness (1986) suggests that long grass, with a dense layer of dead material at the soil surface, may prevent the effective penetration of liquid based Lumbricides to the soil. Lumbricides may, therefore, be more effective on short grass areas bordering runways and taxiways where birds often gather to feed on worms, particularly during periods of wet weather when worms are closer to the surface.

4.3 Soil surface invertebrates: The chemical had a profound effect on the numbers of several invertebrate groups likely to form part of the diet of problem bird species on airfields. Those groups trapped in sufficient numbers to allow meaningful analysis showed broadly similar patterns, with significant reduction in numbers after about 10 days, the maximum differential between sprayed and unsprayed areas after 50-70 days and recovery, (except in the case of arachnids) after 100-150 days. These timings should be interpreted with care, however, since pitfall trapping is dependent on the activity levels of the invertebrates and hence on temperature. If, for example, the chemical reduces activity in those individuals it does not kill, or changes their response to variations in temperature, then the maximum effect at 50-70 days could be a measure of differences in activity levels at that time rather than in numbers. The recovery times and time of maximum effect are likely to be shorter in the summer when higher temperatures will result in greater general activity and increased reproduction, allowing recovery of populations by immigration and reproduction to proceed more quickly. Some difficulty is therefore likely to be encountered in targeting what is a broad spectrum and fairly persistent pesticide against invertebrate groups other than worms.

The main problem likely to be encountered if lumbricides are used regularly on airfields is the disruption of the grassland ecosystem. The removal of worms, which are known to contribute to soil structure and fertility (Curry, 1987) may lead to drainage problems and poor grass growth if repeated over a number of years. Increased expense may result if spiking of the turf and the application of fertilizers are subsequently required. The removal of grassland predators such as spiders may result in a superabundance of their prey species later in the year. If this occurs further insecticide applications may be required to control population explosions of some species that would not otherwise have posed a problem, but which could be major bird attractants.

5. CONCLUSION

The ultimate test of any bird control measure is whether it reduces the number of birds, and hence the risk of a birdstrike, on a particular area. This investigation has not been able to prove that the lumbricide was effective in achieving this aim. The data do suggest, however, that the use of this lumbricide will reduce the numbers of a variety of invertebrate species which may form part of the diet of birds on airfields. The fact that the chemical did not appear to penetrate effectively long grass swards and did not reduce worm numbers significantly suggests that its greatest potential is for use on short grass areas bordering runways and around other installations. The limited use of lumbricides in these areas also avoids the potential for large scale disruption of the grassland ecosystem resulting in problems caused by unchecked population increases in certain species which would require further expensive chemical control.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Baars, M.A. (1979). Catches in pitfall traps in relation to mean densities of Carabid Beetles. Oecologica 41: 25-46.

Barnard, C.J. & Thompson, D.B.A. (1985). Gulls and plovers, Croom Helm, London.

Brough, T. & Bridgman, C.J. (1980). An evaluation of long grass as a bird deterrent on British Airfields. Journal of Applied Ecology, 17: 243-253.

Caithness, T.A. (1986). A granulated insecticide to control invertebrates on airfields. B.S.C.E. 18, WP 24.

Civil Aviation Authority. (1981). Bird Control on Aerodromes. CAP 384. Civil Aviation Authority, London.

Cramp, S. & Simmons, K.E.L. (Eds) (1983). The birds of the Western Palearctic Vol. III. Oxford University Press, Oxford.

Curry, J.P. (1987). The invertebrate fauna of grassland and its influence on productivity. I. The composition of the Fauna. Grass and Forage Science, 42: 103-120.

Edwards, C.A. & Lofty, J.R. (1972). The Biology of Earthworms. Chapman and Hall, London.

Ministry of Agriculture, Fisheries and Food, Health and Safety Executive (1988). Pesticides 1988, HMSO London.

Southwood, T.R.E. (1978). Ecological Methods. Chapman and Hall, London.

Tomlin, A.D. & Spencer, E.Y. (1976). Control of Earthworm Populations at Windsor International Airport through the Application of the Fungicide Benomyml. Field Note No. 70, National Research Council of Canada.