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A SURVEY OF DICOTYLEDONOUS WEEDS IN SPRING SOWN CEREALS IN NORTH EAST SCOTLAND

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Summary In May of 1973, a survey of dicotyledonous weeds in spring sown cereals was carried out in North East Scotland. The survey area was split into six districts. A total of 115 fields on 61 farms was sampled. In each field weed counts were made in 20 quadrats each 1 sq ft. A characteristic North East weed flora was found based on seven species:- Stellaria media, Galeopsis spp., Polygonum aviculare, Spergula arvensis, P. persicaria, Viola spp., and Ranunculus repens. These accounted for 84 per cent of the total weeds.

Considerable differences were found in the proportions in which these species occurred in the various districts. These are related to soil characteristics and farming systems.

INTRODUCTION

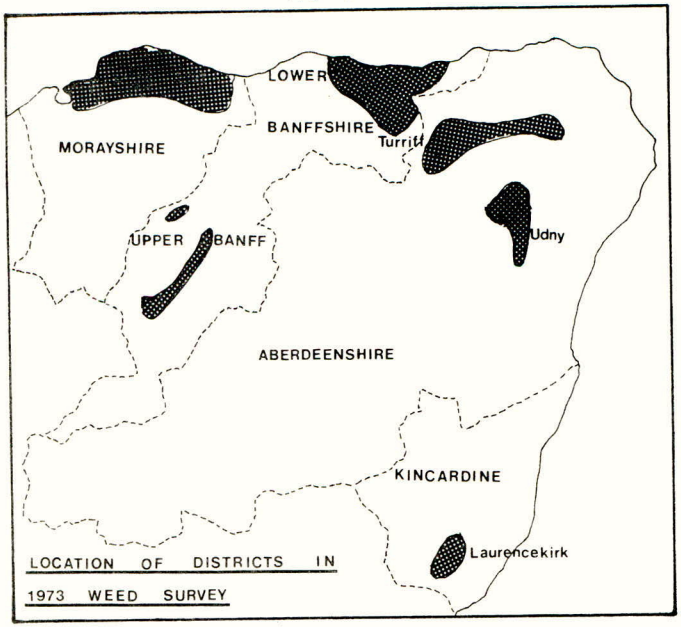
There have been suggestions, based on personal observations, that the weed problems of North East Scotland are different from those of other parts of Britain. In particular, Galeopsis tetrahit, G. speciosa and Spergula arvensis are widespread and abundant. It appears that, in Britain, only in the Fens does Galeopsis rank so highly in importance. In 1967 and 1968 the North of Scotland College of Agriculture carried out a survey of 31 farms throughout the region to assess the effectiveness of spraying in controlling weeds in barley crops (Scragg 1970). This produced useful data on the nature of the weed flora and confirmed that Galeopsis spp. ranked second only to Stellaria media in frequency and abundance.

Fisons national weed survey (O'Leary 1972) was based on visual assessments of the level of weed infestation and it was felt that their figures for Scotland were not representative of the North East. It was therefore decided to carry out a rather larger scale survey from that of 1967-68 to record the abundance and relative significance of dicotyledonous weed species in spring sown cereals. North East Scotland is by no means a homogeneous region in terms of climate, soil type and farming systems and the survey was designed so as to reveal any major differences in the composition of the weed flora in districts within the region. A weed survey of Finland (Mukula, Raatikainen, Lallukka and Raatikainen 1969) provided a useful guide to technique.

METHODS

Probably the best method of assessing the potential weed problem of an area is to determine the number of viable seeds of the various species in the soil. This method was tried but found to be far too laborious to be practicable on a large enough scale. The method which was adopted was to count the seedling weeds just before herbicide spraying operations began in May. Plant counting methods were considered to be more exact than the various visual estimations of vegetation which have been devised. Counts are repeatable without the difficulty of different observers making different assessments, but the method does take much longer. Because of the small number of people available and the short time between maximum emergence of the weed seedlings and crop spraying, it was decided to restrict the sampling to non-undersown spring cereal fields in six districts (see Fig. 1).

FIG 1.



In each of the districts, the local Agricultural Adviser compiled a list of farmers who were willing to co-operate with the College. Ten or 11 farms were visited in each district. In almost all cases the crop was barley. Oats were encountered on the upland farms of Upper Banffshire.

The field was chosen as the sampling unit. Some of the Upper Banffshire farms had only one field in a cereal crop. In all the other districts, however, two fields were taken at random on each farm. In total, 115 fields were sampled. Twenty sq ft quadrats were examined per field. An even coverage was achieved by roughly quartering the field and examining five quadrats across each quarter. The numbers of seedlings of each dicotyledonous annual and perennial weed species were recorded. Shoots of perennials were very few in number and were not recorded. In addition, a note was taken of any species present in the field which was not included in the quadrats.

A soil sample was removed from the surface layer of each quadrat after counting and the 20 samples from a field were bulked and mixed on the spot. Two sub-samples were taken back for analysis. The samples were air-dried and kept until the field-work was completed. A mechanical analysis was carried out using the Hydrometer Method (Bouyoucos 1927) to find the percentage of sand, silt and clay. The percentage loss on ignition was also determined on samples of oven-dried soil as a measure of the organic matter present.

Two people, with occasional assistance, completed the survey within a period of three weeks, commencing at the beginning of May. The average time taken to sample a field was 50 minutes. This varied, depending on the size of the field and the density of the weed infestation. A total of about 300 man hours was spent on the survey and of this about 200 hours was spent in travelling. Repeated visits were necessary to most districts, as not all the fields in a district were ready for counting at one time.

It will be seen that a counting method is practicable in a survey on this scale and it is believed that the accuracy of the results is much higher than would have been obtained by a quicker visual scoring method of assessment.

RESULTS AND DISCUSSION

In assessing the contribution that the various weed species make to the local flora, no attempt has been made to compare their relative competitive importance.

Table 1 shows the frequency of occurrence of 24 weed species found in the area as recorded by Fisons and the North College. Fisons' figures for their North of Scotland region have been made available (Edwards 1973). Because their survey method and area was different from that of the North College, and because their results are presented on an acreage basis, direct comparisons are not possible. There is strong agreement, however, on Galeopsis spp., Stellaria media and Chenopodium album. Major differences are apparent in the ranking of some species. In particular, the brassica weeds rank very highly in the Fisons' survey compared with those of the College. Species such as Capsella bursa-pastoris, Polygonum convolvulus, Spergula arvensis, Tripleurospermum maritimum and, notably, Viola spp. are given a very much lower ranking by Fisons. The differences may be the result of the surveying techniques used. The last five species tend to be much less conspicuous than Galeopsis at the immediate pre-spraying stage.

In an attempt to combine data for frequency and density, three threshold levels of infestation are presented, the percentage of fields with an average of at least one seedling per 20 sq ft, 20 seedlings per 20 sq ft and 100 per 20 sq ft. At one per 20 sq ft species which are casuals, present at a low level in a field, are included. At 20 per 20 sq ft these minor species are eliminated. At 100 per 20 sq ft 11 species remain and only seven of these are present in more than 2 per cent of all fields.

At the level of 20 seedlings per 20 sq ft the 1967 and 1973 surveys are directly comparable. There is good agreement over most of the species. The main exceptions are the figures for Polygonum aviculare and the Brassica weeds. The percentage of fields in which P. aviculare was recorded at this level was considerably higher in 1973. The Brassica weeds, on the other hand, appear to have declined.

Table 1

Percentage fields infested with common dicotyledonous weeds of spring cereals in the North of Scotland

	Fisons	College of Agriculture			
		Threshold levels			
		1 per 20 sq ft	20 per 20 sq ft		100 per 20 sq ft
	1972	1973	1967	1973	1973
Capsella bursa-pastoris	7	57	-	4	0
Chenopodium album	58	48	15	8	2
Chrysanthemum segetum	7	4	3	2	0
Fumaria officinalis	26	51	7	14	2
Galeopsis spp.	96	90	55	58	18
Galium aparine	12	0	0	0	0
Lycopsis arvensis	11	23	5	3	0
Myosotis arvensis	-	41	7	8	0
Papaver spp.	1	0	0	0	0
Polygonum aviculare	52	97	40	62	11
P. convolvulus	24	77	3	9	0
P. persicaria	51	90	32	30	7
Ranunculus repens (seedlings)	-	71	15	18	4
Raphanus raphanistrum	-	17	13	0	0
Rumex spp. (docks) (seedlings)	7	29	-	1	0
Rumex spp. (sorrels) (seedlings)	-	13	-	0	0
Sinapis arvensis	85*	42	17	10	2
Sonchus spp.	0	44	-	0	0
Spergula arvensis	47	94	52	61	11
Stellaria media	72	99	82	86	53
Tripleurospermum maritimum	20	78	15	16	4
Urtica urens	4	1	0	0	0
Veronica spp.	6	32	3	4	0
Viola spp.	4	84	22	28	2

NB Fisons figures are a percentage of the acreage infested

* Sinapis arvensis and Raphanus raphanistrum combined

Table 2

The field occurrence of the major species in all districts

	Percentage total weeds	Percentage fields infested	Mean density plants/20 sq ft
Stellaria media	36	99	174
Galeopsis spp.	13	90	69
Polygonum aviculare	11	97	55
Spergula arvensis	11	94	56
P. persicaria	6	90	31
Viola spp.	4	84	22
Ranunculus repens	3	71	21
	84		

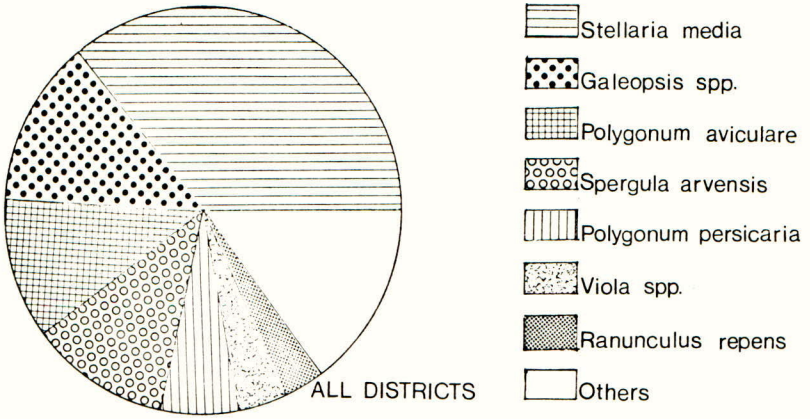
Table 2 shows the top seven weeds as a percentage of the total weeds for the region, as well as figures for their frequency and density. These weeds could be regarded as a North East weed association, the product of climate, soil and husbandry system. A contributory factor in its development could well be the widespread and long-term use of MCPA in the region. The status of Galeopsis spp. is interesting in this respect as it is classed as susceptible to MCPA. It does appear that control of this weed may be poor in practice and enough seed is returned to the soil to maintain the level of infestation.

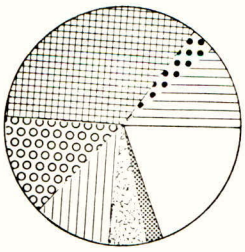
Figure 2 presents the major species as a percentage of the total weeds in each district. The districts all show a basically similar weed flora, but the proportions in which the species are present differs considerably.

Stellaria media accounts for only 11 per cent of the total weeds in Morayshire and 9 per cent in Upper Banffshire. In Laurencekirk the figure is 28 per cent, while in the other three districts, Stellaria media represents over 40 per cent of all weeds. In Morayshire Galeopsis is a minor weed at only 3 per cent of the total. In Laurencekirk, at 17 per cent it ranks next to Stellaria media. In Upper Banffshire it is 35 per cent of all weeds. P. aviculare is 34 per cent of the weeds of Morayshire but only 3 per cent of the Upper Banffshire total. R. repens is present at the same relatively low level in five districts but in Upper Banffshire it reaches 11 per cent of the total. Viola spp. are a much higher percentage (12) in Laurencekirk than in any other district.

FIG. 2

NUMBERS OF SEEDLINGS OF MAJOR SPECIES AS A PERCENTAGE OF TOTAL FOR ALL WEEDS





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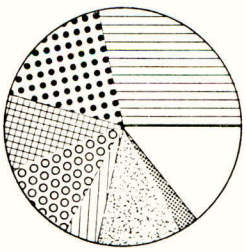
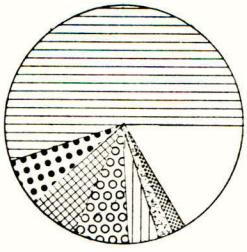
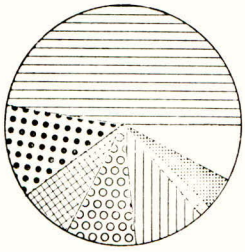


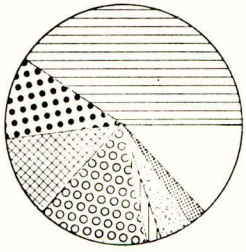
LAURENCEKIRK



LOWER BANFFSHIRE



UDNY



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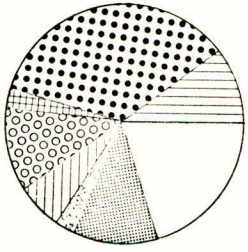

UPPER BANFFSHIRE

Table 3

The field occurrence of minor species according to district

Districts	Species occurring at > 2 per cent of district total	Percentage of total weeds	Percentage of fields infested	Mean density plants/ 20 sq ft
Moray (22)	Chenopodium album	5	73	23
	Lycopsis arvensis	3	73	12
	Polygonum convolvulus	2	91	8
Laurencekirk (15)	Sinapis arvensis	4	73	19
	Tripleurospermum maritimum	3	82	15
	Fumaria officinalis	2	68	13
	Chenopodium album	2	73	12
	Capsella bursa-pastoris	2	82	10
Lower Banff (18)	Fumaria officinalis	7	60	70
	P. convolvulus	2	75	19
Udny (7)	T. maritimum	3	95	19
Turriff (14)	T. maritimum	7	100	38
Upper Banff (21)	Sinapis arvensis	12	69	80

Figures in brackets are total percentage minor species according to district

When the "other species" percentages are examined and the main contributory species listed (Table 3) Laurencekirk emerges as a relatively species rich district with five species contributing almost equally. In Upper Banffshire, Sinapis arvensis alone accounts for more than half of the "others" percentage.

The high figure for Fumaria officinalis in Lower Banffshire is much inflated by a count of over 400 in one field. No explanation for this high infestation can be given. Lycopsis arvensis is a weed considered to be a problem in some parts of Morayshire. Fourteen per cent of fields sampled in the district were found to have the weed present at a level of one or more per quadrat. It was also recorded in Lower Banff and Turriff but at a much lower level of infestation. Chrysanthemum segetum is also thought of as a weed of the light soils of Morayshire. In the present survey it was found in only four fields at an average of 44 plants per 20 sq ft. It represented 2 per cent of the weeds of the district. It was not recorded outside Morayshire.

It is not easy to account for all the obvious district differences. Soil type, climate and cropping pattern almost certainly interact. Most of the site information collected, however, relates to soil type. Table 4 shows the summarised results of a Correlation Analysis carried out on the numbers of each species recorded in every field and the soil factors, percentage loss on ignition, sand, silt and clay content. The significant correlations are listed.

Table 4

Correlation between weed species and soil data

Species	Soil factor	Level of significance
	Loss on Ignition	
Spergula arvensis	Positive correlation	**
Stellaria media	Positive	**
Lycopsis arvensis	Negative	**
Polygonum aviculare	Negative	*
	Sand content	
Lycopsis arvensis	Positive	**
Rumex spp. (sorrels)	Positive	*
Stellaria media	Negative	**
	Silt content	
Galeopsis spp.	Positive	*
Stellaria media	Positive	*
Lycopsis arvensis	Negative	**
	Clay content	
Stellaria media	Positive	**
Tripleurospermum maritimum	Positive	*
Lycopsis arvensis	Negative	**
Chrysanthemum segetum	Negative	*

The soils of Morayshire are sandy with, on the whole, fairly low levels of organic matter. The soils of the survey fields were either sandy loams or loamy sands. The analysis summarised in Table 4 would seem, therefore, to offer a reasonable explanation for the relatively low level of Stellaria media in the district, the high level of P. aviculare and the presence of Lycopsis arvensis and Chrysanthemum segetum.

In Upper Banffshire, the upland farms sampled, all over 800 feet, grow very little cereals. Turnips and swedes are almost the only other arable crops and the fields tended to have rather few weed species although the numbers of individuals were very high. Spraying was adopted more recently than on the lowland farms and, owing to the length of the grass leys, less frequently carried out.

Laurencekirk with its intensive arable cropping on fairly flat, loamy soil is presumably more like mid or South East Scotland than the typical farming pattern of the rest of the North East. A difference in the weed flora might therefore be expected. The Aberdeenshire districts of Udny and Turriff appear to be very similar to Lower Banffshire in the frequency and abundance of most species.

Acknowledgements

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References

BOUYOUCOS, G.J. (1927) The Hydrometer as a new method for the Mechanical Analysis of Soils. Soil Sci., 23, 343.

EDWARDS, C.J. (1973) Personal communication.

MUKULA, J., RAATIKAINEN, M., LALLUKKA, R., & RAATIKAINEN, T. (1969) Composition of Weed Flora in Spring Cereals in Finland. Annales Agric. Fenniae, 8, 59-110.

O'LEARY (1972) Broad-leaved weed infestations in cereals. Fisons Agtec., Spring Edition, 37-41.

SCRAGG, E.B. (1970) Yield Response to Spraying for Weed Control in Barley. Proc. 10th Br. Weed Control Conf.

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A SURVEY OF RAGWORT IN ORKNEY

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Summary A survey of grassland in Mainland Orkney and the islands of Burray and South Ronaldsay revealed that 31 per cent of farms have a ragwort problem of economic proportions. Of the two infesting species, Senecio jacobaea and S. aquaticus, the latter was found to be by far the more important except in Burray. The problem appeared to be the product of a combination of environmental and management factors. Ragwort density was correlated positively with soil surface wetness and sward age, and negatively with sheep stocking rate. It apparently bore no relation to cattle stocking rate, nitrogen application or farm acreage.

INTRODUCTION

The economy of the Orkney Islands centres very firmly on beef production, and to a lesser extent on dairy farming, based on grazed and conserved grass. Eighty-six per cent of the area of cultivated land in the county is under grass, compared with only 65 per cent in Scotland as a whole. Any problem affecting grassland is therefore potentially very important to the Orkney economy.

Ragwort (Senecio jacobaea and S. aquaticus) is such a problem. In the last few years many cattle deaths due to ragwort poisoning have been recorded in Orkney, most of them being attributable to ragwort-contaminated silage. According to local observers, the weed is visibly increasing in range and density. It was against this background that a survey of ragwort in Orkney grassland was planned and executed in the summer of 1973. A survey of ragwort in Anglesey and Pembrokeshire, Wales in similar circumstances was reported by Davies (1953).

The Orkney survey had three main objectives: to assess the scale of the problem; to determine the relative importance of S. jacobaea and S. aquaticus; and most important, to find which environmental and management factors are associated with ragwort infestations. Armed with this knowledge, it should be possible to suggest alterations in grassland management which would help to control the weed.

METHOD

The area surveyed included the whole of Mainland Orkney and the islands of Burray and South Ronaldsay (Fig. 1). The other fourteen inhabited islands were not visited because of transport difficulties, but they also appear to be badly infested.

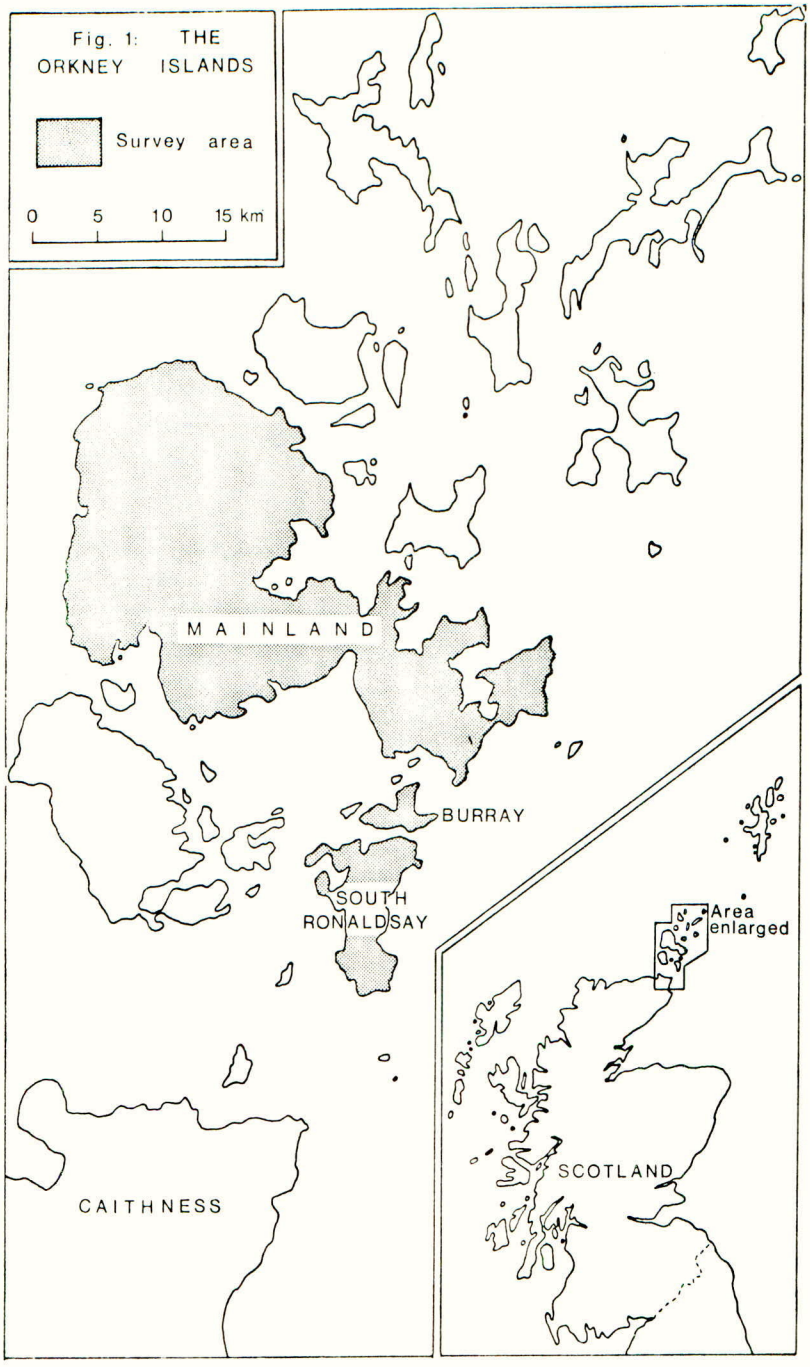
Fig. 1: THE ORKNEY ISLANDS
Survey area
0 5 10 15 km
MAINLAND
BURRAY
SOUTH RONALDSAY
CAITHNESS
Area enlarged
SCOTLAND

From a list of all farms in the survey area, 100 farms were selected by stratified random sampling, so that a similar proportion of all farms in each parish was selected. Ninety-six farms were actually visited, representing about 10 per cent of all holdings. All the field-work was carried out by the author himself in order to minimise error arising from subjective methods of assessment.

On the first visit (in May 1973), each farmer was asked for certain information about his farm as a whole (including acreage, nature of enterprise, and numbers of cattle and sheep), and to give an assessment of the scale of his ragwort problem if any, based on the number of his fields which he considered to be badly infested. Two grass fields were then selected at random on the farm, and details of the management of those particular fields over the past few years were obtained. The farmer's assessment of ragwort infestation in the sample fields was recorded.

On the second visit (in July 1973), various environmental characteristics were recorded for each field, and the density of ragwort plants was estimated on a 0-5 scale. This scale was calibrated by actual counts in specimen fields, and proved to be logarithmic (see Table 2). Farmers' assessments were generally in agreement with those of the author, a "badly infested" field in their judgment corresponding roughly to a score of 3 or over.

RESULTS

Scale of the Ragwort Problem

Table 1 shows the percentages of farms in the survey with different levels of ragwort infestation, based on the farmers' assessments in May 1973.

Table 1

Levels of infestation on farms in survey area

	Per cent of farms
No ragwort on farm	9
A little ragwort present in some fields	26
One field badly infested	33
More than one field badly infested	26
Whole farm badly infested	5

The question of what constitutes an economically important ragwort infestation is difficult to answer. It might be argued that the plant causes no economic loss unless and until stock die from ragwort poisoning. But the probability of deaths occurring is obviously greater in the 5 per cent of farms on which all grass fields are infested than on farms with lower levels of infestation. Where a farmer is restricted by ragwort in the number of fields from which he can safely conserve grass as hay or silage, the weed may well be causing an economic loss by hindering grassland management and reducing his productivity. Such restriction probably applies on farms belonging to the last two categories in Table 1. Thus ragwort causes economic loss on an estimated 31 per cent of farms in Orkney. Infestations occur on 65 per cent of all farms.

Table 2

Ragwort density assessment scale
Percentage of grassland acreage infested at different levels

Field score	0	1	2	3	4	5
Plants/100 m^2	0	0-1	1-10	10-100	100-1000	>1000
Per cent of acreage	46.0	28.0	14.3	6.4	4.2	1.1

From Table 2 it may be calculated that almost 12 per cent of the grassland area was infested at a density exceeding 10 ragwort plants per 100 square metres, and 26 per cent at a density exceeding one ragwort plant per 100 square metres.

Relative Importance of the Two Species

The existence of hybrids between Senecio aquaticus and S. jacobaea in Orkney is indisputable, since they occur wherever the two species meet (Harper 1958). Some observers are of the opinion that most of the so-called S. aquaticus plants forming infestations in Orkney grassland are in fact hybrids. This is a purely taxonomic question which does not affect any of the conclusions to be drawn from the results of this survey, and in this paper the name S. aquaticus will be used to refer to all ragwort except pure S. jacobaea.

S. aquaticus was recorded in 54 per cent of all fields sampled; S. jacobaea in only 6 per cent. In 3 per cent of all fields both species were recorded. Most of the S. jacobaea occurred on the relatively light sandy soil of Burray, but it appeared sporadically, sometimes on heavy wet soil, on Mainland Orkney.

Clearly the Orkney ragwort problem is essentially attributable to S. aquaticus; in this respect it is unusual in Britain, where S. jacobaea accounts for the great majority of ragwort infestations (Harper 1958). Davies (1953) reported that in the counties of Carmarthen, Cardigan and Pembroke in South West Wales infestations of S. aquaticus were widespread, although less common than infestations of S. jacobaea. S. aquaticus is known to be at least as poisonous as S. jacobaea, and possibly more so, at any rate to horses (Davies 1953). Infestations of both species have in Orkney been associated with death of cattle by ragwort poisoning.

Correlations with Environmental and Management Factors

A full statistical analysis of the survey results is not yet available, but in a preliminary analysis eight factors were examined for correlation with ragwort score:

acreage of farm (excluding rough grazing)

soil texture (1 = sandy, 5 = clayey)

soil surface wetness (1 = dry, 5 = very wet)

sward openness (1 = closed, 5 = almost bare)

(logarithm of) age of sward (years)

nitrogen application over past two years

cattle stocking rate

sheep stocking rate

When considered singly, only three of these factors showed correlations with ragwort score which were significant at the 5 per cent level: soil surface wetness (positively), age of sward (positively), and sheep stocking rate (negatively correlated).

None of these findings is surprising: sheep have been shown by observation (Poole and Cairns 1940; Saxby 1943) and experiment (Davies 1953) to exert a controlling influence on ragwort-infested grassland; ploughing is known (Harper 1958) to reduce temporarily the level of ragwort in grassland; and Senecio aquaticus, as its name suggests, is a plant of wet ground. What was surprising, however, was the absence of correlation between ragwort and any of the other five factors.

A multiple regression of ragwort score on all eight factors taken together threw up only the same three factors as having a significant effect on ragwort, and these three accounted for practically all the variation that was attributable to all eight. This confirmed the non-significance of such factors as cattle stocking rate and nitrogen application (indices of intensity of management), which might have been expected to show a negative correlation with ragwort score. The absence of correlation between ragwort and farm acreage dispelled the notion that this was essentially a problem of small holdings.

DISCUSSION

The ragwort problem in Orkney is, as already stated, unusual in that Senecio aquaticus is the main infesting species. In its scale it must also be unusual. Weed surveys tend to be restricted to areas where the weed in question is conspicuously abundant, and data are therefore lacking for the incidence of ragwort on, say, the mainland of Scotland. Davies (1953) estimated that in 1951 about 20 per cent of the grassland acreage in the Fishguard district of Pembrokeshire and 4 per cent of that in North West Anglesey had fairly severe ragwort infestation (over 3 on his 0-5 scale). If his scale is comparable with that used in this survey (see Table 2), the corresponding figure for Orkney is 11.7 per cent.

The climate of Orkney is not unique to those islands, and neither are the soils or the type of grassland management. The severity of the ragwort problem in Orkney cannot therefore be explained by any one of these factors. It must be the interactions between these three characteristics that make Orkney grassland such a favourable habitat for S. aquaticus. According to the Atlas of the British Flora (Perring and Walters ed., 1962), this species is distributed evenly throughout the British Isles: it is in no sense a "northern" species. As an agricultural weed it is more or less restricted to wet grassland, and in this respect its distribution has a westerly bias, but nowhere in Britain is it reported to be so much more abundant than S. jacobaea as in Orkney.

The clay soil deriving from Old Red Sandstone which covers much of Orkney tends to become impermeable near the surface, creating wet conditions under which S. aquaticus rapidly establishes itself. But the absence of correlation between ragwort and soil texture in this survey demonstrates that S. aquaticus is by no means confined to heavy soils.

An almost universal feature of Orkney grassland management is the late autumn grazing of cattle prior to housing for the winter. In 1972, the great majority of farmers left their stock on the grass until the first or second week of November, and some delayed even longer. The mild oceanic winters make this practice feasible in Orkney, but poaching of the swards is likely to occur, particularly on wet land, and create conditions suitable for invasion by ragwort (Harper 1958).

The observed relationship between ragwort density and sward age suggests that more frequent ploughing would reduce the scale of the problem. Indeed the apparent worsening of the problem over the past few years is probably to a large extent a consequence of the declining acreage of arable crops and particularly of roots in Orkney in favour of long ley grassland. It is doubtful whether the increased costs involved in more frequent ploughing would be economically justifiable.

Much of Caithness is climatically and edaphically similar to Mainland Orkney, yet S. aquaticus is virtually absent as a grassland weed from Caithness. The very much denser sheep population (3.39 per acre of grassland in Caithness, 0.77 per acre in Orkney, excluding rough grazing) is probably largely responsible for the difference. It would probably be unsafe to recommend the use of sheep to control heavy infestations of S. aquaticus, as there are well-documented cases of sheep poisoning by two closely related species, S. longilobus (Harris et al., 1957) and S. cineraria (Forsyth 1968). Forsyth also claims that despite popular belief sheep are susceptible to poisoning by S. jacobaea. Sheep grazing as a preventive rather than a remedial control method could, however, be recommended to maintain ragwort at a low level of infestation.

There is a widespread view that ragwort infestation is a symptom of bad grassland husbandry. Grassland that is managed intensively, with high fertiliser inputs and heavy cattle stocking, is normally free of ragwort. Neither nitrogen application nor cattle stocking rate was correlated with ragwort in the Orkney survey, but the sample included only 22 out of 192 fields which received more than 60 units of nitrogen per year, so that no generalisation can be made about the survival of ragwort under very intensive nitrogen regimes.

It appears, therefore, that the ragwort problem in Orkney is a product of the combination of climatic, soil and management factors obtaining there, and its solution must lie in the adoption of a system of management more appropriate to the ecological characteristics of Orkney grassland.

References

DAVIES, A.J. (1953) The ragwort problem in Wales. Proc. 1st Br. Weed Control Conf. 204-210.

FORSYTH, A.A. (1968) British Poisonous Plants. M.A.F.F. Bulletin No. 161.

HARPER, J.L. (1958) The ecology of ragwort (Senecio jacobaea) with especial reference to control. Herb. Abstr., 28, 151-157.

HARRIS, P.N., HENDERSON, F.G. & CHEN, K.K. (1957) Hepatic cirrhosis induced in sheep by Senecio longilobus. Arch. Path., 64, 297-302.

PERRING, F.H. & WALTERS, S.M., ed. (1962) Atlas of the British Flora. Botanical Society of the British Isles.

POOLE, A.L. & CAIRNS, D. (1940) Botanical aspects of ragwort (Senecio jacobaea L.) control. Bull. N.Z. Dep. scient. ind. Res., 82, 1-61.

SAXBY, S.H. (1943) Perennial weeds. N.Z. Jl Agric., 67, 407-410.