

Pesticide Usage in Scotland



A National Statistics Publication for Scotland



Rodenticide Use on Grassland & Fodder Farms 2013

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Executive summary

This report presents the results of a survey of rodenticide use during 2013 on farms growing grassland and fodder crops. This is the fifth survey of rodenticide use on farms growing fodder crops, but the first to include supplementary data collected from grassland farms. This represents a major improvement in survey scope, allowing estimation of rodenticide use on all farms growing stock-feeding crops for the first time. Due to the change in the number and type of farms sampled, comparisons to previous surveys refer only to estimates of use on farms growing fodder crops.

Data were collected from 444 holdings, distributed throughout Scotland, which collectively represented 16 per cent of the fodder crop area and 5 per cent of the grassland area. Rodenticides were used on 72 per cent of the farms sampled. On the majority of farms using rodenticides, baiting was conducted by farmers (60 per cent). However, the use of Pest Control Professionals (PCPs) to conduct rodenticide baiting on fodder farms has significantly increased over time, from 18 per cent in 2002 to 48 per cent in 2013.

An estimated 217 tonnes of rodenticide bait was used on Scottish grassland and fodder farms in 2013. However, anticoagulant rodenticides are effective at very low concentrations and this bait contained less than 11 kg of rodenticide active ingredient. Almost all products used (> 99 per cent) were second generation anticoagulant rodenticides (SGARs), predominantly bromadiolone and difenacoum, which together accounted for 95 per cent of total rodenticide products by weight. The occurrence of first generation anticoagulant rodenticides (FGARs) on fodder farms has significantly decreased since 2002.

The majority of rodenticides (75 per cent) were applied throughout the year, either as permanent use of bait or as multiple baiting operations on the same farm. When broken into season of use, more rodenticides were used in autumn and winter (59 per cent) than in spring and summer (41 per cent). Grain baits were the most commonly used bait type (80 per cent of total use).

For the first time in this survey series, data was collected about user training, compliance with best practice and aspects of farm operation that might affect rodenticide use pattern. All PCPs and 12 per cent of farmers reported they had attended a training course on rodenticide use; representing a significant difference in training uptake. In relation to best practice, the majority of respondents stated that they complied with all elements, with the exception of removal of bait following a targeted baiting period which was adopted by just under half of farmers. The only question which elicited a significantly different response between farmers and PCPs related to carcass removal. All PCPs stated that they searched for and removed rodent carcasses compared to 71 per cent of farmers. In relation to farm operation, farmers that practised rodenticide baiting were significantly more likely to be members of a quality assurance scheme. In addition, farmers using rodenticides were significantly more likely to have a grain store than farmers that did not use rodenticides.

Introduction

The Scottish Government (SG) conducts post-approval surveillance of rodenticide use. This monitoring is conducted by the Pesticide Survey Unit at Science and Advice for Scottish Agriculture (SASA), a division of the Scottish Government's Agriculture, Food and Rural Communities Directorate. As part of this programme a survey of rodenticide use on farms growing grassland and fodder crops was conducted.

This is the fifth survey reporting rodenticide use on farms growing fodder crops, but the first to include additional data collected from grassland farms. The addition of a supplementary grassland farm sample allows estimation of rodenticide use on all Scottish farms growing grass and stock-feeding crops (ca. 42,000 holdings), not just those growing fodder crops (ca. 2,000 holdings). This represents a major improvement in the scope of this survey allowing estimation of rodenticide use on all farms growing stock-feeding crops for the first time.

Whilst the overall estimates from this report cannot be directly compared to the previous surveys in this series, summary data from surveys of rodenticide use on fodder farms conducted in 2002¹ and 2005 are included in this report to enable comparison with rodenticide use on farms growing fodder crops in 2013. It should be noted that no rodenticide data were collected in 2009 and also that the 2005 survey data have not previously been published and are presented here for the first time.

The Scottish Pesticide Usage reports have been designated as Official Statistics since August 2012 and as National Statistics since October 2014. The Chief Statistician (Roger Halliday) acts as the statistics Head of Profession for the Scottish Government and has overall responsibility for the quality, format, content and timing of all Scottish Government national statistics publications, including the pesticide usage reports. As well as working closely with Scottish Government statisticians, SASA receives statistical support from Biomathematics and Statistics Scotland ([BioSS](#)).

All reports are produced according to a published timetable. For information in relation to Pesticide Survey Unit publications and their compliance with the statistical code of practice please refer to the pesticide usage survey section of the [SASA website](#). The website also contains other useful documentation such as [confidentiality](#) and [revision](#) policies, [user feedback](#) and detailed background information on survey [methodology](#).

Additional information regarding pesticide use can be supplied by the Pesticide Survey unit. Please email psu@sasa.gsi.gov.uk or visit the survey unit webpage:

<http://www.sasa.gov.uk/pesticides/pesticide-usage>

Structure of report and how to use these statistics

This report is intended to provide data in a useful format to a wide variety of data users. The results and comparison section presents the results from this survey and also compares the data collected from fodder farms surveyed in 2013 with results from previous surveys of fodder farms¹. Comparisons are also made between the results of this survey and the 2012 survey of rodenticide use on arable farms².

Appendix 1 contains tables of survey results, including estimates of rodenticide use, responses to questions about compliance with best practice and information about sample farm operation. Appendix 2 summarises survey statistics including census and holding information, raising factors and survey response rates. Appendix 3 outlines the estimated financial burden to survey respondents. Appendix 4 defines many of the terms used throughout the report. Appendix 5 describes the methods used during sampling, data collection and analysis as well as measures undertaken to avoid bias and reduce uncertainty. Changes in method from previous survey years are also explained in Appendix 5.

It is important to note that the figures presented in this report are produced from surveying a sample of holdings rather than from a census of all the holdings in Scotland. Therefore the figures are estimates of total rodenticide use on Scottish grassland and fodder farms and should not be interpreted as exact.

Data uses

The Scottish pesticide survey dataset, which encompasses use of plant protection products and rodenticides, is used for a number of purposes including:

- To inform UK and Scottish Government Policy about the post-approval use of pesticides
- To aid Government officials in their response to Scottish Parliamentary and Ministerial questions regarding the use of pesticides
- To inform and complement research projects conducted by agricultural research institutions
- To inform and prioritise monitoring strategies of environmental quality bodies
- To provide data to the pesticide industry to allow insight into the use patterns of pesticidal products
- To provide information to interested or concerned environmental and wildlife groups and members of the public
- To provide an educational resource for teaching and student research projects

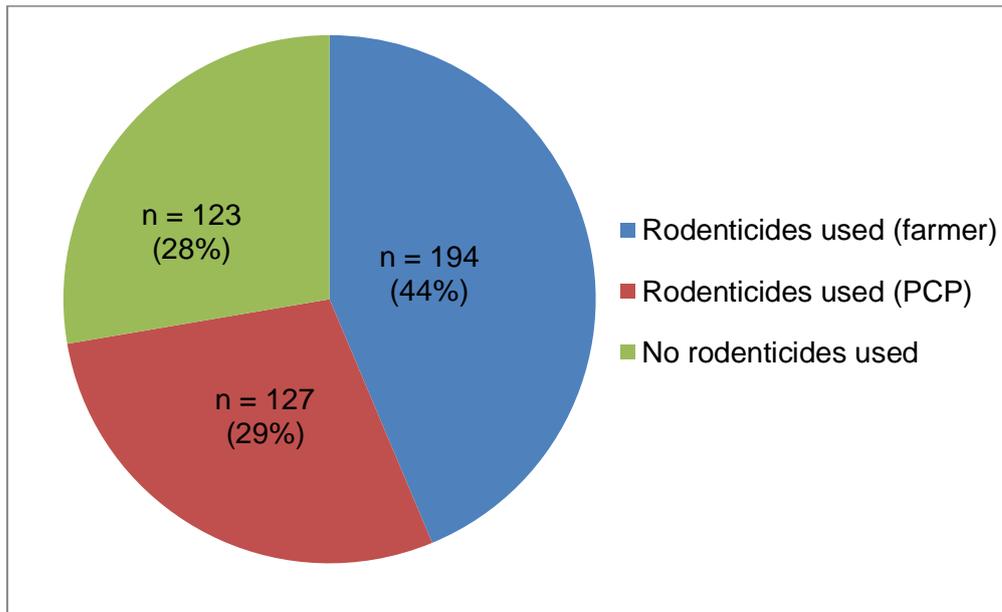
[Case studies](#) of how the Scottish dataset has been used are provided on the SASA webpage.

Results and comparison with other surveys

Proportion of farms using rodenticides and type of user

Seventy two per cent of the grassland and fodder farms surveyed used rodenticides during 2013 (Figure 1). On those farms where rodenticides were used (n = 321) baiting was conducted by pest control professionals (PCPs) on 40 per cent of holdings. On the remaining farms (60 per cent) rodenticides were applied by the farmer.

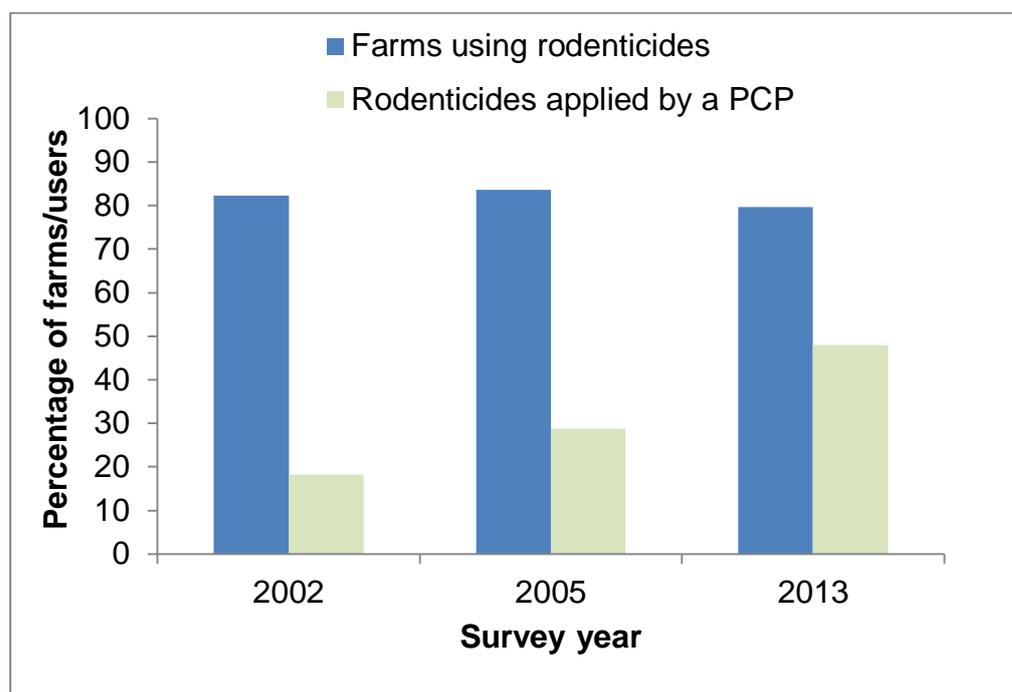
Figure 1 Number of grassland and fodder farms sampled using rodenticides and type of user 2013



The percentage of grassland and fodder farms using rodenticides in this survey is similar to the 78 per cent of arable farms which were reported to use rodenticides in 2012².

Rodenticide use on fodder farms was surveyed in 2002 and 2005 and data from these surveys may be compared to use on the fodder farms sampled in 2013 (Figure 2). The percentage of fodder farms using rodenticides was very similar among surveys (between 80 and 84 per cent). However, the percentage of fodder farms where PCPs conducted the baiting significantly increased over time ($P < 0.001$) from 18 per cent of farms using rodenticides in 2002 to 48 per cent in 2013. This is a similar trend to that found in surveys of rodenticide use on arable farms which are surveyed biennially. From 2002 to 2012² the percentage of arable farms using rodenticides fluctuated between 78 and 86 per cent, but the percentage of farms using PCPs to conduct their baiting significantly increased over time from 27 to 53 per cent ($P < 0.05$). This indicates, that on both arable and livestock farms, there is an increasing trend of farmers using PCPs to conduct rodenticide baiting.

Figure 2 Pattern of rodenticide use and type of users on farms growing fodder crops in Scotland 2002 to 2013



Note: increased use of PCPs on farms over time is statistically significant ($P < 0.001$)

Rodenticide compounds encountered and their estimated occurrence

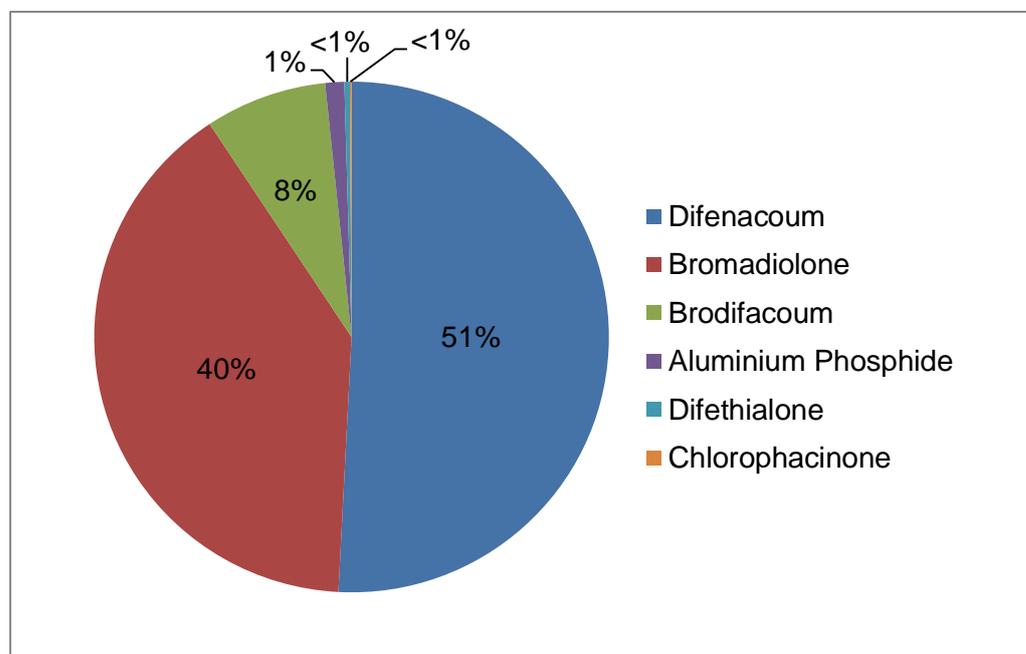
During this survey product information was recorded for 92 per cent of all occurrences of rodenticide use. For the remaining eight per cent, whilst it was recorded that rodenticides had been applied, the product used was not specified. This was either a result of farmers not having records of the product used or PCPs not responding to requests for details of use. This section only discusses specified use of rodenticides.

Six different compounds were encountered during the survey (Table 1 & Figure 3). Five were anticoagulant rodenticides, which prevent the synthesis of blood clotting factors resulting in rodent death by haemorrhage. The most commonly encountered compounds were second generation anticoagulant rodenticides (SGARs) which accounted for 99 per cent of all occurrences of specified rodenticide use. These included difenacoum (51 per cent of all occurrences), bromadiolone (40 per cent) and brodifacoum (eight per cent). Difethialone, the most recently approved SGAR, was estimated to account for less than one per cent of use and flocoumafen was not encountered. The dominance of difenacoum and bromadiolone use is accounted for by their being the only SGARs with approval for outdoor use at the time of this survey.

One first generation anticoagulant rodenticide (FGAR), chlorophacinone, was encountered on two farms. This chlorophacinone use was unapproved as the product's approval had expired in June 2011 and it should not have been used during 2013. Use of warfarin and coumatetralyl was not encountered during this survey.

One non-anticoagulant rodenticide, aluminium phosphide which releases toxic phosphine gas when applied to rodent burrows, was recorded. This compound accounted for one per cent of all rodenticide occurrences in the survey.

Figure 3 Estimated percentage occurrence of specified rodenticides on grassland and fodder farms in Scotland 2013



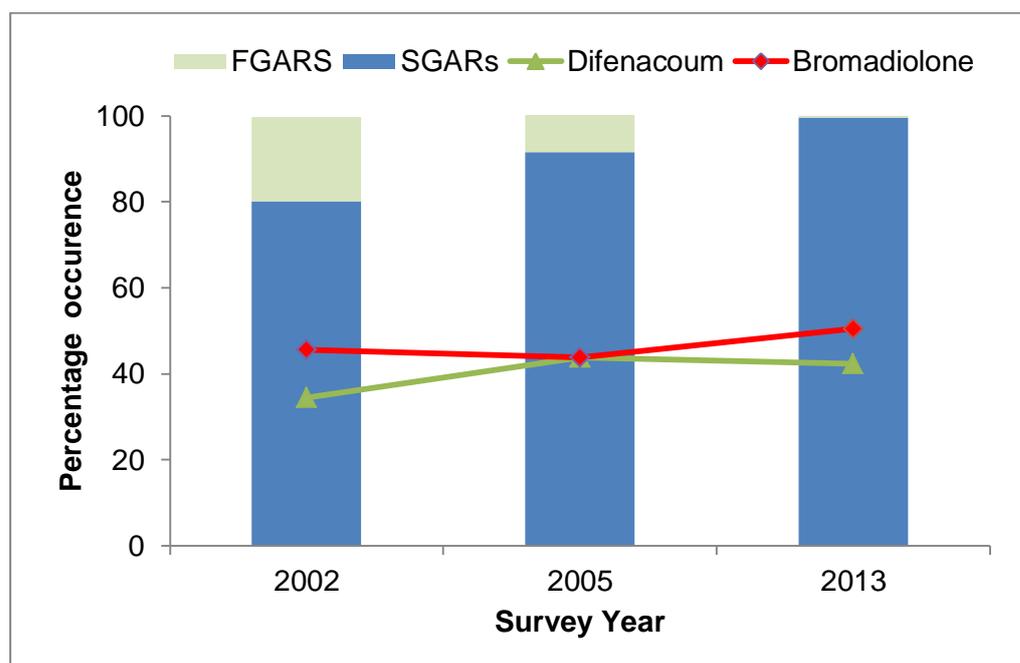
Note: as there were less than 10 occurrences of aluminium phosphide, chlorophacinone and difethialone in the sample, estimates of their use should be treated with caution.

The pattern of rodenticide occurrence encountered in this survey is very similar to that reported on arable farms in 2012². On arable farms SGAR use also accounted for 99 per cent of all occurrences and FGARs and non-anticoagulants accounted for less than one per cent. Bromadiolone and difenacoum were also the most commonly used compounds on arable farms, accounting for 58 and 37 per cent of use respectively.

Estimated occurrence of rodenticides on fodder farms from 2002 to 2013 is displayed in Figure 4. The occurrence of FGAR compounds significantly decreased from 20 per cent of total use in 2002 to less than 1 per cent in 2013 ($P < 0.001$). Conversely, the occurrence of SGAR compounds increased from 80 per cent to almost 100 per cent over the same time period. The majority of occurrences of use (80 to 90 per cent) throughout this period were bromadiolone and difenacoum.

This decline in occurrence of FGARs and increase in SGARS is similar to that found on arable farms. There was a statistically significant increase ($P < 0.05$) in SGAR occurrences on arable farms from 2000 (80 per cent of total) to 2012 (almost 100 per cent). Therefore, on both fodder and arable farms there is an increasing trend of SGAR use replacing FGARs over time.

Figure 4 Estimated occurrence of rodenticides on farms growing fodder crops in Scotland 2002 to 2013



Weight of rodenticide used

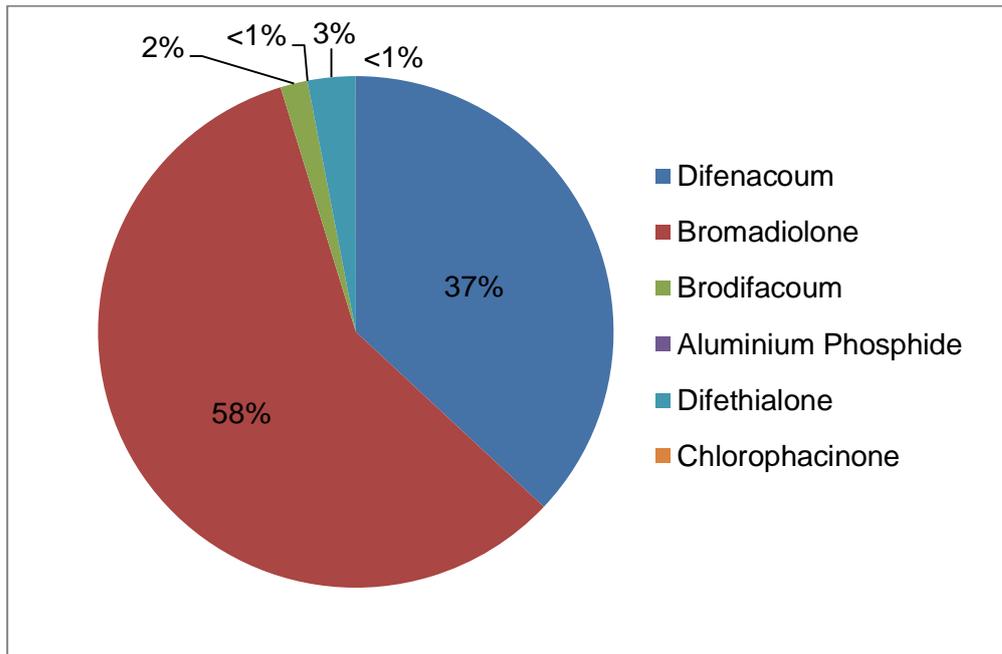
Almost 217 tonnes of rodenticidal products were estimated to have been used on grassland and fodder farms in 2013 (Table 2) and over 99 per cent of these were SGARs (Figure 5). Products containing bromadiolone were the most commonly used (ca. 126 tonnes), accounting for 58 per cent of total rodenticide use by weight. Difenacoum was the second most commonly used (ca. 80 tonnes, 37 per cent of total use).

Individual formulation weights, the weight of active ingredients present in the product not including baits, are presented in Table 3. Anticoagulant rodenticides contain very small amounts of active ingredient. Of the almost 217 tonnes of anticoagulant products applied, less than 11 kg were active ingredient, the remainder being food bait used to attract rodents.

The quantity of rodenticide product used on grassland and fodder farms in 2013 (ca. 217 tonnes) is almost 70 per cent more than was reported to have been use on arable farms in 2012 (ca. 130 tonnes). This reflects the larger number of grassland and fodder farms in Scotland (ca. 42,000 in 2013) in comparison to the number of arable farms (ca. 10,000 in 2012). Therefore although rodenticide use is estimated to be greater overall on grassland and fodder farms, use per holding is greater on arable farms.

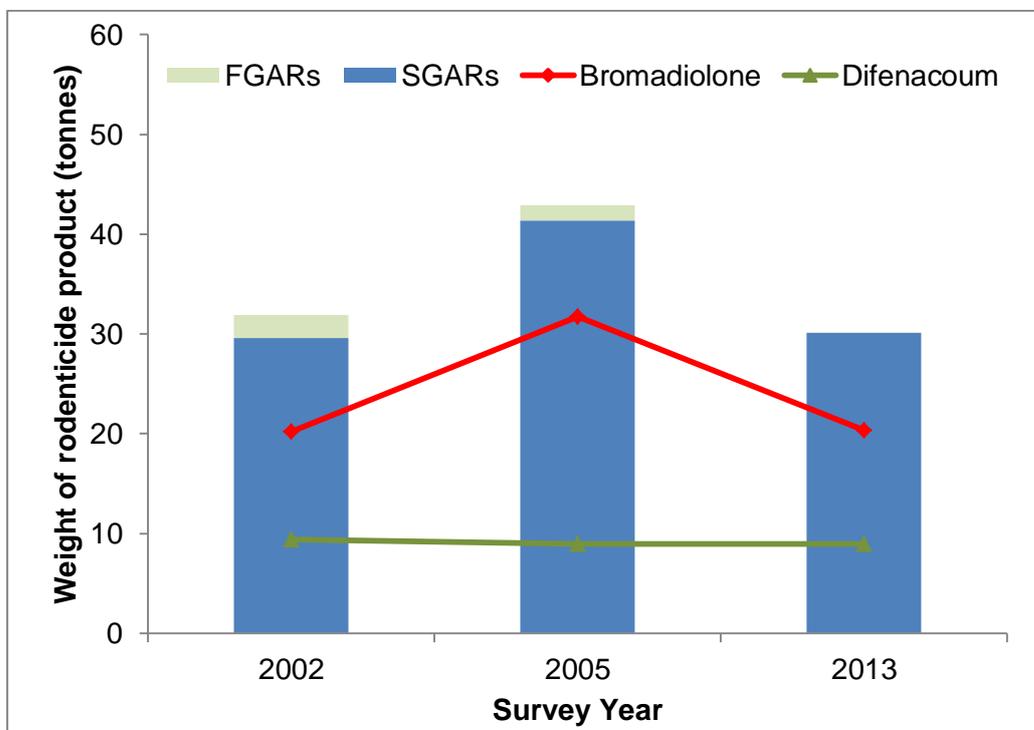
The weight of rodenticides used on fodder farms from 2002 to 2013 is presented in Figure 6. The weights used in 2002 and 2013 were very similar at ca. 30 tonnes. In 2005 around 25 per cent more rodenticide, almost exclusively bromadiolone, was estimated to have been used. The reason for this is not clear and may have been due to increased pest pressure in 2005.

Figure 5 Estimated percentage weight of rodenticide product used on grassland and fodder farms in Scotland 2013



Note: as there were less than 10 occurrences of aluminium phosphide, chlorophacinone and difethialone in the sample, estimates of their use should be treated with caution.

Figure 6 Estimated weight of anticoagulant rodenticide products used on fodder farms in Scotland 2002 to 2013

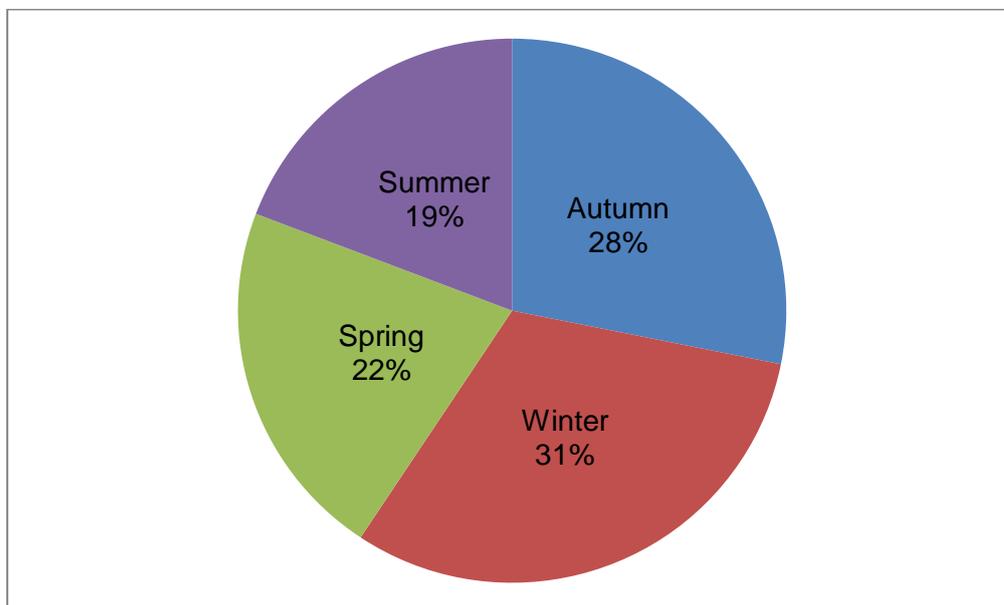


Seasonal use of anticoagulant rodenticides

The season of use was specified for almost 99 per cent of all anticoagulant rodenticides (Figure 7). Seventy five per cent of use was reported to occur throughout the year. This year-round use included both farms practising permanent baiting and those conducting multiple separate baiting operations.

When the quantity used, including year-round use, is separated into season, the greatest use was in winter and autumn (59 per cent) with less use in spring and summer. This is very similar to the seasonal rodenticide use pattern reported on arable farms in 2012 (63 per cent in autumn and winter and 37 per cent in spring and summer) and on fodder farms in 2002 (60 per cent in autumn and winter and 40 per cent in spring and summer). No information is available about seasonal use on fodder farms in 2005.

Figure 7 Seasonal use of anticoagulant rodenticides on grassland and fodder farms in Scotland 2013 (% total quantity)

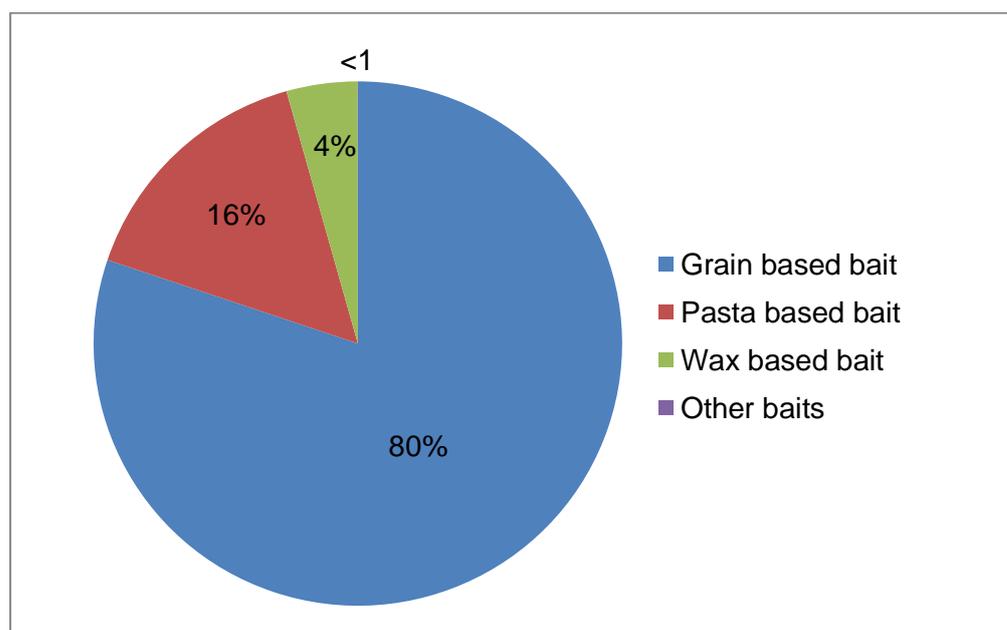


Anticoagulant rodenticide bait type

Baits formulated with grain were the most commonly encountered in this survey accounting for 80 per cent of use by weight (Figure 8). These baits included both loose grain and place packs containing grain. They also include a small amount of grain based paste (one per cent of total grain baits).

The next most frequently used type of rodenticide product was pasta based bait, which contributed to 16 per cent of the total bait used by weight, then wax baits which accounted for four per cent. Ninety three per cent of the wax baits were solid wax blocks whilst the other seven per cent consisted of soft wax bait. Other bait types, which included gel and rodenticide concentrate, accounted for less than one per cent of use. The use of rodenticide concentrate was unapproved, as the product's approval had expired in 2011.

Figure 8 Type of anticoagulant rodenticide bait used on grassland and fodder farms in Scotland 2013 (% total quantity)



Grain baits were also the most commonly applied baits in the survey of rodenticides on arable farms in 2012² (89 per cent of total product use by weight) and on fodder crops in 2002¹ (78 per cent). No information is available about bait type used on fodder farms in 2005. However, this is the first survey in which more pasta based rodenticide bait has been encountered than wax baits. Pasta baits, which are a relatively new form of rodenticide delivery, accounted for less than <1 per cent of bait used on arable farms in 2012².

Compliance with rodenticide best practice

All farmers and PCPs who were responsible for rodenticide baiting on the surveyed farms were provided with a questionnaire containing six questions concerning their training history and their compliance with the principles of best practice of rodenticide use (Table 4). Completion of the questionnaire was voluntary and it is important to note that no attempt was made to check the accuracy of the responses given.

Ninety eight per cent of farmers who conducted their own baiting (n=190) provided responses to the compliance questions. Seventy three per cent of the PCPs (n=24) also provided responses. These 24 respondents were collectively responsible for baiting on 72 per cent of the farms (n=93) using a contractor during this survey.

These data are expressed as percentage of respondents giving a positive answer to each question, where significant differences in the response between farmers and PCPs were found these are noted.

All PCPs and 12 per cent of farmers had attended a training course on rodenticide use. The uptake of training was significantly different between farmers and PCPs ($P < 0.001$).

All PCPs and 92 per cent of farmers stated that they recorded the quantity and location of baits and all PCPs and 98 per cent of farmers stated that these baits were protected from non-target animals.

Bait was reported to be regularly inspected by all PCPs and 97 per cent of farmers and 57 per cent of PCPs and 49 per cent of farmers removed the bait after targeted baiting periods.

All PCPs and 71 per cent of farmers stated that they searched for and removed rodent carcasses. Compliance with this element of best practice was significantly different between farmers and PCPs ($P < 0.001$).

The same compliance questions were asked during the arable 2012 survey and a similar pattern of responses was obtained. However in the arable survey only 14 per cent of PCPs stated that they removed bait after a targeted baiting period, which was significantly lower than the percentage of farmers (59 per cent) ($P < 0.01$). In addition, in the arable survey there was no significant difference between the number of farmers and PCPs reporting that they searched for and removed rodent carcasses.

Farm operation data

Farmers were asked to respond to a series of questions relating to aspects of their farm's operation which might affect rodenticide use pattern (Table 5). Seventy seven per cent ($n=344$) of the farms surveyed provided this information; this represented 88 per cent of farms that used rodenticides in 2013 and 50% of those not that did not use rodenticides.

The majority of farms surveyed (68 per cent) were a member of a quality assurance scheme. A range of assurance schemes were encountered; the most common were Quality Meat Scotland (QMS) and Scottish Quality Crops (SQC). Both of these schemes specify that effective rodent control measures must be in place, although the use of anticoagulant rodenticides is not mandatory. However, significantly more farms that practised rodenticide baiting were members of a quality assurance scheme (73 per cent) than farms that did not use rodenticides (48 per cent) ($P < 0.001$).

As the farms surveyed grow crops for stock-feeding the majority kept livestock on their holdings (91 per cent). Very few of these farms reared pigs or poultry and those that did, did so on a small scale (4 and 2 per cent of farms respectively). There were no significant differences in livestock rearing between farms that did or did not use rodenticides.

Lastly, farmers were asked if their holding had an on-farm grain store. A significantly greater number of farms using rodenticides had a grain store (39 per cent) than farms that did not use rodenticides (5 per cent) ($P < 0.001$).

These data may be useful in future to help inform surveyors and data users to what extent temporal changes in baiting pattern are in response to pest pressure or whether they are also influenced by operational differences which may vary with composition of the sample.

Appendix 1 – Estimated rodenticide use tables

Table 1 Estimated occurrence of rodenticide use on grassland and fodder farms in Scotland 2013

Number of occurrences of each rodenticide formulation and percentage of total occurrences

Formulation	All Grassland and Fodder Farms		Grassland Farms	Fodder Farms
	No. of occurrences	% of total specified occurrences	No. of occurrences	No. of occurrences
Aluminium Phosphide*	233	1	233	0
Brodifacoum	1,489	8	1,342	147
Bromadiolone	7,758	40	6,653	1,105
Chlorophacinone*	21	<1	12	9
Difenacoum	9,884	51	8,957	926
Difethialone*	67	<1	67	0
Unspecified Rodenticide†	1,802		1,506	296
Total (excluding unspecified)	19,451		17,264	2,187
Total first generation anticoagulants‡	21	<1	12	9
Total second generation anticoagulants§	19,198	99	17,019	2,178
Total non-anticoagulants¶	233	1	233	0

Note: data from grassland and fodder farms are reported both in combination and separately to aid comparison with previous surveys

* Estimates are based on <10 occurrences in the survey dataset and should therefore be treated with caution

† Rodenticides are recorded as unspecified when use has been recorded but product information is unavailable

‡ First generation anti-coagulant compounds: chlorophacinone (unapproved use)

§ Second generation anti-coagulant compounds: brodifacoum, bromadiolone, difenacoum, difethialone.

¶ Non-anticoagulant rodenticides: aluminium phosphide

Table 2 Estimated weight of rodenticide products on grassland and fodder farms in Scotland 2013

Weight of specified rodenticide products (active ingredients and bait) applied and percentage of total weight

Formulation	Grassland and Fodder Farms		Grassland Farms	Fodder Farms
	Weight (kg)	% of product weight	Weight (kg)	Weight (kg)
Aluminium Phosphide*	10	<1	10	0
Brodifacoum	3,683	2	2,927	756
Bromadiolone	126,347	58	105,969	20,378
Chlorophacinone*	10	<1	6	4
Difenacoum	80,165	37	71,206	8,959
Difethialone*	6,525	3	6,525	0
Total†	216,740		186,644	30,097
Total first generation anticoagulants‡	10	<1	6	4
Total second generation anticoagulants§	216,720	100	186,627	30,093
Total non-anticoagulants¶	10	<1	10	0

Note: data from grassland and fodder farms are reported in combination and separately to aid comparison with previous surveys

* Estimates are based on <10 occurrences in the survey dataset and should therefore be treated with caution

† Not including unspecified rodenticides (see Appendix 5 - survey methodology)

‡ First generation anti-coagulant compounds: chlorophacinone (unapproved use)

§ Second generation anti-coagulant compounds: brodifacoum, bromadiolone, difenacoum, difethialone.

¶ Non-anticoagulant rodenticides: aluminium phosphide

Table 3 Estimated weight of rodenticide formulations on grassland and fodder farms in Scotland 2013

Weight of rodenticide formulations (combination of active ingredients) applied (kg) excluding bait

Formulation	Grassland and Fodder Farms	Grassland Farms	Fodder Farms
Aluminium Phosphide*	5.80	5.80	0
Brodifacoum	0.16	0.13	0.03
Bromadiolone	6.32	5.30	1.02
Chlorophacinone*	0.03	0.02	0.01
Difenacoum	4.01	3.56	0.45
Difethialone*	0.16	0.16	0
Total†	16.48	14.96	1.52
Total first generation anticoagulants‡	0.03	0.02	0.01
Total second generation anticoagulants§	10.65	9.15	1.50
Total non-anticoagulants¶	5.80	5.80	0

Note: data from grassland and fodder farms are reported in combination and separately to aid comparison with previous surveys. A percentage comparison of weights of formulation has not been presented due to the very different application rates between non-anticoagulant, first generation anticoagulant and second generation anticoagulant compounds. Please refer to Table 2 (weight of products applied) for an indication of comparative use in relation to weight.

* Estimates are based on <10 occurrences in the survey dataset and should therefore be treated with caution

† Not including unspecified rodenticides (refer to Appendix 5 - survey methodology)

‡ First generation anti-coagulant compounds: chlorophacinone (unapproved use)

§ Second generation anti-coagulant compounds: brodifacoum, bromadiolone, difenacoum, difethialone.

¶ Non-anticoagulant rodenticides: aluminium phosphide.

Table 4 Response to training and compliance questions

Response to questions regarding training and compliance with best practice of rodenticide use provided by farmers and pest control professionals responsible for rodenticide baiting on the surveyed farms

Question	Percentage yes response	
	Farmer (n=190)†	Pest control professional (n=24)‡
1) Have you attended a training course on rodenticide use?	12*	100*
2) Are quantity and location of baits recorded?	92	100
3) Are bait points protected from non-target animals?	98	100
4) Is bait regularly inspected?	97	100
5) Is bait removed after targeted baiting periods? (answer no if laid permanently or left after treatment has finished)	49	57
6) Are rodent carcasses searched for and removed?	71*	100*

Note: These responses are as reported by the rodenticide users and no attempt has been made to check their accuracy

†This represented 98 per cent of the farmers who conducted their own baiting during this survey

‡This represented 73 per cent of the contractors encountered during this survey. These 24 PCPs collectively conducted baiting on 72 per cent (n=93) of those farms using a PCP

* Responses marked with an asterisk are significantly different between farmers and PCPs (P<0.001)

Table 5 Response to farm operation questions

Question	Percentage yes response		
	All farms (n=344)†	Farms using rodenticides (n=283)†	Farms not using rodenticides (n=61)†
1) Is your farm a member of a quality assurance scheme	68	73*	48*
2) Is livestock kept on your farm?	91	92	85
3) Are pigs kept on your farm?	4‡	4	5
4) Is poultry kept on your farm?	2‡	1	3
6) Do you have a grain store?	33	39*	5*

† these data represent 77% of the farms sampled overall, 88% of those using rodenticides and 50% of those not using rodenticides.

‡ In neither of these categories was large scale pig or poultry raising encountered. This question is included to try to record large pig or poultry units which may result in greater rodenticide use than on an average farms. In future surveys the approximate number of livestock will be recorded.

* Responses marked with an asterisk are significantly different between those farms that did or did not use rodenticides in 2013 (P<0.001)

Appendix 2 – Survey statistics

Census and sample information

Table 6 Distribution of grassland holdings sampled in Scotland 2013

Size Group (ha)	Highlands and Islands	Caithness and Orkney	Moray Firth	Aberdeen	Angus	East Fife & Lothian	Central Lowlands	Tweed Valley & Southern Uplands	Solway	Scotland
0.01 – 19.99	14	2	4	4	1	1	6	3	1	36
20.00 – 49.99	9	6	2	10	1	2	14	3	4	51
50.00 – 99.99	13	4	5	9	3	3	13	8	7	65
100.00 – 149.99	4	3	2	5	2	1	11	8	10	46
150.00 +	13	9	5	8	2	2	18	28	9	94
Total	53	24	18	36	9	9	62	50	31	292

Table 7 Distribution of grassland holdings in Scotland 2013

Size Group (ha)	Highlands and Islands	Caithness and Orkney	Moray Firth	Aberdeen	Angus	East Fife & Lothian	Central Lowlands	Tweed Valley & Southern Uplands	Solway	Scotland
0.01 – 19.99	9,926	1,460	1,968	3,666	1,398	1,323	837	1,588	1,253	25,964
20.00 – 49.99	1,216	493	494	1,107	286	280	231	512	459	6,210
50.00 – 99.99	672	293	271	579	167	169	143	445	597	4,332
100.00 – 149.99	255	128	97	175	61	66	107	289	342	1,849
150.00 +	251	110	77	99	50	66	156	467	303	1,731
Total	12,320	2,484	2,907	5,626	1,962	1,904	1,474	3,301	2,954	40,086

Table 8 Distribution of fodder holdings sampled in Scotland 2013

Size Group (ha)	Highlands and Islands	Caithness and Orkney	Moray Firth	Aberdeen	Angus	East Fife & Lothian	Central Lowlands	Tweed Valley & Southern Uplands	Solway	Scotland
0.01 – 4.99	7	4	3	7	1	0	3	1	1	27
5.00 – 9.99	4	3	5	4	3	2	8	5	5	39
10.00 – 14.99	3	2	2	4	1	1	3	5	4	25
15.00 – 19.99	1	1	1	2	2	2	4	4	5	22
20.00 +	3	1	3	2	1	1	4	7	17	39
Total	18	11	14	19	8	6	22	22	32	152

Table 9 Distribution of fodder holdings in Scotland 2013

Size Group (ha)	Highlands and Islands	Caithness and Orkney	Moray Firth	Aberdeen	Angus	East Fife & Lothian	Central Lowlands	Tweed Valley & Southern Uplands	Solway	Scotland
0.01 – 4.99	316	166	220	350	70	47	136	97	80	1,482
5.00 – 9.99	56	45	71	119	38	33	99	99	78	638
10.00 – 14.99	12	14	21	31	20	10	53	37	50	248
15.00 – 19.99	10	*	13	15	7	*	15	23	34	127
20.00 +	10	*	19	17	11	*	27	35	47	187
Total	404	233	344	532	146	113	330	291	289	2,682

* Regional data have not been provided in order to prevent disclosure of information relating to fewer than five holdings

Raising factors

Table 10 Raising and adjustment factors for grassland holdings

Region	Size group (ha)					Adjustment factor
	0.01–19.99	20.00–49.99	50.00–99.99	100.00–149.99	150 +	
Highlands and Islands	709.00	135.11	51.69	63.75	19.31	1.00
Caithness and Orkney	730.00	82.17	73.25	42.67	12.22	1.00
Moray Firth	492.00	247.00	54.20	48.50	15.40	1.00
Aberdeen	916.50	110.70	64.33	35.00	12.38	1.00
Angus	1398.00	286.00	55.67	30.50	25.00	1.00
East Fife & Lothian	1323.00	140.00	56.33	66.00	33.00	1.00
Central Lowlands	563.67	97.36	87.62	39.64	17.11	1.00
Southern Uplands & Tweed Valley	529.33	170.67	55.63	36.13	16.68	1.00
Solway	1253.00	114.75	85.29	34.20	33.67	1.00

Note: The sampled data within a region and size group were multiplied by the appropriate raising and adjustment factors to create an estimate of national use (please refer to Appendix 5 for description of statistical estimation process). For example, a total recorded rodenticide use of 10 kg on 100-150 ha sized farms in Aberdeen would be multiplied by 35 (raising factor) and 1.00 (adjustment factor) to give an estimated rodenticide use in that region and size group of 350 kg.

Table 11 Raising and adjustment factors for fodder holdings

Region	Size group (ha)					Adjustment factor
	0.01 – 4.99	5.00 - 9.99	10.00 – 14.99	15.00 – 19.99	20 +	
Highlands and Islands	45.14	14.00	4.00	10.00	3.33	1.00
Caithness and Orkney	41.50	15.00	7.00	*	*	1.00
Moray Firth	73.33	14.20	10.50	13.00	6.33	1.00
Aberdeen	50.00	29.75	7.75	7.50	8.50	1.00
Angus	70.00	12.67	20.00	3.50	11.00	1.00
East Fife & Lothian	N/A	28.25	17.12	*	*	1.71
Central Lowlands	45.33	12.38	17.67	3.75	6.75	1.00
Southern Uplands & Tweed Valley	97.00	19.80	7.40	5.75	5.00	1.00
Solway	80.00	15.60	12.50	6.80	2.76	1.00

* Regional data have not been provided in order to prevent disclosure of information relating to fewer than five holdings
 N/A = not applicable, none sampled

Survey response rates

Table 12 Response rate for grassland sample

	2013	% total
Letters sent	925	
Achieved rodenticide responses	292	32
Total number of refusals/non-contact	633	

Table 13 Response rate for fodder sample

	2013	% total
Target sample	200	
Total number farms approached	237	
Achieved rodenticide responses	152	76
Total number of refusals/non-contact	85	

Appendix 3 – Financial burden of grassland and fodder crop surveys

The information below refers to the financial burden to grassland fodder farmers resulting from their participation in both the plant protection product and rodenticide surveys as the two datasets were collected at the same time.

In order to minimise the burden on farmers the survey team use non-visit methods of collection, such as email, post or telephone call, where possible. The grassland survey was carried out by postal questionnaire, so required no visits and very few telephone calls. The fodder survey was carried out predominantly by telephone, with only one visit.

All respondents to the grassland postal survey were asked how long it had taken for them to fill out the survey form. Out of 329 respondents 177 provided this information (54 per cent). The median time taken to provide information for the grassland survey was 15 minutes. The time taken to provide the data requested was recorded for all 189 respondents to the fodder survey. The median time taken to provide information for the fodder survey was 20 minutes. In addition, PCPs were also asked to estimate how long they took to provide information on rodenticide use on surveyed farms. Of the 16 who provided an estimate the median time taken to provide information for the survey was 20 minutes.

The following formula was used to estimate the total cost of participating:

Burden (£) = No. surveyed x mean time taken (hours) x typical hourly rate*
(* using median “full Time Gross” hourly pay for Scotland of £12.63³)

The total financial burden, accounting for all farmers’ participation in the 2013 grassland survey was £1,039. This equates to £3.16 per farmer.

The total financial burden, accounting for all farmers’ participation in the 2013 fodder survey was £796. This equates to £4.21 per farmer.

The total financial burden, accounting for all PCPs’ participation in the 2013 fodder survey was £88. This equates to £4.21 per PCP.

Therefore the total burden to respondents to the grassland and fodder crop surveys of plant protection products and rodenticides was estimated to be £1923.

Appendix 4 – Definitions and notes

1) **Rodenticide** is used throughout this report to describe a substance used to kill or control rodents. Only chemical control of rats and mice was recorded; information on other control methods such as trapping was not collected.

2) An **active ingredient** (or active substance) is any substance which has a general or specific action against harmful organisms. In this report an active ingredient refers to a substance which has a detrimental effect on rodents.

3) The term **product** is used to describe a marketed rodenticide product which contains active ingredients, bait and other co-formulants.

4) The term **formulation(s)** is used to describe an active ingredient or mixture of active ingredients formulated together in a product. In this survey all products encountered contained only one active ingredient; however in previous surveys some rodenticides were composed of more than one active ingredient therefore this terminology has been retained.

5) Rodenticides are classified in this report as **anticoagulant** (which prevent the synthesis of blood clotting factors resulting in rodent death by haemorrhage) or **non-anticoagulant** compounds. The anticoagulant rodenticides are broken down further into first and second generation compounds (**FGARs** and **SGARs** respectively). The FGARs, which were the first anticoagulant compounds to be developed, are generally less acutely toxic than SGARs.

6) The **rodenticides approved for use** in the UK during the 2013 survey period were: FGARs (coumatetralyl and warfarin), SGARs (brodifacoum, bromadiolone, difenacoum, difethialone and flocoumafen) and non-anticoagulant rodenticides (alphachloralose, aluminium phosphide and powdered corn cob). The **rodenticides encountered** in this survey were; aluminium phosphide, brodifacoum, bromadiolone, chlorophacinone, difenacoum and difethialone.

6) The term **holding** is the basic unit used in the agricultural census and, in this report, is synonymous with the term 'farm'. In this survey, **fodder farms** are defined as farms growing crops for stock-feeding such as turnips, swede, kale, fodder rape, fodder beet, maize and arable silage (grain and legumes) while **grassland farms** primarily grow grass for grazing or silage. Fodder farms usually also have some grassland and grassland farms may also grow some fodder crops.

7) The term **occurrence** is used to describe the number of holdings on which a formulation has been used. Multiple uses of the same formulation at a holding are recorded as a single occurrence.

8) When collecting information regarding **seasonal use** of rodenticides, farmers were asked to report seasonal baiting patterns. Farmers used their own definition of season which may vary among respondents. Where exact dates of use were provided these were assigned to season as follows: spring (March, April, May), summer (June, July, August), autumn (September, October, November) and winter (December, January, February).

9) Throughout the tables, data based **on fewer than 10 sampled occurrences** (encountered on less than 10 holdings) are marked with an asterisk and should be treated with caution as these estimates are likely to have a high associated error. In this survey only bromadiolone, difenacoum and brodifacoum were encountered on more than 10 holdings.

10) Data from the 2002¹ and 2005 surveys of rodenticide use on fodder farms are provided for comparison with the estimates from fodder farms in this survey. They cannot be compared with overall 2013 estimates as these include data from a supplementary grassland sample. It should be noted that differences in use between years may be influenced by a number of factors such as rodent populations or the proportion of farms sampled in that year which had livestock or grain stores or were members of a quality assurance scheme in which rodenticide use was mandatory or encouraged. To help address this issue in future surveys information about some of these factors has been collected during this survey.

11) Due to rounding, there may be slight differences in totals both within and between tables.

12) The **June Agricultural Census** is conducted annually by the Scottish Government's Rural and Environmental Science Analytical Services (RESAS). The June Agricultural Census collects data on land use, crop areas, livestock and the number of people working on agricultural holdings. For this report the Census was used to draw a sample of farms growing the relevant crops to participate in the survey.

Appendix 5 – Survey methodology

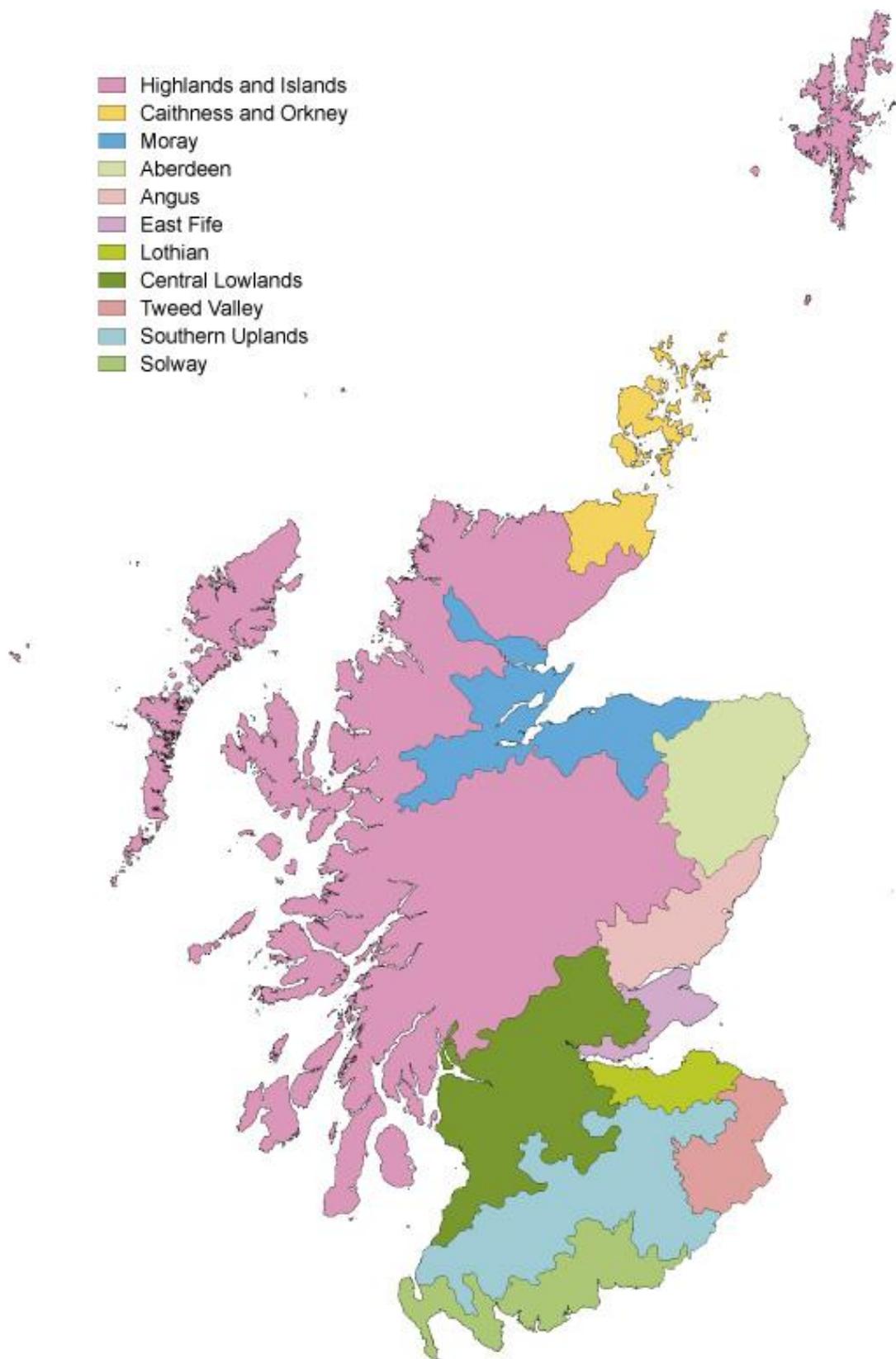
Sampling and data collection

Using the June 2013 Agricultural Census⁴ two samples were selected, one taken from holdings with grassland, the second from holdings growing fodder crops. For the purpose of sampling, the country was divided into 11 land-use regions⁵ (Figure 9) and five size groups. The size groups were different for grassland and fodder crops (Table 7 & 9 respectively) and were based on the total areas of crops grown on the holding. Holdings were chosen at random within each of these strata, with the number of holdings selected being proportional to the total area of crops grown. Thus more holdings were sampled in the main grass and fodder crop growing regions in the North and West of the country. Sample size groups were based on crop area rather than number of holdings, so that smaller holdings did not dominate. This stratification was designed to take into account differences in rodenticide use in relation to geography and farm size when making estimates of national use.

In previous surveys in this series, only farms growing fodder crops were sampled. Although most of these farms also had some grassland, the area of grass sampled under-represented the area of grass grown in Scotland and therefore estimates of rodenticide use were only made for those holdings growing fodder crops. In 2013, the fodder crop sample was supplemented with an additional postal survey of rodenticide use on grassland farms. This ensured that the large areas of grassland grown in Scotland were adequately represented in the survey and allowed estimates of rodenticide use to be made for all farms growing stock-feeding crops. Rodenticide use data were collected from 444 holdings in total. Of these, 152 were holdings growing fodder crops. These represent six per cent of Scottish holdings growing fodder crops and collectively cover 16 per cent of the total fodder crop area. The remaining 292 holdings were grassland farms; whilst these represented less than one per cent of the grassland holdings in Scotland they collectively accounted for 5 per cent of the Scottish grassland area. It should be noted that while fodder farms are defined as farms growing crops for stock-feeding and grassland farms grow grass for grazing or silage, fodder farms usually also have some grassland and grassland farms may also grow fodder crops.

The survey covered rodenticide use during the 12 month period January to December 2013. Following an introductory letter, data was gathered from farms growing fodder crops by telephone interview or email. For the grassland survey a postal questionnaire was sent out which farmers completed and returned, followed up with a phone call where necessary. When rodenticides were applied by a pest control professional (PCP) and data were not available from the farmer the information was obtained directly from the contractor. If it was recorded that rodenticides were used but product data were not obtainable from either the farmer or PCP this was recorded as unspecified rodenticide use. The data collected were products used, quantity applied and season of use. All farmers and PCPs encountered in the survey were also asked to respond to a simple questionnaire containing six questions relating to whether they had received training in use of rodenticides and their self-reported compliance with best use practice for rodenticides⁶.

Figure 9 Land use regions of Scotland



Estimation of national rodenticide use

The figures presented in this report are produced by surveying a sample of holdings rather than conducting a census of all the holdings in Scotland. Therefore the figures are estimates of total rodenticide use for Scotland and should not be interpreted as exact.

National rodenticide use was estimated from the sample data by ratio raising. This is a standard statistical technique for producing estimates from a sample. This method involves multiplying the sample data by raising factors (Tables 10 & 11) dependant on the number of farms within each region and size group to match the data recorded in the relevant June Agricultural Census⁴. It is the same methodology used for all surveys produced by the Pesticide Survey Unit, allowing comparability over time. The data from some similar regions were merged to provide a more robust sample and a secondary adjustment factor was applied to the raising factors to account for region and size groups for which no holdings were sampled. Details of regions, size groups, region merging, raising and adjustment factors are presented in Appendix 2.

Changes from previous years and statistical analyses

In previous surveys in this series, only farms growing fodder crops were sampled. Although these farms also had grassland areas these were under-sampled in relation to the total area of grass grown in Scotland and therefore rodenticide use estimates were only made for those farms growing fodder crops (ca. 2,000 farms). For the first time in this survey a supplementary sample of grassland farms was surveyed, allowing estimates of rodenticide use to be made for all grassland and fodder farms (ca, 42,000 farms). This represents a major improvement to the scope of the survey but means that the results cannot be directly compared with previous surveys. However, in this report estimates for fodder and grassland farms have been presented both in combination and separately to allow a measure of comparison with previous surveys on farms growing fodder crops.

As estimates are based on a random stratified sample of farms in each survey year and individual farms may be sampled more than once in the time series, there is no simple method of statistical comparison for estimated rodenticide use on fodder farms over time. However, the percentage of farms using rodenticides, the percentage of farms on which baiting was conducted by PCPs and the percentage occurrence of first and second generation compounds have been analysed using Pearson's chi-squared test. The percentage occurrence of first and second generation compounds was analysed using the number of holdings as a base. These conservative analyses do not take into account the stratification, finite population sampling or common farms between years and are therefore less likely to find significant differences. All significant differences are highlighted in the following text.

In addition, for the first time in this series of surveys the farmers and PCPs were asked a series of questions relating to whether they had attended a training course and their self-reported compliance with best practice of rodenticide use. These questions are listed in Table 4 and are the same as

those asked in the rodenticides on arable farms survey conducted in 2012². Also for the first time, farmers were asked to supply operational information about factors that may influence rodenticide use pattern on their farms, such as whether they were members of a quality assurance scheme, or whether they have livestock or a grain store. This information is presented in Table 5 and will be collected for all future surveys to attempt to help to interpret trends and differences in rodenticide use between survey years.

Both the responses to the compliance questions, by farmers and pest control professionals, and the responses to the operational questions, from those farms which did and did not use rodenticides, were compared using Fisher's exact test.

Data quality assurance

The data undergo several validation processes as follows; (i) checking for any obvious errors upon data receipt (ii) checking and identifying inconsistencies with use and rodenticide approval conditions once entered into the database (iii) 100 per cent checking of data held in the database against the raw data. Where inconsistencies are found these are checked against the records and with the farmer/pest control professional if necessary. Additional quality assurance is provided by sending reports for external review before publication. In addition, the Scottish pesticide survey unit is accredited to ISO 9001:2008. All survey related processes are documented in Standard Operating Procedures (SOPs) and our output is audited against these SOPs by internal auditors annually and by external auditors every three years.

Potential sources of bias

These surveys may be subject to measurement bias as they are reliant on respondents recording data accurately. As surveys are not compulsory they may also be subject to non-response bias, as some farmers and PCPs may be more likely to respond than others. However, the use of a random stratified sample is an appropriate survey methodology and reserve lists of farms are held for each stratum to allow non-responding farms to be replaced with similar holdings.

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