Pesticide Usage in Scotland

A National Statistics Publication for Scotland

Rodenticides on Arable Farms 2014
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Executive summary ....................................................................................... 1

Introduction .................................................................................................... 2

Structure of report and how to use these statistics........................................ 3
Data uses ........................................................................................................ 3
Results and comparison with previous surveys ............................................. 4
Proportion of farms using rodenticides and type of user ............................... 4
Rodenticide compounds encountered and their estimated occurrence ......... 5
Estimated Weight of rodenticide used ........................................................... 7
Seasonal use of anticoagulant rodenticides .................................................. 9
Rodenticide bait type ..................................................................................... 9
Target of rodenticide baiting ........................................................................ 10
Non-chemical rodent control ....................................................................... 11
Compliance with rodenticide best practice .................................................. 12
Farm operation data .................................................................................... 13
Rodenticide approval and stewardship ........................................................ 13

Appendix 1 – Estimated Application Tables .............................................. 14

Appendix 2 – Survey statistics ..................................................................... 18

Census and sample information ................................................................ 18
Survey response rates ................................................................................ 19

Appendix 3 - Financial burden of rodenticides on arable farm surveys .20

Appendix 4 – Definitions and notes ........................................................... 21

Appendix 5 – Survey methodology ............................................................ 23

Sampling and data collection ..................................................................... 23
Estimation of national rodenticide use ........................................................ 25
Changes from previous years and statistical analyses ......................... 25
Data quality assurance .............................................................................. 25
Main sources of bias .................................................................................. 26

Acknowledgements ..................................................................................... 27

References ................................................................................................... 27
List of figures and tables

Figure 1  Number of arable farms sampled using rodenticides and type of user 2014 .................................................................4
Figure 2  Pattern of rodenticide use, and type of user, on arable farms in Scotland 2010 to 2014 .......................................................5
Figure 3  Estimated percentage occurrence of specified rodenticide formulations on arable farms in Scotland 2014 ..................6
Figure 4  Estimated percentage occurrence of anticoagulant rodenticides on arable farms in Scotland 2010 to 2014 ....................7
Figure 5  Estimated percentage weight of rodenticide product used on arable farms in Scotland 2014 ...........................................8
Figure 6  Estimated weight of anticoagulant rodenticide products used on arable farms in Scotland 2010 to 2014 .............................8
Figure 7  Seasonal use of anticoagulant rodenticides on arable farms in Scotland 2014 (percentage of total quantity) ....................9
Figure 8  Type of rodenticide bait used on arable farms 2014 (percentage of total quantity) ..............................................................10
Figure 9  Target of rodenticide use on arable farms 2014 (percentage of total quantity) .................................................................10
Figure 10 Non-chemical control methods used on arable farms 2014 ......11
Figure 11 Land use regions of Scotland ...........................................24

Table 1  Estimated occurrence of rodenticide use on arable farms in Scotland 2014 .................................................................14
Table 2  Estimated weight of rodenticide products used on arable farms in Scotland 2014 .............................................................15
Table 3  Response to training and compliance questions ..................16
Table 4  Response to farm operation questions ................................17
Table 5  Distribution of arable holdings sampled in Scotland 2014 .......18
Table 6  Distribution of arable holdings in Scotland 2014 ...............18
Table 7  Raising and adjustment factors for arable holdings ..........19
Table 8  Response rates for rodenticide survey ...............................19
Executive summary

This report presents the results of a survey of rodenticide use on arable farms in Scotland in 2014. Data were collected from 273 holdings representing three per cent of arable farms. These sample data were used to estimate total rodenticide use in Scottish arable agriculture.

It was estimated that rodenticides were used on 87 per cent of arable farms in 2014, which is similar to that reported in previous surveys. On farms which used rodenticides, pest control professionals (PCPs) were responsible for rodent control on 57 per cent of holdings.

An estimated 113 tonnes of rodenticide bait was used in 2014. This bait contained less than 6 kg of rodenticide active substance. Almost all rodenticide use, in relation to both occurrence of use and weight applied, was of second generation anticoagulant compounds. First generation anticoagulant rodenticide use has been declining over time and this is the first survey in which their use has not been encountered. As in previous surveys, the most frequently used compounds were bromadiolone and difenacoum. These compounds accounted for 97 per cent of all occurrences of use and 99 per cent of the total weight of bait applied.

Just over half of farms conducted rodenticide baiting throughout the year, either as permanent baiting or as multiple baiting operations. However, more bait was used in autumn and winter (60 per cent) than in spring and summer. Grain baits were the most common type encountered (93 per cent of total use), with the remainder being wax, gel and pasta baits. The main targets of rodenticides were rats (60 per cent) or a combination of rats and mice (38 per cent).

Forty four per cent of farms which did not use rodenticides, and 10 per cent of those which did, employed non-chemical rodent control. The most commonly used methods were cats and dogs but trapping, shooting and use of electronic rat scarers were also encountered.

Data were collected about training, compliance with best practice and aspects of farm operation. As in previous surveys, significantly more PCPs had attended a training course on rodenticide use than farmers. In relation to best practice, the majority of users stated that they complied with all elements, with the exception of removal of bait following a targeted baiting period which was adopted by 26 per cent of PCPs. This was significantly lower than the percentage of farmers removing bait (69 per cent). In contrast, farmers were significantly less likely to search for and remove rodent carcasses than PCPs (74 and 100 per cent respectively). In relation to farm operation, farmers that practised rodenticide baiting were significantly more likely keep livestock on their farm and have a grain store than farmers that did not use rodenticides.

This data set will be useful to monitor changes in rodenticide use pattern and compliance with best practice of use which may arise in response to scheduled changes in UK rodenticide authorisations and the recently launched industry stewardship scheme.
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 arable crops was conducted in 2014. This is the 12th survey in this series carried out biennially since 1992.

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 survey specific statistical support from Biomathematics and Statistics Scotland (BioSS).

All reports are produced according to a published timetable. For further information in relation to Pesticide Survey Unit publications and their compliance with the 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 compares the data with results from previous surveys in 2010\(^1\) and 2012\(^2\).

Appendix 1 contains tables of 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 or data collection from previous survey years are also outlined 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 a census of all the holdings in Scotland. Therefore the figures are estimates of total rodenticide use on Scottish arable farms and should not be interpreted as exact.

Data uses

The data collected by the Pesticide Survey Unit are 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 previous surveys

Proportion of farms using rodenticides and type of user

Eighty seven per cent of the 273 arable holdings surveyed during 2014 used rodenticides (Figure 1). On those holdings where rodenticides were used (n=237) baiting was conducted by pest control professionals (PCPs) on 57 per cent (n=135). On the remaining 43 per cent of holdings (n=101) rodenticides were applied by the farmer. On one holding rodenticides were applied by both the farmer and by a PCP.

Figure 1  Number of arable farms sampled using rodenticides and type of user 2014

![Diagram showing rodenticides usage and type of user]

The percentage of sampled farms using rodenticides and type of user encountered in the previous two surveys (2010 and 2012) are presented in Figure 2. The percentage of farms using rodenticides in 2014, 87 per cent, was similar to that reported in 2010 and 2012 (85 and 78 per cent respectively), with more than three quarters of farmers employing chemical pest control throughout this period.

The proportion of holdings using rodenticides on which PCPs conducted baiting in 2014 was also very similar to that reported in previous surveys (55 and 53 per cent in 2010 and 2012 respectively). Prior to 2010 farmers had conducted rodenticide baiting on the majority of holdings sampled in the surveys."
Rodenticide compounds encountered and their estimated occurrence

During this survey product information was recorded for 98 per cent of all occurrences of rodenticide use. For the remaining two 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 active substances were encountered during this survey (Table 1 & Figure 3). Five were second generation anticoagulant rodenticides (SGARs) which prevent the synthesis of blood clotting factors and result in death by haemorrhage. These SGARs collectively accounted for more than 99 per cent of all occurrences of specified rodenticide use. The most commonly encountered SGARS were bromadiolone and difenacoum (61 and 36 per cent of all occurrences respectively). Most bromadiolone and difenacoum use was in products containing a single active substance, however some use of a formulation containing both compounds was encountered (<1 per cent of rodenticide occurrences). Limited use of brodifacoum, difethialone and flocoumafen was also recorded; accounting for 2, <1 and <1 per cent of total estimated occurrences respectively. 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.

Despite two first generation anticoagulants (FGARs) being approved for use during 2014, warfarin and coumatetralyl, neither was encountered. This is the first Scottish rodenticide survey in which FGAR use has not been recorded.
One non-anticoagulant rodenticide, alphachloralose, was encountered. Alphachloralose depresses brain activity, slows the heart rate and depresses metabolic rate leading to death through hypothermia and respiratory failure. This compound is only approved for use to control mice indoors and accounted for less than one per cent of all estimated rodenticide occurrences. No use of the other approved non-anticoagulant rodenticides, aluminium phosphide and powdered corn cob, was encountered.

Figure 3  Estimated percentage occurrence of specified rodenticide formulations on arable farms in Scotland 2014

Note: as there were 10 or fewer occurrences of alphachloralose, bromadiolone/difenacoum, difethialone and flocoumafen in the sample, estimates of their use should be treated with caution.

Estimated occurrence of anticoagulant rodenticides on arable farms from 2010 to 2014 is presented in Figure 4. The occurrence of FGAR compounds, which accounted for 20 per cent of use in 2000\(^1\) decreased from 3 per cent of total use in 2010 to one per cent in 2012. No FGARs were encountered in the 2014 survey. The occurrence of SGAR compounds, which represented 80\% of total use in 2000\(^1\) increased from 97 per cent to 100 per cent over the same time period. The proportion of both FGAR and SGAR occurrences changed significantly between 2010 and 2014 (P<0.01). The estimated occurrence of bromadiolone and difenacoum is very similar over the three most recent surveys; with a range of 58 to 61 per cent of total use for bromadiolone and 30 to 37 per cent for difenacoum.
Almost 113 tonnes of rodenticidal products are estimated to have been used on Scottish arable farms in 2014 (Table 2). More than 99 per cent of the total quantity used was SGAR containing products (Figure 5), the remainder being products containing alphachloralose. Products containing bromadiolone were the most commonly used (ca. 87 tonnes), accounting for 77 per cent of total rodenticide use by weight. Difenacoum products were the second most commonly used (ca. 24 tonnes) accounting for 22 per cent of total use.

Individual formulation weights, the weight of active substances present in the product not including baits, are also presented in Table 2. Anticoagulant rodenticide products contain very small amounts of active substance. The 113 tonnes of rodenticide used on arable farms in 2014 contained less than 6 kg of active substance, the remainder being food bait used to attract rodents.

The estimated weight of rodenticides used on arable farms from 2010 to 2014 is presented in Figure 6. The weights reported in 2010 and 2012 were very similar (ca. 126 and 130 tonnes respectively). However, despite more farms in the current survey using rodenticides (87 per cent compared to 78 per cent in 2012) the estimated total weight of bait was 13 per cent lower (113 tonnes). The quantity of bromadiolone rodenticide applied in 2014 was similar to that reported in previous years (91, 86 and 86 tonnes in 2010, 2012 and 2014 respectively). However, the use of difenacoum rodenticides in 2014 was over 40 per cent lower than in 2012 (30, 41 and 24 tonnes in 2010, 2012 and 2014 respectively). The reason for the reduction in estimated weight of rodenticides used, both overall and of difenacoum in particular, is unclear but
may be related to differences in pest pressure between survey years. Changes in the use pattern of active substances may also be influenced by product efficacy in some areas; resistance to both difenacoum and bromadiolone has been reported in South West Scotland.

Figure 5  Estimated percentage weight of rodenticide product used on arable farms in Scotland 2014

Note: as there were 10 or fewer occurrences of alphachloralose, bromadiolone/difenacoum, difethialone and flocoumafen in the sample, estimates of their use should be treated with caution.

Figure 6 Estimated weight of anticoagulant rodenticide products used on arable farms in Scotland 2010 to 2014
Seasonal use of anticoagulant rodenticides

Season of use was specified for almost 99 per cent of all anticoagulant rodenticides surveyed (Figure 7). Fifty one 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. This is a lower proportion than in 2012, when it was reported that 65 per cent of anticoagulant rodenticide use occurred throughout the year.

When the quantity used, including year-round use, is separated into season, the greatest use was in winter and autumn (60 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).

Figure 7  Seasonal use of anticoagulant rodenticides on arable farms in Scotland 2014 (percentage of total quantity)

Rodenticide bait type

Baits formulated with grain were the most commonly encountered in this survey accounting for 93 per cent of use by weight (Figure 8). These baits were primarily loose grain and place packs containing grain, but also included a small amount of grain based paste (one per cent of total grain baits).

The other types of rodenticide products encountered were wax baits which accounted for four per cent of use. Ninety per cent of the wax formulations were solid wax blocks, with the remainder being soft wax baits. The next most frequently used type of rodenticide product was pasta based bait, which is a relatively new form of rodenticide delivery, contributing three per cent of total use. The only other rodenticide bait type encountered was gel bait which accounted for less than one per cent of use.
Grain baits were also the most commonly applied baits in the survey of rodenticides on arable farms in 2012\(^2\) (89 per cent), with wax and pasta baits accounting for 10 and <1 per cent respectively.

**Figure 8** Type of rodenticide bait used on arable farms 2014 (percentage of total quantity)

![Pie chart showing the percentage of different types of rodenticide baits used on arable farms in 2014. The largest segment is grain-based bait at 93%, followed by pasta-based bait at 4%, wax-based bait at 3%, gel bait at less than 1%, and other types at 1%.

**Target of rodenticide baiting**

Survey respondents were asked to state the target of their rodenticide use (Figure 9). Where reason data were supplied the most common target was rats (60 per cent) followed by a combination of rats and mice (38 per cent). Only two per cent of use (solely alphachloralose) was targeted at mice alone.

**Figure 9** Target of rodenticide use on arable farms 2014 (percentage of total quantity)

![Pie chart showing the percentage of different targets of rodenticide use on arable farms in 2014. The largest segment is rats at 60%, followed by rats and mice at 38%, mice at 2%, and other types at less than 1%.

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10
Non-chemical rodent control

For the first time in this series of surveys farmers were asked about non-chemical methods employed for rodent control (Figure 10). On holdings on which rodenticides were not used (n=36) 44 per cent of the farmers reported using some form of non-chemical control. A range of measures were encountered; the most common methods were use of cats (58 per cent) or dogs (16 per cent) to control rodents. Farmers also reported use of shooting, traps and electronic rat scarers.

On holdings using rodenticides (n=237) 10 per cent of farmers reported using additional non-chemical methods of rodent control. Again, the most common method was use of cats or dogs (62 and 17 per cent respectively) with 21 per cent using traps.

Figure 10  Non-chemical control methods used on arable farms 2014
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 3). 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 nine per cent of farmers who conducted their own baiting (n=100) provided responses to the compliance questions. Seventy seven per cent of the PCPs (n=23) also provided responses. These 23 respondents were collectively responsible for baiting on 93 per cent of the farms (n=126) 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 22 per cent of farmers had attended a training course on rodenticide use. The uptake of training was significantly different between farmers and PCPs (P<0.01).

All PCPs and 94 per cent of farmers stated that they recorded the quantity and location of baits and all PCPs and 99 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 farmers.

Twenty six per cent of PCPs and sixty nine per cent of farmers removed the bait after targeted baiting periods. Compliance with this element of best practice was significantly different between farmers and PCPs (P<0.01).

All PCPs and 74 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<0.01).

The same compliance questions were asked during the 2012 survey and a similar pattern of responses was obtained. However in 2012 the number of farmers and PCPs searching for and removing carcasses (84 and 100 per cent respectively) was not significantly different.
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 4). Ninety five per cent (n=258) of the farms surveyed provided this information; this represented 97 per cent of farms that used rodenticides and 81 per cent of those that did not.

The majority of farms surveyed (96 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. More farms that practised rodenticide baiting were members of a quality assurance scheme (97 per cent) than farms that did not use rodenticides (90 per cent) but this was not significantly different.

Sixty two per cent of the farms surveyed kept livestock on their holdings. Very few of these farms reared pigs or poultry and those that did, did so on a small scale (1 per cent of farms in both instances). Farms that used rodenticides were significantly more likely to have livestock that those that did not use rodenticides (65 and 41 per cent respectively, P<0.01).

Lastly, 60 per cent of holdings had an on-farm grain store, and a significantly greater number of farms using rodenticides had a grain store (65 per cent) than farms that did not use rodenticides (24 per cent) (P<0.01).

Rodenticide approval and stewardship

EU and UK Regulatory risk assessments have concluded that the use of First and Second Generation Anticoagulant Rodenticides (FGARs and SGARs) outdoors present a higher level of risk to non-target animals (such as predatory birds and mammals) than would normally be considered acceptable. A survey of SGAR residues in Scottish raptors has demonstrated exposure of many species to these active substances. As a result, outdoor use of these rodenticides would normally not be approved. However the Government recognises that, despite these risks, outdoor use of FGARs and SGARs is necessary as part of a properly managed rodent control strategy.

In order to be able to authorise these rodenticides for use outdoors, Government must be assured that the risks will be properly managed. This is being addressed by the introduction of an industry led stewardship scheme, managed by the Campaign for Responsible Rodenticide use. The conditions of use of some of these compounds, particularly in relation to where they can be applied, are also being amended at product authorisation.

The data collected in these usage reports should reflect and monitor changes both in use pattern, resulting from changes to authorisation conditions, and in user training and compliance with the conditions of stewardship.
## Appendix 1 – Estimated Application Tables

### Table 1  Estimated occurrence of rodenticide use on arable farms in Scotland 2014

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

<table>
<thead>
<tr>
<th>Formulation</th>
<th>No. occurrences</th>
<th>Percentage of total specified occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphachloralose*</td>
<td>14</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Brodifacoum</td>
<td>205</td>
<td>2</td>
</tr>
<tr>
<td>Bromadiolone</td>
<td>5,031</td>
<td>61</td>
</tr>
<tr>
<td>Bromadiolone/difenacoum*</td>
<td>10</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Difenacoum</td>
<td>2,921</td>
<td>36</td>
</tr>
<tr>
<td>Difethialone*</td>
<td>14</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Flocoumafen*</td>
<td>8</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Unspecified rodenticide†</td>
<td>194</td>
<td></td>
</tr>
<tr>
<td><strong>Total (excluding unspecified use)</strong></td>
<td><strong>8,203</strong></td>
<td></td>
</tr>
<tr>
<td>Total first generation anticoagulants‡</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total second generation anticoagulants§</td>
<td>8,189</td>
<td>&gt;99</td>
</tr>
<tr>
<td>Total non-anticoagulants¶</td>
<td>14</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

*Estimates are based on 10 or fewer occurrences and should therefore be treated with caution
† Rodenticides are recorded as unspecified when use has been recorded but product information is not available (refer to methods)
‡ No first generation anti-coagulant compounds were encountered in 2014
§ Second generation anti-coagulant compounds: brodifacoum, bromadiolone, difenacoum, difethialone, flocoumafen.
¶ Non-anticoagulant rodenticides: alphachloralose
Table 2  Estimated weight of rodenticide products used on arable farms in Scotland 2014

Estimated quantity of rodenticides applied (kg), expressed as formulations (combination of active substances) and products (active substances, bait and other co-formulants)

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Formulation (kg)</th>
<th>Product (kg)</th>
<th>Percentage of total use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphachloralose*</td>
<td>0.01</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Brodifacoum</td>
<td>0.06</td>
<td>1,497</td>
<td>1</td>
</tr>
<tr>
<td>Bromadiolone</td>
<td>4.33</td>
<td>86,551</td>
<td>77</td>
</tr>
<tr>
<td>Bromadiolone/difenacoum*</td>
<td>&lt;0.01</td>
<td>5</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Difenacoum</td>
<td>1.22</td>
<td>24,409</td>
<td>22</td>
</tr>
<tr>
<td>Difethialone*</td>
<td>&lt;0.01</td>
<td>35</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Flocoumafen*</td>
<td>&lt;0.01</td>
<td>35</td>
<td>&lt;1</td>
</tr>
<tr>
<td><strong>Total†</strong></td>
<td><strong>5.62</strong></td>
<td><strong>112,533</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Total first generation anticoagulants‡</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total second generation anticoagulant§</td>
<td></td>
<td>5.61</td>
<td>112,533</td>
</tr>
<tr>
<td>Total non-anticoagulants¶</td>
<td>0.01</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

*Estimates are based on 10 or fewer occurrences and should therefore be treated with caution
† Not including unspecified rodenticides
‡ No first generation anti-coagulant compounds were encountered in 2014
§ Second generation anti-coagulant compounds: brodifacoum, bromadiolone, difenacoum, difethialone, flocoumafen.
¶ Non-anticoagulant rodenticides: alphachloralose
Table 3  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

<table>
<thead>
<tr>
<th>Question</th>
<th>Percentage yes response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Farmer (n = 100)†</td>
</tr>
<tr>
<td>1) Have you attended a training course on rodenticide use?</td>
<td>22*</td>
</tr>
<tr>
<td>2) Are quantity and location of baits recorded?</td>
<td>94</td>
</tr>
<tr>
<td>3) Are bait points protected from non-target animals?</td>
<td>99</td>
</tr>
<tr>
<td>4) Is bait regularly inspected?</td>
<td>100</td>
</tr>
<tr>
<td>5) Is bait removed after targeted baiting periods? (answer no if laid permanently or left after treatment has finished)</td>
<td>69*</td>
</tr>
<tr>
<td>6) Are rodent carcasses searched for and removed?</td>
<td>74*</td>
</tr>
</tbody>
</table>

Note: These responses are as reported by the rodenticide users and no attempt has been made to check their accuracy
†This represented 99 per cent of the farmers who conducted their own baiting during this survey
‡This represented 77 per cent of the contractors encountered during this survey. These 23 PCPs collectively conducted baiting on 93 per cent (n=126) of those farms using a PCP
* Responses marked with an asterisk are significantly different between farmers and PCPs (P<0.01)
Table 4  Response to farm operation questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Percentage yes response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All farms (n=258)†</td>
</tr>
<tr>
<td>1) Is your farm a member of a quality assurance scheme?</td>
<td>96</td>
</tr>
<tr>
<td>2) Is livestock kept on your farm?</td>
<td>62</td>
</tr>
<tr>
<td>3) Are pigs kept on your farm?</td>
<td>1</td>
</tr>
<tr>
<td>4) Is poultry kept on your farm?</td>
<td>1</td>
</tr>
<tr>
<td>5) Do you have a grain store?</td>
<td>60</td>
</tr>
</tbody>
</table>

† these data represent 95 per cent of the farms sampled overall, 97 per cent of those using rodenticides and 81 per cent of those not using rodenticides.

* Responses marked with an asterisk are significantly different between those farms that did or did not use rodenticides in 2014 (P<0.01)
Appendix 2 – Survey statistics
Census and sample information

### Table 5  Distribution of arable holdings sampled in Scotland 2014

<table>
<thead>
<tr>
<th>Size Group (ha)</th>
<th>H&amp;I and C&amp;O</th>
<th>Moray Firth</th>
<th>Aberdeen</th>
<th>Angus</th>
<th>East Fife &amp; Lothian</th>
<th>Central Lowlands</th>
<th>TV, SU &amp; Solway</th>
<th>Scotland</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 – 19.99</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>20.00 – 49.99</td>
<td>3</td>
<td>3</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>37</td>
</tr>
<tr>
<td>50.00 – 99.99</td>
<td>1</td>
<td>4</td>
<td>21</td>
<td>11</td>
<td>11</td>
<td>9</td>
<td>7</td>
<td>64</td>
</tr>
<tr>
<td>100.00 – 149.99</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>12</td>
<td>10</td>
<td>3</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>150.00 +</td>
<td>0</td>
<td>9</td>
<td>19</td>
<td>28</td>
<td>24</td>
<td>7</td>
<td>20</td>
<td>107</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>24</strong></td>
<td><strong>63</strong></td>
<td><strong>57</strong></td>
<td><strong>48</strong></td>
<td><strong>29</strong></td>
<td><strong>40</strong></td>
<td><strong>273</strong></td>
</tr>
</tbody>
</table>

H&I=Highlands & Islands, C&O=Caithness & Orkney, TV=Tweed Valley, SU=Southern Uplands

### Table 6  Distribution of arable holdings in Scotland 2014

<table>
<thead>
<tr>
<th>Size Group (ha)</th>
<th>H&amp;I and C&amp;O</th>
<th>Moray Firth</th>
<th>Aberdeen</th>
<th>Angus</th>
<th>East Fife &amp; Lothian</th>
<th>Central Lowlands</th>
<th>TV, SU &amp; Solway</th>
<th>Scotland</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 – 19.99</td>
<td>1,450</td>
<td>420</td>
<td>924</td>
<td>290</td>
<td>208</td>
<td>648</td>
<td>560</td>
<td>4,500</td>
</tr>
<tr>
<td>20.00 – 49.99</td>
<td>145</td>
<td>247</td>
<td>625</td>
<td>305</td>
<td>181</td>
<td>353</td>
<td>313</td>
<td>2,169</td>
</tr>
<tr>
<td>50.00 – 99.99</td>
<td>57</td>
<td>184</td>
<td>481</td>
<td>314</td>
<td>244</td>
<td>218</td>
<td>179</td>
<td>1,677</td>
</tr>
<tr>
<td>100.00 – 149.99</td>
<td>13</td>
<td>75</td>
<td>175</td>
<td>170</td>
<td>150</td>
<td>61</td>
<td>114</td>
<td>758</td>
</tr>
<tr>
<td>150.00 +</td>
<td>3</td>
<td>87</td>
<td>150</td>
<td>198</td>
<td>185</td>
<td>65</td>
<td>169</td>
<td>857</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,668</strong></td>
<td><strong>1,013</strong></td>
<td><strong>2,355</strong></td>
<td><strong>1,277</strong></td>
<td><strong>968</strong></td>
<td><strong>1,345</strong></td>
<td><strong>1,335</strong></td>
<td><strong>9,961</strong></td>
</tr>
</tbody>
</table>

H&I=Highlands & Islands, C&O=Caithness & Orkney, TV=Tweed Valley, SU=Southern Uplands
### Table 7  Raising and adjustment factors for arable holdings

<table>
<thead>
<tr>
<th>Region</th>
<th>Size Group (ha)</th>
<th></th>
<th></th>
<th></th>
<th>Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-19.9</td>
<td>20-49.9</td>
<td>50-99.9</td>
<td>100-149.9</td>
<td>150+</td>
</tr>
<tr>
<td>Caithness &amp; Orkney and Highlands &amp; Islands</td>
<td>241.67</td>
<td>48.33</td>
<td>57.00</td>
<td>6.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Moray Firth</td>
<td>210.00</td>
<td>82.33</td>
<td>46.00</td>
<td>12.50</td>
<td>9.67</td>
</tr>
<tr>
<td>Aberdeen</td>
<td>231.00</td>
<td>52.08</td>
<td>22.90</td>
<td>25.00</td>
<td>7.89</td>
</tr>
<tr>
<td>Angus</td>
<td>290.00</td>
<td>61.00</td>
<td>28.55</td>
<td>14.17</td>
<td>7.07</td>
</tr>
<tr>
<td>East Fife &amp; Lothian</td>
<td>208.00</td>
<td>90.50</td>
<td>22.18</td>
<td>15.00</td>
<td>7.71</td>
</tr>
<tr>
<td>Central Lowlands</td>
<td>216.00</td>
<td>50.43</td>
<td>24.22</td>
<td>20.33</td>
<td>9.29</td>
</tr>
<tr>
<td>Solway, Southern Uplands &amp; Tweed Valley</td>
<td>186.67</td>
<td>62.60</td>
<td>25.57</td>
<td>22.80</td>
<td>8.45</td>
</tr>
</tbody>
</table>

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 25 (raising factor) and 1.00 (adjustment factor) to give an estimated rodenticide use in that region and size group of 250 kg.

### Survey response rates

#### Table 8  Response rates for rodenticide survey

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>Percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target sample</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>Total number of farms approached</td>
<td>423</td>
<td></td>
</tr>
<tr>
<td>Achieved rodenticide responses</td>
<td>273</td>
<td>78</td>
</tr>
<tr>
<td>Total number of refusals/non-contact</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3 - Financial burden of rodenticides on arable farms survey

In order to minimise the burden on farmers, the survey team used non-visit methods of collection such as email, post or telephone call, where possible.

To determine the total burden that the 2014 Rodenticide Use on Arable Farms Survey placed on those providing the information, the surveyors recorded the time that 230 farmers spent providing the data during the survey. This sample represents 84 per cent of farmers surveyed. Information was recorded from all strata of the sample to ensure that the overall estimate of burden was representative. The median time farmers took to provide the information was three minutes.

In addition, 18 PCPs who provided rodenticide use data and three PCPs who provided compliance data were asked to estimate how long they took to provide information. The median time taken for the PCPs providing rodenticide use data was 20 minutes and for those providing compliance data was five minutes.

The following formula was used to estimate the total cost of participating:
Burden (£) = No. surveyed x median time taken (hours) x typical hourly rate*
(* using median “full Time Gross” hourly pay for Scotland of £13.026)

The total financial burden, accounting for all farmers’ participation in the 2014 rodenticide survey was £162.91. This equates to £0.60 per farmer.

The total financial burden, accounting for all PCPs' providing rodenticide use data in the 2014 rodenticide survey was £78.12. This equates to £4.34 per PCP.

The total financial burden, accounting for all PCPs' providing compliance data in the 2014 rodenticide survey was £3.26. This equates to £1.09 per PCP.

Therefore the total burden to respondents for the 2014 rodenticide survey was estimated to be £244.29.
Appendix 4 – Definitions and notes

1) **Rodenticide** is used throughout this report to describe a substance used to kill or control rodents.

2) An **active substance** (or active ingredient) is any substance which has a general or specific action against harmful organisms. In this report an active substance 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 substances, bait and other co-formulants.

4) The term **formulation(s)** is used to describe an active substance or mixture of active substances formulated together in a product.

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 2014 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; alphachloralose, brodifacoum, bromadiolone, difenacoum, difethialone and flocoumafen.

7) 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, arable farms are defined as farms growing combinable and/or potato crops.

8) 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.

9) When collecting information regarding **seasonal use** of rodenticides, farmers and contractors were asked to report seasonal baiting patterns. The definition of season 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).

10) Throughout the tables, data based on **10 or less sampled occurrences** (encountered on 10 or less 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.
11) Data from the 2010\textsuperscript{1} and 2012\textsuperscript{2} surveys of rodenticide use on arable farms are provided for comparison with the estimates from arable farms in this survey. 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.

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

13) The \textbf{June Agricultural Census}\textsuperscript{7} 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 2014 Agricultural Census, a sample was drawn representing arable cultivation in Scotland. The country was divided into 11 land-use regions (Figure 11). Each sample was stratified by these land-use regions and according to holding size. The holding size groups were based on the total area of arable crops grown. The sampling fractions used within both regions and size groups were based on the areas of relevant crops grown rather than number of holdings, so that smaller holdings would not dominate the sample.

The survey covered rodenticide use during the 12 month period January to December 2014. Following an introductory letter and telephone call, data were collected by personal interview, telephone interview, email or post. When rodenticides were applied by a pest control professional (PCP) the data were obtained from either the farm rodent control record book or by post/telephone interview from the contractor. If it was recorded that rodenticides were used but product data were not obtainable this was recorded as unspecified rodenticide use.

In total, information was collected from 273 holdings (Table 5). These 273 holdings represent 3 per cent of the total arable holdings in Scotland. The data collected were product(s) used, bait type, quantity applied, target and season of use. Information about use of non-chemical rodent control methods was also recorded. National rodenticide use was estimated from the sample data using a standard ratio raising statistical technique. This method involves multiplying the sample data by a factor dependent on the number of farms within each region and size group to match the data recorded in the relevant June Agricultural Census for arable crops. Due to small sample sizes the data from some regions were merged 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, raising and adjustment factors are presented in Table 7.

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 rodenticides. Farmers were also asked to provide operation details about their farm, such as whether they kept livestock or had a grain store, to allow comparison in farm operation in relation to whether they used rodenticides.
Figure 11  Land use regions of Scotland

- Highlands and Islands
- Caithness and Orkney
- Moray
- Aberdeen
- Angus
- East Fife
- Lothian
- Central Lowlands
- Tweed Valley
- Southern Uplands
- Solway
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 (Table 7) dependant on the number of farms within each region and size group to match the data recorded in the relevant June Agricultural Census7. 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

For the first time in this series of rodenticide surveys farmers were asked to identify the target of their rodenticide use and also any non-chemical control methods that they employed.

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 arable 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 text of the report.

Data quality assurance

The dataset undergoes several validation processes as follows; (i) checking for any obvious errors upon data receipt (ii) checking and identifying inconsistencies with use and pesticide 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 if necessary. Additional quality assurance is provided by sending reports for independent review. 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 output is audited against these SOPs by internal auditors annually and by external auditors every three years.
Main 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.

Experience indicates that stratified random sampling, including reserves, coupled with personal interview technique, delivers the highest quality data and minimises non-response bias.
Acknowledgements

The authors would like to thank the farmers and pest control professionals who provided the information used in this report. In addition, Paul Gavin at the Scottish Government’s Agricultural Census Analysis Team and Adrian Roberts of Biomathematics & Statistics Scotland also provided advice and support. The authors would also like to thank Alan Buckle (University of Reading) for his helpful comments on the manuscript.

References


6. Annual Survey of Hours and Earnings (ASHE) 2013 (Table 3.5a) http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-328216


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ISBN 978-1-78544-684-9 (web only)

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