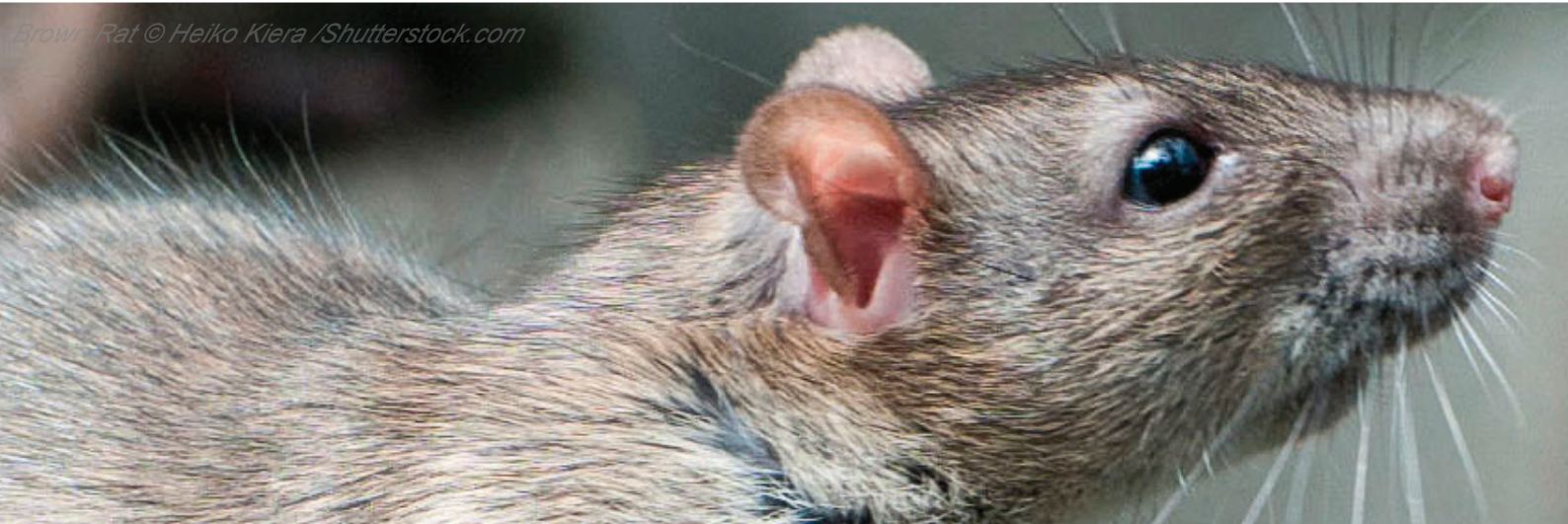


Pesticide Usage in Scotland



A National Statistics Publication for Scotland



Rodenticides on Grassland & Fodder Farms 2021

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Executive summary

This report presents the results of a survey of rodenticide use on Scottish farms growing grass and fodder crops in 2021. Information was collected from 601 holdings, which collectively grew three per cent of the 2021 fodder and grass crop area. Data from this sample were used to estimate total Scottish rodenticide use in this crop sector.

It was estimated that rodenticides were used on 27 per cent of all grass and fodder farms in 2021, significantly fewer than in 2017 (35 per cent) and 2013 (43 per cent). Farmers conducted the baiting on 56 per cent of holdings using rodenticides and applied 58 per cent of rodenticides by weight, with the remainder being applied by pest control professionals (PCPs). This is significantly lower than in 2017, where farmers were responsible for baiting on 73 per cent of farms where rodenticides were used. In 2021, an estimated 85 tonnes of rodenticide products were used on grassland and fodder farms. This is a decrease of 34 per cent since 2017 and 61 per cent lower than in 2013. The products used contained ca. six kg of rodenticide active substance. As in previous surveys, almost all products used (>99 per cent) were second generation anticoagulant rodenticides, primarily bromadiolone and difenacoum (94 per cent by weight).

Sixty nine per cent of rodenticides were applied throughout the year, either used permanently or in multiple individual baiting operations. This is an increase in year-round use from 2017 (54 per cent) but lower than 2013 (75 per cent). Most rodenticides were used in Autumn and Winter (61 per cent). Grain baits were the most common product type (89 per cent) and the main targets were a combination of rats and mice (69 per cent). Forty seven per cent of farms that did not use rodenticides and 48 per cent of those that did, employed non-chemical rodent control; most commonly cats and traps.

Data were collected about training, compliance with best practice and aspects of farm operation. Fifty four per cent of farmers were aware of rodenticide stewardship. Overall, 17 per cent of farmers had completed stewardship compliant training and 21 per cent planned to in the future. As in previous surveys, significantly more PCPs had completed training than farmers. In relation to best practice, the majority of farmers and PCPs stated they complied with all elements and responses were similar to those in 2017. Whilst a higher proportion of PCPs reported compliance, the only difference was, there was some evidence that farmers were less likely to search for and remove rodent carcasses. In addition, PCPs were significantly more likely to use non-toxic indicator baits to monitor rodent activity than farmers. In relation to farm operation, farmers that practised rodenticide baiting were significantly more likely to be members of a quality assurance scheme and to have livestock and a grain store than farmers that did not use rodenticides.

Twenty per cent of the responding PCPs stated they had encountered or suspected resistance to rodenticides on farm. Sixty seven per cent of these PCPs stated they changed bait formulation due to this suspected resistance, 17 per cent switched to using traps and 17 per cent stated they suspected it

was behavioural resistance only. Farmers were not asked about suspected resistance during this survey, but this data will be collected in future surveys.

This dataset is the second in this series to be conducted since the industry led stewardship scheme was introduced in 2015. This survey, and the previous survey in 2017, display a trend of decreased rodenticide usage, increased baiting by PCPs rather than farmers, and increased uptake of best practice which is likely to have been influenced by the introduction of stewardship and concurrent regulatory changes.

Introduction

Whilst there is no statutory requirement to survey rodenticide usage, the Scottish Government (SG) conducts periodic post-approval surveillance of use in arable, grass and fodder and local authority sectors. This monitoring is conducted by the Pesticide Survey Unit at SASA, a division of the Scottish Government's Agriculture and Rural Economy Directorate.

As part of this programme, a survey of rodenticide use on farms growing grassland and fodder crops was carried out in 2021. This is the 7th survey in this series. The previous surveys were conducted in 1993, 1997, 2002, 2005, 2013 and 2017. The first four surveys (1993 to 2005) focussed on rodenticide use on farms growing fodder crops (ca. 2,000 holdings in Scotland). From 2013 onwards the surveys were extended to include data from a supplementary sample of grassland farms to allow estimation of rodenticide use on all Scottish farms growing grass and stock feeding crops (ca. 42,000 holdings).

The Scottish Pesticide Usage reports have been designated as Official Statistics since August 2012 and as National Statistics since October 2014. The interim Chief Statistician (Ally McAlpine) 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 receive 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 [SASA privacy policies](#) and [SASA revision policies](#), a [pesticide usage report feedback survey](#) and detailed background information on the [survey methodology used](#) and [uses of the PSU pesticide usage dataset](#).

Additional information regarding rodenticide use can be supplied by the Pesticide Survey unit. Please email psu@sasa.gov.scot or visit the [SASA survey unit webpage](#).

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 in comparison with results from the previous surveys in 2013⁽¹⁾ and 2017⁽²⁾.

Appendix 1 contains data, including estimates of rodenticide use, responses to questions about compliance with best practice and rodenticide stewardship and operational information about sample farms. Appendix 2 summarises survey statistics including census and holding information, raising factors, survey response rates and outlines the estimated financial burden to survey respondents. Appendix 3 defines the terms used throughout the report. Appendix 4 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 the previous survey years are also outlined in Appendix 4.

It is important to note that the figures presented in this report are produced by 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 grassland and fodder farms and should not be interpreted as exact.

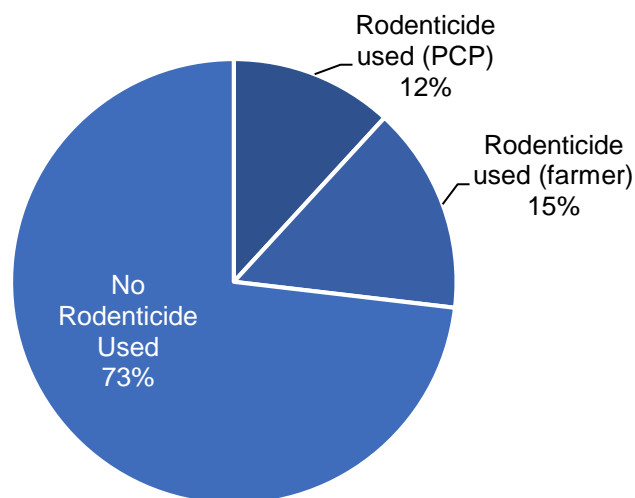
Rodenticide use data

Rodenticide use data were collected from 601 grassland and fodder holdings (423 and 178 respectively) in Scotland in 2021. The growers surveyed represented seven per cent of the holdings growing fodder crops and one per cent of those with grassland. These holdings collectively grew three per cent of the total 2021 Scottish fodder and grass crop area. Rodenticide use data from these sampled farms were used to estimate rodenticide use on all Scottish grassland and fodder farms in 2021.

Percentage of farms using rodenticides and type of user

It was estimated that on almost three quarters of Scottish grass and fodder farms (73 per cent) no rodenticides were used in 2021 (Figure 1). On those farms where rodenticides were applied (27 per cent of farms) over half of all baiting operations (56 per cent) were implemented by farmers. Pest Control Professionals (PCPs) conducted baiting on the remainder of these farms. Similar proportions were recorded in relation to the quantity of rodenticide used with farmers responsible for 58 per cent of the total use by weight of product.

Figure 1 Percentage of grassland and fodder farms using rodenticides and type of user – 2021

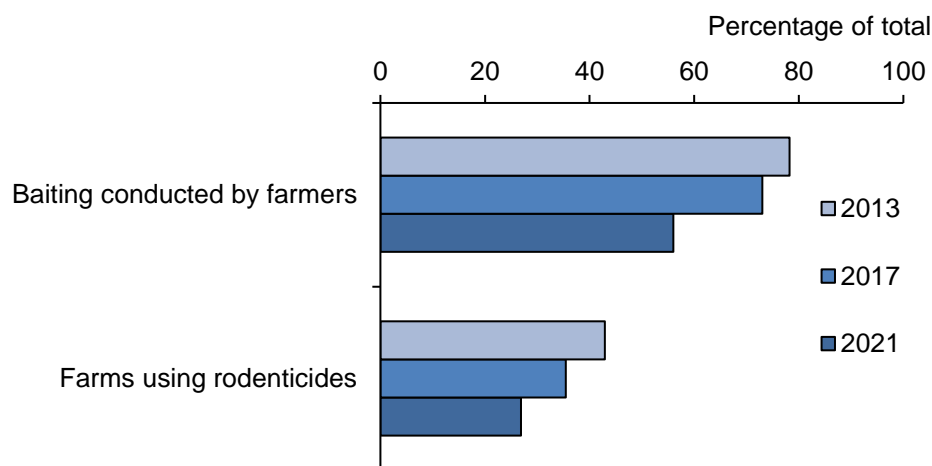


The estimated percentage of farms using rodenticides, and associated user type, in the previous two surveys (2013 and 2017) is presented in Figure 2. The proportion of grassland and fodder farms using rodenticides in 2021 (27 per cent) was lower to that in 2017 (35 per cent, p -value ≤ 0.01) and in 2013 (43 per cent). There was very strong evidence that the proportion of farms using rodenticides has declined over the last three surveys (p -value ≤ 0.001).

In 2021, on farms where rodenticides were used, there was very strong evidence the proportion applied by PCPs (44 per cent) increased from the

2017 survey (27 per cent, $p\text{-value} \leq 0.001$), and from the 2013 survey (22 per cent, $p\text{-value} \leq 0.001$). Recent surveys, since the introduction of the rodenticide stewardship scheme, have shown a trend of an increasing proportion of farms using PCPs to apply rodenticides (with the exception of the 2020 Rodenticide Use on Arable Farms survey⁽³⁾ which reported a slight decline in the use of PCPs possibly influenced by the impact of COVID-19 related restrictions).

Figure 2 Percentage of grassland and fodder farms using rodenticides and user type – 2013 to 2021



Note: There was very strong evidence that the proportion of farms using rodenticides declined over the three surveys ($p\text{-value} \leq 0.001$). There was also very strong evidence that the proportion of baiting conducted by farmers decreased between 2017 and 2021 and across the three surveys ($p\text{-value} \leq 0.001$).

Rodenticides encountered and their estimated occurrence

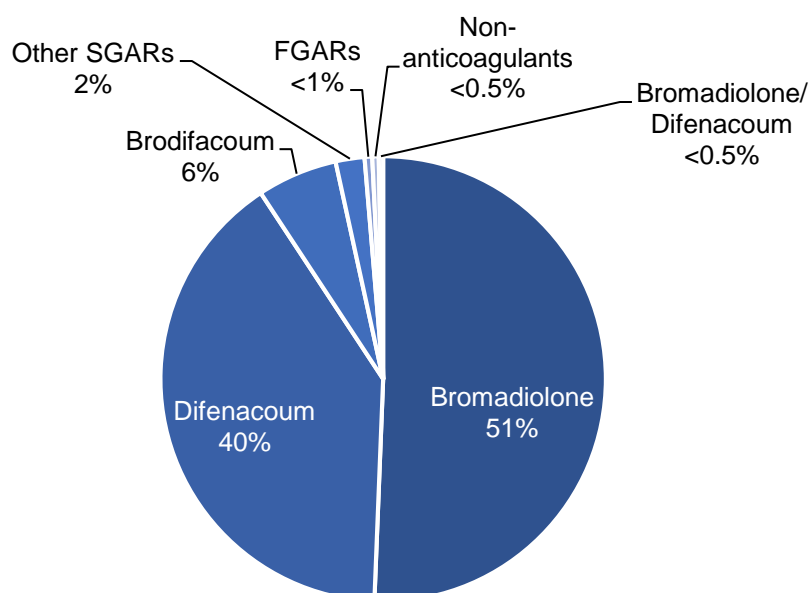
During this survey, product information was recorded for 90 per cent of all occurrences of rodenticide use. For the remaining 10 per cent, whilst it was recorded that rodenticides had been applied, the product used was not specified. This was either a result of farmers not having adequate records of the exact product used or PCPs not responding to requests for product details. The level of unspecified rodenticides in 2021 was similar to that encountered in 2017 (11 per cent) and 2013 (eight per cent). The following sections only discuss the use of specified rodenticides.

Rodenticide occurrence is the number of holdings on which a formulation (the combination of active substances formulated together in a product) is encountered. Multiple uses of the same formulation at the same holding are counted as a single occurrence (refer to Appendix 3 for further explanation of these definitions).

Nine active substances were recorded on grass and fodder farms in 2021: alphachloralose, brodifacoum, bromadiolone, cholecalciferol, coumatetralyl, difenacoum, difethialone, flocoumafen and warfarin (Table 1, Figure 3). The

majority of the rodenticides encountered were anticoagulants, which prevent the synthesis of blood clotting factors and cause rodent death by haemorrhage. The active substances encountered represent all anticoagulant rodenticides currently approved in the UK.

Figure 3 Percentage occurrence of rodenticide formulations on grassland and fodder farms – 2021



Note: Other SGARs are difethialone and flocoumafen. FGARs are coumatetralyl and warfarin. Non-anticoagulants are alphachloralose and cholecalciferol

Five of these compounds are second generation anticoagulant rodenticides (SGARs; brodifacoum, bromadiolone, difenacoum, difethialone and flocoumafen), two are first generation anticoagulant rodenticides (FGARs; coumatetralyl and warfarin) and two are non-anticoagulant compounds (alphachloralose and cholecalciferol). Cholecalciferol was previously authorised for use in the UK but was then withdrawn. It was re-authorised from October 2020, therefore this is the first pesticide usage survey to record its use since 2010 (on arable farms). Cholecalciferol causes rodent death by inducing abnormally high levels of calcium in the blood (hypercalcaemia). Over the last three surveys rodenticide use has been almost exclusively SGARs (99, >99 and 99 percent in 2013, 2017 and 2021 respectively).

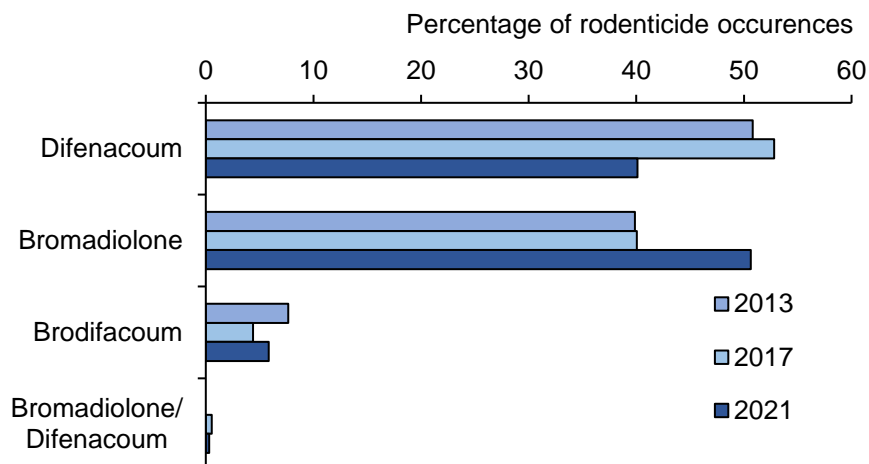
The most commonly encountered formulations were bromadiolone and difenacoum (51 and 40 per cent of all occurrences respectively). Other formulations included brodifacoum (six per cent of occurrences), difethialone (two per cent), alphachloralose, bromadiolone/difenacoum, cholecalciferol, coumatetralyl, flocoumafen and warfarin (all less than one per cent).

The dominance of bromadiolone and difenacoum occurrence reflects these being the most commonly available rodenticides. At the time of writing, bromadiolone and difenacoum containing products account for 57 per cent of all anticoagulant rodenticide approvals, 59 per cent of those approved for

outdoor use around buildings and 99 per cent of those approved for use in open areas⁽⁴⁾.

The combined use of bromadiolone, brodifacoum and difenacoum has changed little over time, accounting for 97, 98 and 99 per cent of total occurrences in 2021, 2017 and 2013 respectively. However, the relative proportions of these compounds have changed since the last survey. In 2021, the number of farms using bromadiolone was higher (p-value ≤ 0.001) than in 2017. In contrast, fewer farmers used difenacoum in 2021 (p-value ≤ 0.001) than in 2017. Difenacoum was the most commonly used rodenticide in the previous two surveys. The number of farms using brodifacoum, the third most commonly encountered rodenticide in this survey, was similar to previous surveys (six, four and eight per cent in 2021, 2017 and 2013 respectively). There was no evidence that the proportion of farms using brodifacoum differed between 2017 and 2021 though there was some evidence that the three years differed, perhaps corresponding to higher levels in 2013 (p-value ≤ 0.05). The relative proportions of these compounds vary in the longer-term dataset (particularly in the more frequently collected rodenticide use on arable farm data series - 1992 onwards) and it is not clear what the drivers for these variations are. It is possible that this may be a response to product efficacy in some areas; resistance to both difenacoum and bromadiolone has been reported in Scotland⁽⁵⁾. PCP experience of suspected resistance to rodenticides on farms is discussed in the compliance with rodenticide best practice section. It may also represent a response to differences in the range of approved products available and their marketing strategies over time. Two non-anticoagulant rodenticides were reported to have been used in the 2021 survey, alphachloralose and cholecalciferol, both accounting for less than one per cent of total rodenticide occurrences. In contrast no non-anticoagulant rodenticides were reported to have been used in the previous survey in 2017. In 2013 a small amount of aluminium phosphide was reported to have been used for rodent control (one per cent of total rodenticide occurrences).

Figure 4 Percentage occurrence of main rodenticides on grassland and fodder farms – 2013 to 2021

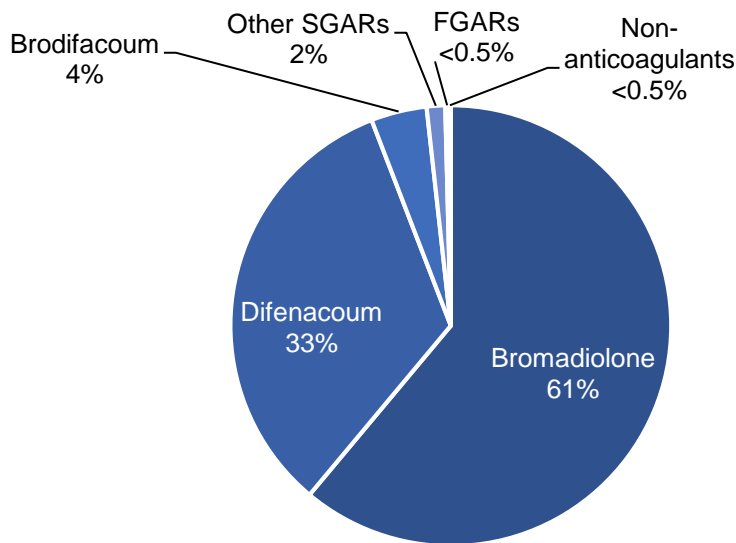


Weight of rodenticides used

Approximately 85 tonnes of rodenticidal products are estimated to have been used on Scottish grassland and fodder farms in 2021 (Table 2, Figure 5).

In line with the occurrence data, more than 99 per cent of the total weight used was of SGAR products. Products containing bromadiolone were the most commonly used (ca. 52 tonnes), accounting for 61 per cent of total rodenticide use by weight. Difenacoum products were the second most commonly used (ca. 28 tonnes) accounting for 33 per cent of total use. Brodifacoum was the only other rodenticide regularly encountered (ca. 3 tonnes), accounting for four 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 ca. 85 tonnes of rodenticide product used on grass and fodder farms in 2021 contained only ca. 6.4 kg of active substance, the remainder of the product weight is almost exclusively food bait used to attract rodents. This is very similar to the estimated weight of active substance reported in 2017 (ca. 6.5 kg) despite a 34 per cent decrease in weight of rodenticide product. This may have been influenced by the presence of the active substance alphachloralose which was recorded in 2021 but not in 2017. Alphachloralose products contain much higher levels of active substance (four per cent w/w) compared with anticoagulants (ca. 0.005 w/w). Therefore, although alphachloralose accounted for less than one per cent of the total product use in 2021 (by weight), it accounts for 33 per cent of total active substance use.

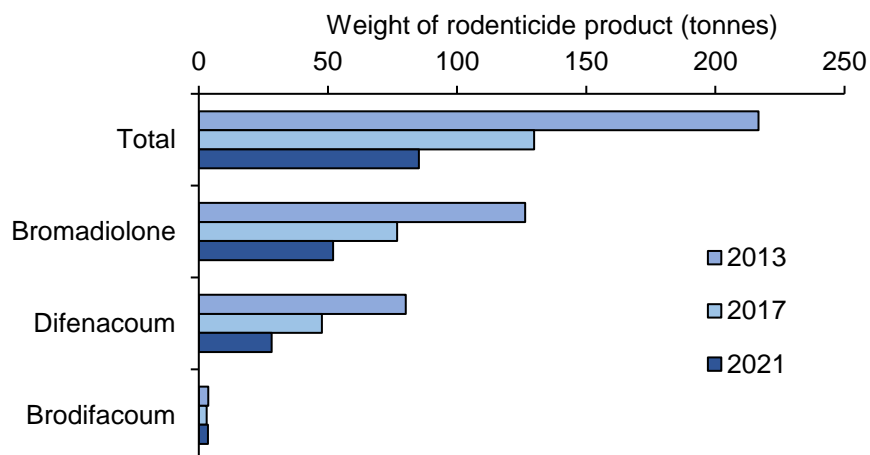
Figure 5 Percentage weight of rodenticide product used on grassland and fodder farms – 2021



Note: Other SGARs are bromadiolone/difenacoum, difethialone and flocoumafen. FGARs are coumatetralyl and warfarin. Non-anticoagulants are alphachloralose and cholecalciferol

The estimated weights of the three main rodenticides recorded in the 2013, 2017 and 2021 grassland and fodder crop surveys are presented in Figure 6. There has been a large decrease in overall weight of rodenticide products applied between these three surveys. Rodenticidal product use in 2021 (ca. 85 tonnes, was 34 per cent lower than in 2017 (ca. 130 tonnes) and 61 per cent lower than in 2013 (ca. 217 tonnes). This overall reduction is being driven by a decline in SGARs, which decreased by 32 per cent since 2017 and 61 per cent since 2013. In contrast the use of FGARs and non-anticoagulants have increased although these both make up less than one per cent of the total weight of rodenticide products used. The decline in overall rodenticide use on grassland and fodder farms is similar to that recorded in recent arable farm surveys (with the exception of the 2020 Rodenticide use on arable farms which recorded a 27 per cent increase in weight compared with 2018, possibly impacted by the COVID-19 pandemic). Estimated rodenticide use on arable farms in 2020 was 32 per cent lower than in 2016 (ca. 91 tonnes) and 57 per cent lower than that reported in 2000 (ca. 144 tonnes)⁽⁶⁾. This has partly been driven by a decline in the proportion of farms on which baiting is conducted and may also have been influenced by the greater use of PCPs.

Figure 6 Weight of rodenticide product used on grassland and fodder farms - 2013 to 2021



Note: Bromadiolone/difenacoum products have been included in total

PCPs applied 42 per cent of the total weight of rodenticide used in 2021. The weight applied by PCPs declined by 45 per cent despite an increase in the use of PCPs (responsible for 44 per cent of farms in 2021 where rodenticides were used, compared to 27 per cent in 2017). In contrast the weight of pesticide applied by farmers in 2021 only reduced by 24 per cent compared to the previous survey. Farmers were responsible for 56 per cent of the farms where rodenticides were used in 2021 compared to 73 per cent in 2017. Therefore, the decrease in estimated rodenticide use in this survey stems largely from a decrease in use by PCPs.

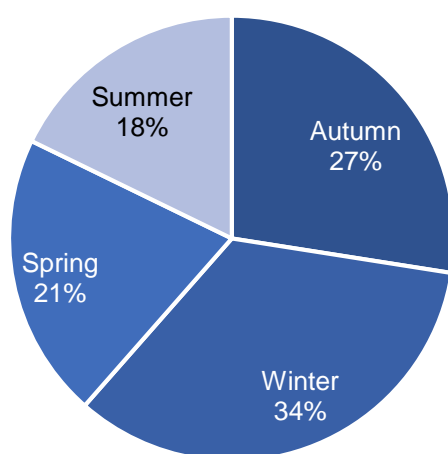
At active substance level, there were declines in weight recorded for both difenacoum and bromadiolone use (41 and 32 per cent decrease respectively) in 2021 compared with 2017. In contrast, applications of products containing brodifacoum increased by 16 per cent in 2021 compared with 2017 but were similar (five per cent lower) to use in 2013 (Figure 6). The reasons for these changes are unclear, and it should be noted that rodent populations, and thus rodenticide use, fluctuate over time. The decline in rodenticide use and increased use of PCPs, which have been detected in both arable (pre 2020) and grass and fodder crop systems, are likely to have been influenced by the Campaign for Responsible Rodenticide Usage (CRRU) guidance for best practice⁽⁷⁾ and the 2015 launch of the UK industry led rodenticide stewardship scheme⁽⁸⁾. The CRRU Code of Best Practice was revised and published in 2021 following a number of changes regarding regulation and permitted practical uses of professional rodenticides (see rodenticide approval and stewardship section for further details).

Seasonal use of rodenticides

The season in which rodenticides were used was specified for over 99 per cent of all rodenticides encountered. Sixty-nine per cent of use was reported to occur throughout the year. This included farms practising permanent baiting and those conducting multiple separate baiting operations. This is an increase from the level of year-round baiting encountered in the 2017 survey in which 54 per cent of rodenticides were reported to be used in year round baiting regimes. However, it is slightly lower than the 75 per cent reported in 2013. Year-round baiting was also lower in the Rodenticide Use on Arable Farms 2020 report where 45 per cent of rodenticides were reported to have been applied throughout the year. It is possible the increased use of PCPs in 2021 may have resulted in increased year-round use of rodenticides as PCPs are often contracted to visit farms on a monthly basis.

When the weight used, including year-round use, is separated into constituent seasons, the greatest use was in winter (34 per cent) and autumn (27 per cent), with lower use during spring and summer (Figure 7). This is a very similar seasonal pattern to that encountered in previous surveys of rodenticide use in both grassland and arable systems.

Figure 7 Seasonal use of rodenticides on grassland and fodder farms (percentage of total weight) - 2021



Rodenticide bait type and target

As in previous surveys, baits formulated with grain were the most commonly encountered in this survey, accounting for 89 per cent of use by weight, compared with 88 per cent in 2017 and 80 per cent in 2013 (Figure 8). These baits were primarily loose grain and place packs containing grain, but also included a small amount of pelletized/block grain (nine per cent of total grain baits) and grain based paste (one per cent).

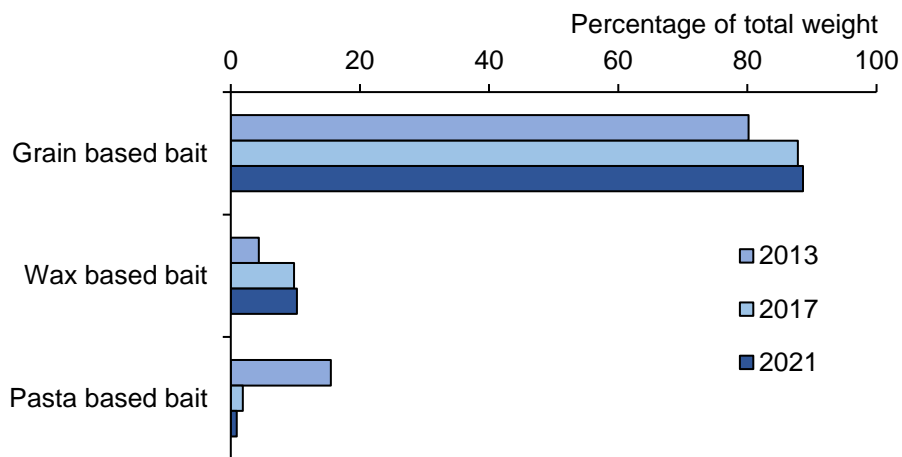
The other types of rodenticide products encountered in 2021 included wax based baits, which accounted for 10 per cent of use. Eighty five percent of

wax baits were solid wax blocks and 15 per cent were soft wax. Pasta based bait contributed one per cent of total use and other paste rodenticides (for which the type of bait wasn't specified) accounted for less than one per cent.

The use of grain baits has slightly increased during the last three surveys from 80 per cent of all rodenticide bait in 2013 to 88 per cent in 2017 and 89 per cent in 2021 (Figure 8). The type of grain bait also appears to be changing slightly. Use of loose grain and place packs containing grain has declined slightly from 99 per cent of all grain bait in 2017 to 90 per cent in 2021. In contrast, the use of pelletized or block grain has increased from one per cent in 2017 to nine per cent in 2021. Use of grain paste continues to be low.

The use of wax-based bait has also increased from four per cent of all rodenticide bait in 2013 but then has remained at 10 per cent in both 2017 and 2021. Although use was similar between the last two surveys, the wax types have changed. Use of soft wax has increased (four per cent of all wax bait in 2017 to 15 per cent in 2021) with wax block use decreasing. The use of pasta bait has declined in recent years, from 15 per cent of all rodenticide bait in 2013 to only two per cent in 2017 and one per cent in 2021. Use of other bait types such as gel, concentrates or other unspecified pastes have consistently contributed to less than one per cent of total weight applied in recent surveys.

Figure 8 Type of rodenticide bait used on grassland and fodder farms (percentage of total weight) – 2013 to 2021

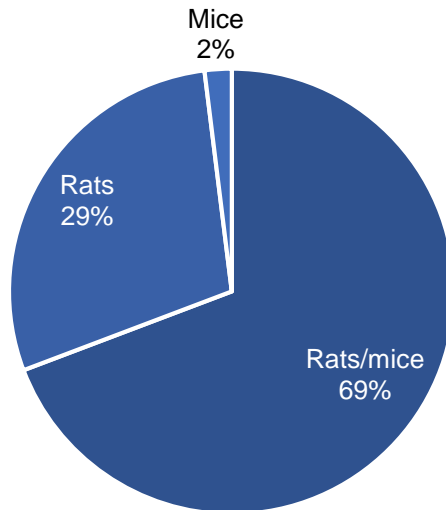


Note other bait such as gel/concentrate/unspecified paste has been excluded as it represents < one per cent of total weight applied

Survey respondents were asked to state the target of their rodenticide baiting regimes (Figure 9) and this information was supplied for over 99 per cent of estimated use by weight. Where reason data were supplied the most common target was a combination of rats and mice (69 per cent), followed by

rats 29 per cent. Only two per cent of rodenticide use was targeted at mice alone. In the previous survey in 2017 the principal target was rats (57 per cent) followed by a combination of rats and mice (37 per cent). Rodenticide target data were not collected in the 2013 grass and fodder farm survey.

Figure 9 Target of rodenticide use on grassland and fodder farms (percentage of total weight) - 2021



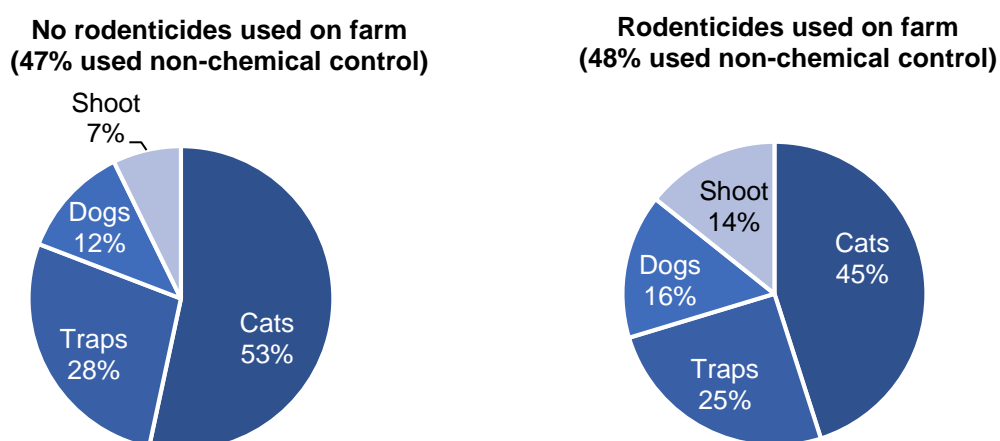
Supplementary data

In addition to the collection of rodenticide usage data, farmers were also asked a series of supplementary questions relating to aspects of their farm operation, their use of non-chemical rodent control, rodenticide stewardship and their compliance with best practice in rodenticide use. In contrast to the rodenticide usage data presented in the previous sections of this report, this information is not raised to provide national estimates of use, but is presented as responses from the sample surveyed.

Non-chemical rodent control

Farmers were asked about non-chemical methods employed for rodent control. A range of measures were conducted, with some farmers employing more than one method (Figure 10).

Figure 10 Non-chemical control on grassland and fodder farms (percentage of total methods used) – 2021



On holdings on which rodenticides were not used (n=314), 47 per cent of the farmers reported using one or more non-chemical control approaches. The most commonly encountered methods were use of cats and traps (53 and 28 per cent of all methods reported respectively). Dogs and shooting were also used to control rodents. In addition, two per cent of farmers who did not use rodenticides (n=5) reported that rodent populations were controlled by natural predators (owls and badgers were cited).

On holdings using rodenticides (n=280), 48 per cent of farmers reported that they used additional non-chemical methods of rodent control. Again, the most common methods used were cats and traps (45 and 25 per cent of all methods reported respectively) with lower use of shooting and dogs.

PCPs were also asked if they used non-chemical methods of control. Fifty seven per cent of PCPs who responded (n=30) and were responsible for rodenticide baiting on the surveyed farms stated they used non-chemical methods of control. Seventy one per cent of all methods reported were traps and use of dogs and shooting accounted for 14 per cent each. PCPs were

asked to specify the type of trap used. Fifty five per cent were snap traps (also known as break-back traps), 27 per cent were spring traps with the remainder being unspecified. Farmers were not asked to provide information on trap type but this will be collected in future surveys.

For holdings where rodenticides were used, the number of farmers reporting that they employed non-chemical rodent control was lower in 2021 than in 2017 (47 and 56 per cent respectively). For holdings where no rodenticides were used the numbers reporting the use of non-chemical control was slightly higher in 2021 than in 2017 (48 and 45 per cent respectively). Non-chemical control data were not collected in the 2013 grass and fodder farm survey as this data point was added to the rodenticide survey series in 2014. The control methods reported in this survey were very similar to those reported in the previous survey in 2017 and in recent arable surveys, with cats and traps being the most commonly used approach.

Compliance with rodenticide best practice

All farmers and PCPs who were responsible for rodenticide baiting on the surveyed farms were asked about their training history and their compliance with the principles of best practice of rodenticide use⁽⁷⁾ (Table 3).

These data are expressed as percentage of respondents giving a positive answer to each question. Not all farmers returned compliance data and some responses were only partial. There were a total 136 farmers who conducted their own rodenticide baiting during this survey. The numbers of farmers responding to each question are provided in Table 3 to give context to the percentage yes response. Likewise, not all PCPs returned compliance data. Thirty PCPs returned some compliance data, this represented 71 per cent of the contractors encountered during this survey and collectively conducted baiting on 59 per cent of those farms using a PCP. Any evidence of a statistical difference in response between farmers and PCPs is indicated by a p-value.

There was very strong evidence for a difference in training uptake between farmers (25 per cent) and PCPs (100 per cent), (p -value ≤ 0.001). In 2017 only 12 per cent of farmers had attended a training course, less than half of that recorded in 2021.

All PCPs and 94 per cent of farmers (90 per cent in 2017) 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 (all PCPs stated these were tamper proof bait stations). Bait was reported to be regularly inspected by all PCPs and 98 per cent of farmers.

Seventy six per cent of PCPs and 65 per cent of farmers removed bait after targeted baiting periods. Therefore, levels of permanent baiting have declined since 2017 (Sixty eight per cent of PCPs and 57 per cent of farmers removed bait after targeted baiting periods in 2017). The CRRU UK Rodenticide Stewardship regime published updated permanent baiting guidance in July

2019⁽⁹⁾ following changes to make the rules around permanent baiting more prescriptive.

All of PCPs and 82 per cent of farmers stated that they searched for and removed rodent carcasses compared with 96 per cent of PCPs and 63 per cent of farmers in 2017. There was some evidence that compliance with this element of best practice was different between farmers and PCPs (p -value ≤ 0.05). Many respondents stated that they rarely saw carcasses. However, those farmers who did encounter carcasses employed a range of disposal methods; primarily burying and incineration, but also via landfill and disposal with fallen stock. PCPs disposed of carcasses by burial, incineration, removal by a waste contractor and landfill (refer to Table 3 for details).

There was very strong evidence for a difference in the use of non-toxic indicator baits to monitor rodent activity on farm between PCPs (63 per cent) and farmers (two per cent). (p -value ≤ 0.001). This is the first time in this series that both PCPs and farmers have been asked about the use of indicator baits.

The pattern of responses to these questions, both by farmers and PCPs, are similar to those provided in the 2017 grassland and fodder crop survey. The level of training and use of non-toxic indicator baits were the only questions where there was strong evidence for a difference between farmer and PCP response with some evidence for a difference in searching for rodent carcasses.

For the first time in this data series, PCPs were asked if they had ever encountered or suspected resistance to rodenticides on farm. Twenty per cent of the responding PCPs stated they had ($n=29$). These PCPs were also asked if they changed bait formulation or used an alternative method in response. Sixty seven per cent stated they changed bait due to suspected resistance (three quarters of which specified they switched to using brodifacoum), 17 per cent switched to using traps and 17 per cent stated they suspected it was behavioural resistance only. Farmers were not asked about suspected resistance during this survey, but this data will be collected in future surveys.

Farm operation data

Farmers were asked a series of questions relating to aspects of farm operation which might affect rodenticide use pattern (Table 4). Not all of those surveyed provided this data, responses were provided by 594 farmers, representing 99 per cent of the farms sampled overall.

The majority of respondents (75 per cent) were a member of a quality assurance scheme, lower than the 86 per cent recorded in 2017 but greater than the 68 per cent recorded in 2013. 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. Membership of both QMS and SQC also permits purchase and use of rodenticide products authorised under stewardship conditions. There was very strong evidence to suggest that farms that practised rodenticide baiting were more likely to be members of a quality assurance scheme (93 per cent) than farms that did not use rodenticides (60 per cent) (p-value ≤ 0.001).

Ninety-one per cent of those surveyed kept livestock on their holdings, compared to 96 per cent in 2017 and 91 per cent in 2013. Unlike the previous two surveys, there was very strong evidence that farms with livestock in 2021 were more likely to use rodenticides (p-value ≤ 0.001). Only one per cent of farms had a pig unit and two per cent had a poultry unit (same as 2017). These intensive livestock production sectors tend to be greater users of rodenticides due to storage of large volumes of feed and concern about feed spoilage and rodent related disease introduction.

Lastly, 19 per cent of holdings surveyed had an on-farm grain store. There was very strong evidence to suggest that a greater number of farms using rodenticides had a grain store (30 per cent) than farms that did not use rodenticides (nine per cent) (p-value ≤ 0.001).

In 2013 and 2017, very strong evidence for differences between those farmers using and not using rodenticides, were only in relation to quality assurance membership uptake and presence of a grain store. This was also true in 2021 with the additional difference that there was very strong evidence in 2021 of a greater proportion of those using rodenticides also keeping livestock.

Rodenticide approval and stewardship

EU and UK Regulatory risk assessments have concluded that the use of First and Second Generation Anticoagulant Rodenticides outdoors presents a higher level of risk to non-target animals (such as predatory birds and mammals) than would normally be considered acceptable. As a result, outdoor use of these rodenticides would not usually be approved. However, the UK Government recognises that, despite these risks, outdoor use of anticoagulant rodenticides is necessary for rodent control.

In order to be able to re-authorise these rodenticides for use outdoors, Government must be assured that the risks will be properly managed to minimise unacceptable effects to non-target species. This has been addressed by an industry led stewardship scheme, managed by the Campaign for Responsible Rodenticide Use (CRRU)⁽⁷⁾, which was launched in 2015. With the launch of the stewardship scheme providing environmental risk mitigation measures for rodenticide use, the Health and Safety Executive (HSE), during 2016 and 2017, re-approved rodenticide product authorisations. As part of this re-authorisation the approval conditions for some products were amended, notably in relation to the outdoor use of active substances that were previously restricted to use inside buildings (brodifacoum, flocoumafen and difethialone).

During the last five years CRRU has continued to seek ways to strengthen the regime. The CRRU Code of Best Practice has recently been revised (September 2021) to take into account these regulatory changes and permitted practical uses of professional rodenticides. For example, in the updated code rodenticide use for permanent, pulsed or burrow baiting, or in covered and protected bait stations, is now only legal if the product label specifically permits these 'non-standard' scenarios. The updated code also includes new information about two active substances returning to the UK market, cholecalciferol and hydrogen cyanide, including their roles in rodenticide resistance management.

When first published in 2015, the code's legal status was guidance. Since then, the Biocidal Products Regulation governing rodenticide authorisations has determined that "biocidal products shall be used in compliance with the terms and conditions of authorisation". These are summarised on product labels, thereby placing a legal obligation on pest controllers, farmers and gamekeepers. The 2021 Code of Best Practice also contains new details for using a risk hierarchy to plan effective rodent control at minimum risk to people, non-target animals and the environment. Pre-control environmental risk assessments are also recommended. These changes have been designed to influence rodenticide usage patterns. As discussed earlier, it is likely that decreased rodenticide usage and increased use of PCPs reported in 2021 and 2017 have been influenced by the introduction of the stewardship scheme and increased requirement to adhere to best practice.

Farmers were asked a series of questions to investigate knowledge and participation in the rodenticide stewardship scheme (Table 5). Not all of those surveyed provided this data; there were a total 136 farmers who conducted their own rodenticide baiting during this survey. The number of farmers responding to each question varied (see table 5 for details).

Fifty four per cent of farmers were aware of the rodenticide stewardship scheme's existence in 2021. Seventeen per cent of all responding farmers surveyed had attended a stewardship compliant training scheme which provided certification acceptable for point of sale purchase of professional rodenticide products. In addition, 21 per cent of farmers stated they intended to complete this training in future. In 2017, 61 per cent of farmers were aware of the scheme, seven per cent had completed stewardship compliant rodenticide use training and 32 per cent intended to complete training in the future. The difference in intention to complete stewardship training may be due to the fact that more farmers are now trained or motivation to complete training has reduced now rodenticides can be purchased via membership of a compliant quality assurance scheme (this had been an interim measure during the last survey). A reduction in the number of farmers intending to complete stewardship training has also been recorded in recent rodenticide use on arable farm surveys.

Farmers were also asked how they last purchased rodenticides. The majority (78 per cent) obtained rodenticides by demonstrating membership of a stewardship compliant quality assurance scheme (53 per cent in 2017),

followed by production of a stewardship compliant training certificate (16 percent, seven per cent in 2017). Nine per cent of farmers reported buying amateur products (15 per cent of purchases in 2017).

Appendix 1 - Estimated rodenticide use and supplementary data tables

Table 1 Total estimated occurrence of rodenticide use on grassland and fodder farms - 2021

Number of occurrences of each rodenticide formulation (combination of active substances) and percentage of total occurrences

Formulation	Number of occurrences	Percentage of total specified occurrences
Alphachloralose ⁽¹⁾	37	<1
Brodifacoum	698	6
Bromadiolone	6,061	51
Bromadiolone/Difenacoum ⁽¹⁾	38	<1
Cholecalciferol ⁽¹⁾	19	<1
Coumatetralyl ⁽¹⁾	43	<1
Difenacoum	4,801	40
Difethialone ⁽¹⁾	186	2
Flocoumafen ⁽¹⁾	65	<1
Warfarin ⁽¹⁾	23	<1
Unspecified Rodenticide ⁽²⁾	1,390	12
Total (excluding unspecified use)	11,972	
FGARs ⁽³⁾	66	<1
SGARs ⁽⁴⁾	11,850	99
Non-anticoagulant ⁽⁵⁾	56	<1

(1) Estimates are based on <10 occurrences in the sample and should therefore be treated with caution

(2) Rodenticides are recorded as unspecified when use has been recorded but product information is not available (refer to Appendix 3)

(3) First generation anticoagulant compounds: coumatetralyl, warfarin

(4) Second generation anticoagulant compounds: brodifacoum, bromadiolone, difenacoum, difethialone, flocoumafen

(5) Non-anticoagulant rodenticide compounds: alphachloralose, cholecalciferol

Table 2 Total estimated weight of rodenticides used on grassland and fodder farms in Scotland – 2021

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

Formulation	Formulation weight	Product weight	
		Kg	Percentage of total
Alphachloralose ⁽¹⁾	2.12	53	<1
Brodifacoum	0.16	3,485	4
Bromadiolone	2.60	52,024	61
Bromadiolone/Difenacoum ⁽¹⁾	0.00	75	<1
Cholecalciferol ⁽¹⁾	0.04	53	<1
Coumatetralyl ⁽¹⁾	0.06	167	<1
Difenacoum	1.40	28,166	33
Difethialone ⁽¹⁾	0.02	837	1
Flocoumafen ⁽¹⁾	0.01	243	<1
Warfarin ⁽¹⁾	0.04	73	<1
Total⁽²⁾	6.45	85,175	
FGARs ⁽³⁾	0.10	240	<1
SGARs ⁽⁴⁾	4.19	84,829	>99
Non-anticoagulant ⁽⁵⁾	2.16	106	<1

(1) Estimates are based on <10 occurrences in the sample and should therefore be treated with caution

(2) Excluding unspecified rodenticides (refer to Appendix 3)

(3) First generation anticoagulant compounds: coumatetralyl, warfarin

(4) Second generation anticoagulant compounds: brodifacoum, bromadiolone, difenacoum, difethialone, flocoumafen

(5) Non-anticoagulant rodenticide compounds: alphachloralose, cholecalciferol

Table 3 Farmer and PCP response to training and compliance questions - 2021

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 ⁽¹⁾	PCPs ⁽²⁾
1) Have you attended a training course on rodenticide use? ⁽³⁾	*25 (n=129)	*100 (n=30)
2) Are quantity and location of baits recorded?	94 (n=130)	100 (n=30)
3) Are bait points protected from non-target animals?	99 (n=132)	100 (n=30)
4) Is bait regularly inspected?	98 (n=132)	100 (n=30)
5) Is bait removed after targeted baiting periods?	65 (n=130)	76 (n=29)
6) Are rodent carcasses searched for and removed? ⁽⁴⁾	82 (n=131)	100 (n=30)
7) Use of non-toxic indicator baits to monitor rodent activity?	*2 (n=131)	*63 (n=30)

(1) Not all farmers returned compliance data and some responses were only partial. There were a total of 136 farmers who conducted their own rodenticide baiting during this survey. The number of farmers responding to each question are provided in brackets to give context to the percentage yes response

(2) Not all PCPs returned compliance data. Thirty PCPs returned some compliance data, this represented 71 per cent of the contractors encountered during this survey and collectively conducted baiting on 59 per cent of those farms using a PCP

(3) Training uptake by farmer here refers to all rodenticide use training, this differs from that reported in Table 5 which only records training that is compliant with rodenticide stewardship and allows professional rodenticide products to be purchased

(4) 104 farmers gave a response in relation to carcass disposal method, although five per cent stated they never saw any carcasses; of those who did see carcasses, the most common methods were burying (55 per cent) and incineration (29 per cent). Other methods included landfill and disposal with fallen stock (15 and one per cent respectively). Please note five farmers used more than one disposal method. Twenty six PCPs supplied disposal methods, the most common was burial (42 per cent) followed by incineration (36 per cent), removal by a waste contractor (14 per cent) and landfill (eight per cent). Eight PCPs use more than one disposal method.

* Responses marked with an asterisk indicate very strong evidence of a statistical difference in response between farmers and PCPs (p-value \leq 0.001)

Table 4 Farmer response to farm operation questions - 2021

Question	Percentage yes response		
	All farms (n=594) ⁽¹⁾	Farms using rodenticides (n=280) ⁽¹⁾	Farms not using rodenticides (n=314) ⁽¹⁾
1) Is your farm a member of a quality assurance scheme?	75	*93	*60
2) Is livestock kept on your farm?	91	*96	*87
3) Do you have a pig unit on your farm?	1	1	1
4) Do you have a poultry unit on your farm?	2	3	2
5) Do you have a grain store?	19	*30	*9

(1) Not all farmers returned farm operation data. These data represent 99 per cent of the farms sampled overall, 99 per cent of those using rodenticide and 98 per cent of those not using rodenticides

* Responses marked with an asterisk are significantly different between farms that used and did not use rodenticides (p-value ≤ 0.001)

Table 5 Farmer response to rodenticide stewardship questions - 2021

Question	Percentage yes response ⁽¹⁾
1) Are you aware of the rodenticide stewardship scheme?	54 (n=123)
2a) Have you completed a stewardship compliant training course?	17 (n=127)
2b) If no, do you intend to complete a stewardship compliant training course in the future?	21 (n=119)
3) When you last purchased rodenticides did you:	
3a) Show a certificate of competence/training in rodenticide use	16 (n=128)
3b) Demonstrate membership of a compliant quality assurance scheme	78 (n=128)
3c) Purchase non-professional/amateur rodenticides (<1.5 kg pack)	9 (n=128)

1) Not all farmers responded to all stewardship questions. There were a total 136 farmers who conducted their own rodenticide baiting during this survey. The number of farmers responding to each question are provided in brackets to give context to the percentage yes response

Appendix 2 - Survey statistics

Census and sample information

Table 6 Distribution of grassland holdings sampled - 2021

Size Group (ha)	H & I and C & O	Moray Firth	Aberdeen	Angus & East Fife	Lothian & Central Lowlands	TV & SU	Solway	Scotland
0.01 – 19.99	23	8	10	7	13	6	2	69
20.00 – 49.99	17	5	14	4	20	4	4	68
50.00 – 99.99	21	4	13	6	28	15	8	95
100.00 – 149.99	16	5	6	2	19	6	10	64
150.00 +	25	3	4	5	28	42	20	127
Total	102	25	47	24	108	73	44	423

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

Table 7 Census distribution of grassland holdings (excluding rough grazing) - 2021

Size Group (ha)	H & I and C & O	Moray Firth	Aberdeen	Angus & East Fife	Lothian & Central Lowlands	TV & SU	Solway	Scotland
0.01 - 19.99	10,514	1,988	3,654	2,144	4,122	1,665	1,257	25,344
20.00 - 49.99	1,510	447	933	410	1,260	482	387	5,429
50.00 - 99.99	888	240	526	229	1,052	421	490	3,846
100.00 - 149.99	375	102	160	89	498	242	319	1,785
150.00 +	392	83	115	96	392	484	352	1,914
Total	13,679	2,860	5,388	2,968	7,324	3,294	2,805	38,318

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

Table 8 Distribution of fodder holdings sampled - 2021

Size Group (ha)	H & I and C & O	Moray Firth	Aberdeen	Angus & East Fife	Lothian & Central Lowlands	Tweed Valley & Southern Uplands	Solway	Scotland
0.01 – 4.99	9	6	8	3	3	2	1	32
5.00 – 9.99	10	7	11	5	9	6	4	52
10.00 – 14.99	5	5	3	3	4	7	6	33
15.00 – 19.99	3	1	4	2	4	5	3	22
20.00 +	5	5	2	4	5	9	9	39
Total	32	24	28	17	25	29	23	178

H&I=Highlands & Islands, C&O=Caithness & Orkney

Table 9 Census distribution of fodder holdings - 2021

Size Group (ha)	H & I and C & O	Moray Firth	Aberdeen	Angus & East Fife	Lothian & Central Lowlands	Tweed Valley & Southern Uplands	Solway	Scotland
0.01 – 4.99	450	174	332	83	135	81	56	1,311
5.00 – 9.99	130	86	139	73	83	73	59	643
10.00 – 14.99	29	25	32	20	40	47	30	223
15.00 – 19.99	14	11	18	9	17	22	22	113
20.00 +	14	21	14	14	24	29	39	155
Total	637	317	535	199	299	252	206	2,445

H&I=Highlands & Islands, C&O=Caithness & Orkney

Raising factors

Table 10 Raising and adjustment factors for grassland holdings - 2021

Region	Size group (ha)					Adjustment factor
	0.01–19.99	20.00–49.99	50.00–99.99	100.00–149.99	150 +	
Highlands & Islands/Caithness & Orkney	457.13	88.82	42.29	23.44	15.68	1
Moray Firth	248.50	89.40	60.00	20.40	27.67	1
Aberdeen	365.40	66.64	40.46	26.67	28.75	1
Angus/East Fife	306.29	102.50	38.17	44.50	19.20	1
Central Lowlands & Lothian	317.08	63.00	37.57	26.21	14.00	1
Southern Uplands & Tweed Valley	277.50	120.50	28.07	40.33	11.52	1
Solway	628.50	96.75	61.25	31.90	17.60	1

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 4 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 26.67 (raising factor) and 1.00 (adjustment factor) to give an estimated rodenticide use in that region and size group of 266.7 kg.

Table 11 Raising and adjustment factors for fodder holdings - 2021

Region	Size group (ha)					Adjustment factor
	0.01 – 4.99	5.00 - 9.99	10.00 – 14.99	15.00 – 19.99	20 +	
Highlands & Islands/Caithness & Orkney	50.00	13.00	5.80	4.67	2.80	1
Moray Firth	29.00	12.29	5.00	11.00	4.20	1
Aberdeen	41.50	12.64	10.67	4.50	7.00	1
Angus/East Fife	27.67	14.60	6.67	4.50	3.50	1
Central Lowlands & Lothian	45.00	9.22	10.00	4.25	4.80	1
Southern Uplands & Tweed Valley	40.50	12.17	6.71	4.40	3.22	1
Solway	56.00	14.75	5.00	7.33	4.33	1

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 4 for description of statistical estimation process). For example, a total recorded rodenticide use of 10 kg on 15-19.99 ha sized farms in Aberdeen would be multiplied by 4.5 (raising factor) and 1 (adjustment factor) to give an estimated rodenticide use in that region and size group of 45 kg.

Survey response rates

Table 12 Response rate for grassland survey - 2021

	2021	Percentage of total
Number of postal surveys sent out	1,298	
Achieved rodenticide responses (no. returns)	423	33
Total number of refusals/non-contact	875	

Table 13 Response rate for fodder survey - 2021

	2021	Percentage of total
Target sample	200	
Total achieved	178	89
Total number of farms approached	281	
Total number of refusals/non-contact	103	

Financial burden to survey respondents

In order to minimise the burden on farmers and to comply with the restrictions imposed by COVID-19, the survey team use non-visit methods of data collection such as email, post or telephone call.

To determine the total burden that the 2021 rodenticide use on grassland and fodder farms survey placed on those providing the information, farmers were asked to estimate the time that they spent providing data. Ninety-seven per cent of the farmers surveyed provided this information. The median time taken was three minutes (this includes all responses, including those who did not use rodenticides).

In addition, PCPs were also asked to estimate how long they took to provide information. Seventy per cent of the PCPs supplying data provided this information. The median time taken was 15 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 £16.07⁽¹⁰⁾)

It is estimated that the total financial burden to respondents for the 2021 grassland and fodder crop rodenticide survey was £552.

Appendix 3 - Definitions and notes

- 1) **Rodenticide** is used throughout this report to describe a substance used to kill or control rodents.
- 2) An **active substance** is any substance which has a general or specific action against harmful organisms. In this report this refers to a substance with a detrimental effect on rodents.
- 3) The term **product** is used to describe a marketed rodenticide product which contains active substance(s), bait and other co-formulants.
- 4) The term **formulation** is used to describe an active substance or mixture of active substances formulated together in a product. A formulation is not synonymous with a product; the same formulation of active substances is present in many different products.
- 5) Rodenticides are classified as **anticoagulant** (which prevent the synthesis of blood clotting factors resulting in rodent death by haemorrhage) or **non-anticoagulant** compounds. The anticoagulant rodenticides are classified into first and second generation compounds (**FGARs** and **SGARs** respectively). The FGARs, which were the first anticoagulant compounds to be developed, are less acutely toxic than SGARs.
- 6) The **rodenticides approved for use** in the UK during the 2021 survey period were: FGARs (coumatetralyl and warfarin), SGARs (brodifacoum, bromadiolone, difenacoum, difethialone and flocoumafen) and non-anticoagulant rodenticides (alphachloralose, aluminium phosphide, cholecalciferol and carbon dioxide). The **rodenticides encountered** in this survey were; alphachloralose, brodifacoum, bromadiolone, cholecalciferol, coumatetralyl, difenacoum, difethialone, flocoumafen and warfarin.
- 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, 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). 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.
- 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** (rodenticide formulations encountered on 10 or less holdings) are highlighted 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 2013⁽¹⁾ and 2017⁽²⁾ surveys of rodenticide use on grassland and fodder farms are provided for comparison with the estimates 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, weather patterns, 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 effective rodent control was required.

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

13) The **June Agricultural Census**⁽¹¹⁾ 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.

14) The UK Rodenticide Stewardship Scheme⁽⁸⁾ was implemented in April 2016 to reduce risks to wildlife and the environment from anticoagulant rodenticides. By mitigating these risks to the environment, the scheme aims to provide the Health and Safety Executive (HSE) with the confidence it requires to permit the continued authorisation of anticoagulant rodenticides for rodent pest management.

Appendix 4 - Survey methodology

Sampling and data collection

Using the June 2021 Agricultural Census⁽¹¹⁾ 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 regions⁽¹²⁾ (Figure 11) 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. 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.

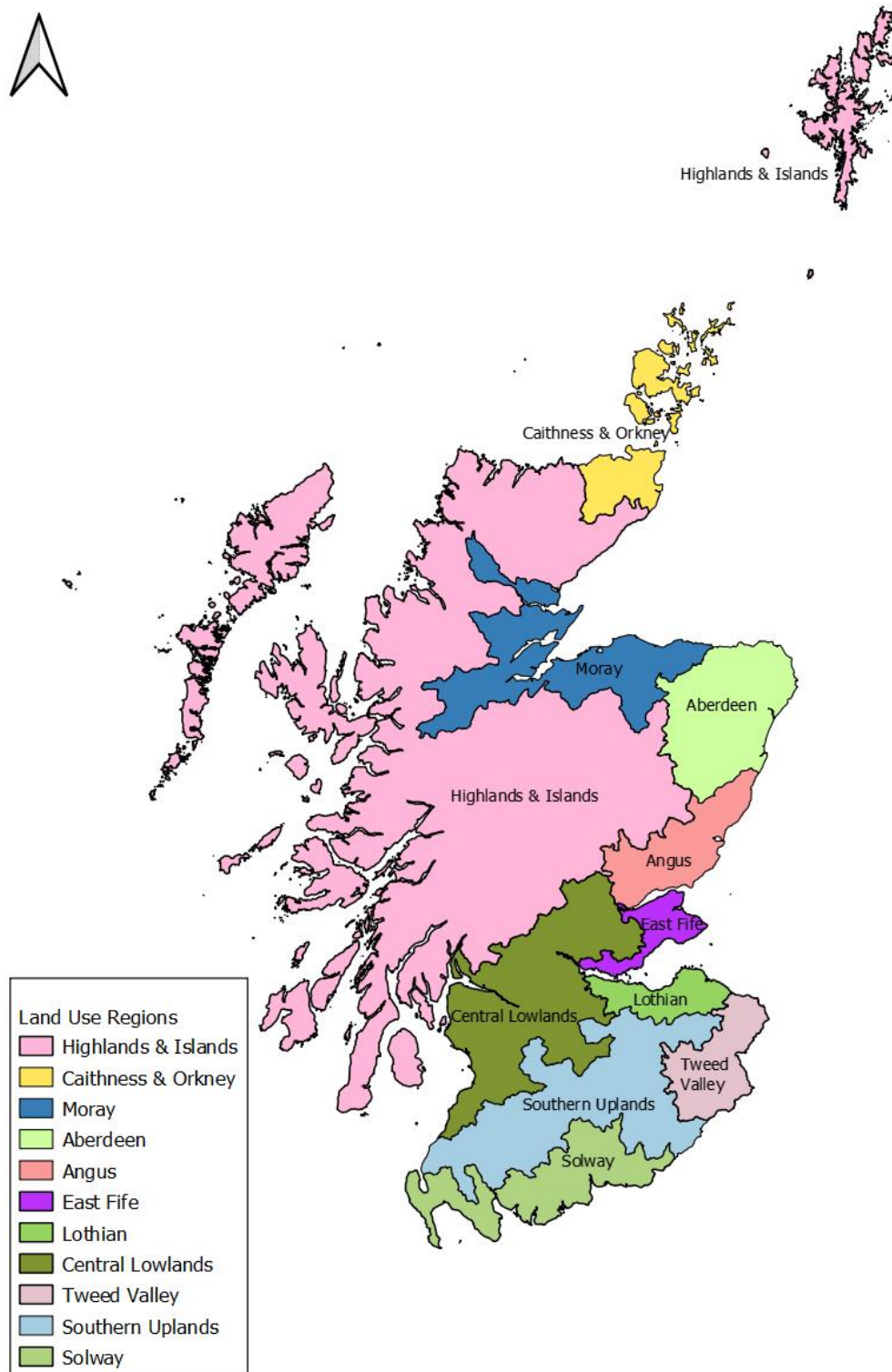
The survey covered rodenticide use during the 12 month period January to December 2021. Following an introductory letter, data was gathered from farms growing fodder crops by telephone interview or email. For the grassland survey a postal questionnaire was sent out which farmers completed and returned, 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.

In total, information was collected from 601 holdings (Table 12 & 13). These holdings represent seven per cent of the 2021 Scottish fodder crop holdings (Table 8) and one per cent of the grassland holdings (Table 6). The data collected were; rodenticide user, product(s) used, bait type, weight applied, target and season of use. Information about use of non-chemical rodent control methods was also recorded.

All farmers and PCPs encountered in the survey were also asked to respond to a simple questionnaire containing questions relating to whether they had received training in use of rodenticides, their self-reported compliance with best use practice for rodenticides and their knowledge of rodenticide stewardship. 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.

It should be noted that, in relation to all data collected, responses are as reported by the rodenticide users and no attempt has been made to check their accuracy.

Figure 11 Land use regions of Scotland⁽¹²⁾



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 (holdings using rodenticides, rodenticide occurrence and weight) 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 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 grassland and fodder 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 Tables 10 and 11.

The remainder of the data (use of non-chemical control methods, details of farm operation, compliance with best practice and knowledge of rodenticide stewardship) are unraised and represent the information collected from the sample.

Changes from previous years

For the first time in this series of surveys, both farmers and PCPs were asked about the use of non-toxic indicator baits to monitor rodent activity. Use of these confirms rodent activity before baiting regimes are implemented and is good practice when using rodenticides. In addition, PCPs were asked if they had ever encountered or suspected resistance to rodenticides on farm and if they changed their method/type of control in response. PCPs were also asked about the types of traps they use. It is intended to also ask farmers these questions in future surveys.

Like the previous survey, some of the rodenticide data was collected via a postal questionnaire (grassland survey). Unfortunately, due to limited resource, it was not possible to follow-up with farmers if certain questions had been missed, this led to some partial data for the responses to some of the training and compliance questions. To take these unanswered questions into account, the percentage yes response was calculated on the number of respondents for each question rather than the overall number of survey respondents. This is why n (number of respondents) is variable in tables 3 and 5. Previously the yes response was calculated on the total sample number less the total blanks i.e. respondents who did not answer any question, partial blanks (which were minimal) were ignored. This should have minimal impact when making comparisons with the previous surveys.

In previous reports in this series (pre-2017), data about the type of rodenticide user (i.e. farmer or PCP) were based on the proportions encountered in the sample surveyed. Whilst this was made clear in the reports, it was in contrast

to the weight and occurrence data presented, which were estimates of use in the total population of grassland and fodder farms. Due to database improvements, population estimates of user type were published in the 2017 report for both the 2017 and 2013 data sets. This has resulted in differences in 2013 user data presented in 2017 and 2021 and in the original 2013 report.

Statistical analyses

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 grass and 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 text and tables of this 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 9001:2015. 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.

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