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Pesticide Usage in Scotland



A National Statistics Publication for Scotland



Rodenticides on Arable Farms 2020

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Executive summary

This report presents the results of a survey of rodenticide use on arable farms in Scotland in 2020. Information was collected from 268 holdings, collectively growing seven per cent of the 2020 arable crop area. Data from this sample was used to estimate total Scottish rodenticide use in this crop sector.

It was estimated that rodenticides were used on 61 per cent of all arable farms in 2020, slightly higher than the 55 per cent reported in 2018 but significantly fewer than the 78 per cent reported in 2016. Farmers conducted the baiting on 57 per cent of holdings using rodenticides and applied 59 per cent of rodenticides by weight, with the remainder being applied by pest control professionals (PCPs). In 2020 an estimated 62 tonnes of rodenticide products were used on arable farms. This is an increase of 27 per cent since 2018 and a decrease of 32 per cent since 2016. The products used contained ca. 3 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 (97 per cent by weight).

Forty five per cent of rodenticides were applied throughout the year, either used permanently or in multiple individual baiting operations. This is a decrease in year-round use from 2018 (61 per cent) but similar to 2016 (46 per cent). Most rodenticides were used in autumn and winter (73 per cent). Grain baits were the most common product type (82 per cent) and the main targets were a combination of rats and mice (51 per cent). Fifty one per cent of farms that did not use rodenticides and 52 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. Eighty seven per cent of farmers were aware of rodenticide stewardship, of these 28 per cent had completed stewardship compliant training and nine 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 2018. 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 a grain store than farmers that did not use rodenticides.

This dataset is the third in this series to be conducted since the industry led stewardship scheme was introduced in 2015. The previous surveys in 2018 and 2016 reported decreased rodenticide usage, increased adoption of non-chemical control and increased uptake of best practice which was likely to have been influenced by the introduction of the stewardship and regulatory changes. The increase in rodenticide use in 2020 and the reduction in use of PCPs could potentially indicate that the impact of the stewardship scheme has plateaued. However, it is also possible that rat populations, farmer use of PCPs and, as a consequence, bait volumes were impacted by COVID-19 restrictions during 2020. The impact of the pandemic on trends in baiting operations may be clearer in subsequent surveys.

Introduction

The Scottish Government (SG) conducts post-approval surveillance of rodenticide use. This monitoring is conducted by the Pesticide Survey Unit at SASA, a division of the Scottish Government's Agriculture and Rural Economy Directorate. The current rodenticide surveillance programme consists of surveys of rodenticide use on arable farms (biennial), grass and fodder farms (every four years) and use by Scottish local authorities (every four years). As part of this programme, a survey of rodenticide use on farms growing arable crops was carried out in 2020. This is the 15th 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 receive survey specific statistical support from Biomathematics and Statistics Scotland ([BioSS](#)).

All reports are produced according to a published timetable. For further information about 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 [privacy](#) and [revision](#) policies, [user feedback](#) and detailed background information on survey [methodology](#) and [data uses](#).

Additional information regarding rodenticide use can be supplied by the Pesticide Survey unit. Please email psu@sasa.gov.scot 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 present the results from this survey in comparison with results from the previous surveys in 2016⁽¹⁾ and 2018⁽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 arable farms and should not be interpreted as exact.

Rodenticide use data

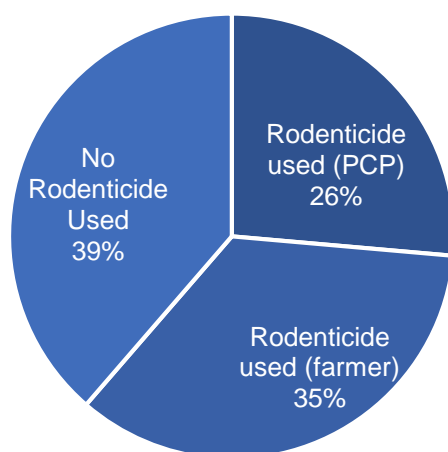
Rodenticide use data were collected from 268 arable holdings in Scotland in 2020. The farms surveyed represented three per cent of the total arable holdings in Scotland. These holdings collectively grew seven per cent of the 2020 arable crop area. The data collected from this sample were used to estimate rodenticide use on all Scottish arable farms in 2020.

Percentage of farms using rodenticides and type of user

It was estimated that approximately 61 per cent of Scottish arable farms used rodenticides in 2020 (Figure 1). Over half of all baiting operations (57 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 amounts of rodenticides used with farmers responsible for 59 per cent of the total use by weight of product.

Figure 1 Percentage of arable farms using rodenticides and type of user – 2020

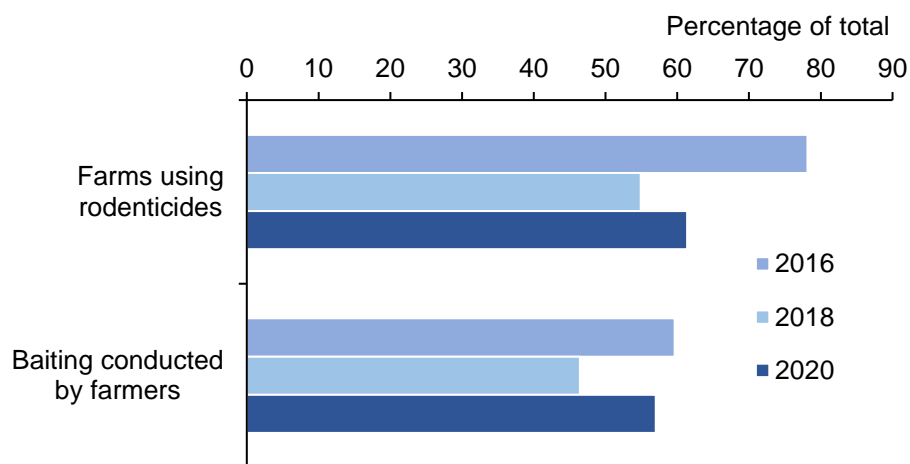


The estimated percentage of farms using rodenticides, and associated user type, in the previous two surveys (2016 and 2018) is presented in Figure 2. The proportion of arable farms using rodenticides in 2020 (61 per cent) was similar (p-value 0.17) to that in 2018 (55 per cent) but significantly lower than in 2016 (78 per cent, p-value <0.001).

In 2020, on farms where rodenticides were used, the proportion applied by PCPs (43 per cent) was lower than in 2018 (54 per cent, p-value 0.025) but similar to 2016 (40 per cent). 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. It is possible the decline in use of PCPs in 2020 was influenced by COVID-19 and the subsequent lockdown. Although pest management was classed as an essential sector

during the pandemic some farmers may have preferred to conduct their own baiting rather than using external contractors, which may also have influenced the amount of rodenticides used. The impact of the pandemic on overall trends in baiting operations may be clearer in subsequent surveys.

Figure 2 Percentage of arable farms using rodenticides and type of user – 2016 to 2020



Note: There was no statistical difference in the number of farms using rodenticides (p-value 0.17) between 2018 and 2020. There was some evidence that the proportion of baiting conducted by farmers increased between 2018 and 2020 (p-value 0.025).

Rodenticides encountered and their estimated occurrence

During this survey, product information was recorded for 78 per cent of all occurrences of rodenticide use. For the remaining 22 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 information. The level of unspecified rodenticides in 2020 was almost double that encountered in the previous survey (13 per cent), possibly linked to the change in data collection method in 2020 (see Appendix 4 - changes from previous years). The following sections only discuss the use of specified rodenticides.

Rodenticide occurrence is defined as 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).

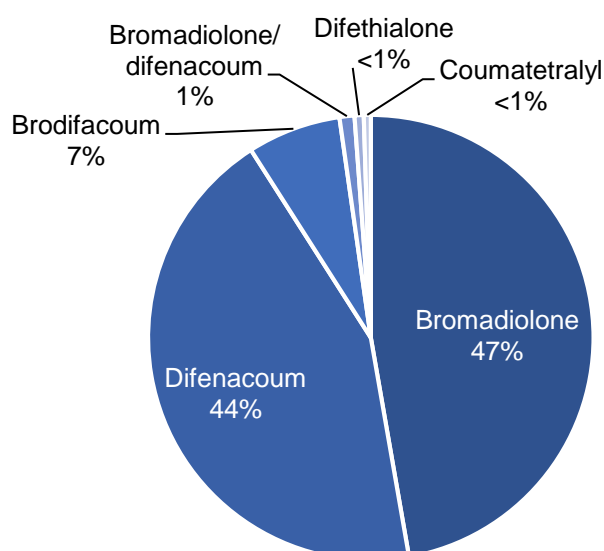
Five active substances were recorded on arable farms in 2020; brodifacoum, bromadiolone, coumatetralyl, difenacoum and difethialone (Figure 3, Table 1). All the rodenticides encountered were anticoagulants, which prevent the synthesis of blood clotting factors and cause rodent death by haemorrhage.

One of the active substances was a first generation anticoagulant rodenticide (FGAR; coumatetralyl). The other four active substances were second generation anticoagulant rodenticides (SGARs) and these SGARs collectively accounted for more than 99 per cent of all occurrences of specified rodenticide use in 2020. Over the last three surveys rodenticide use has been almost exclusively composed of SGARs (>99, > 98 and >99 per cent in 2016, 2018 and 2020 respectively, no significant difference between years).

The most commonly encountered formulations were bromadiolone and difenacoum (47 and 44 per cent of occurrences respectively). Other formulations recorded were brodifacoum (seven per cent of occurrences), bromadiolone/difenacoum (one per cent), difethialone and coumatetralyl (both 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, 60 per cent of those approved for outdoor use around buildings and 99 per cent of those approved for use in open areas⁽³⁾.

Figure 3 Percentage occurrence of rodenticide formulations on arable farms – 2020

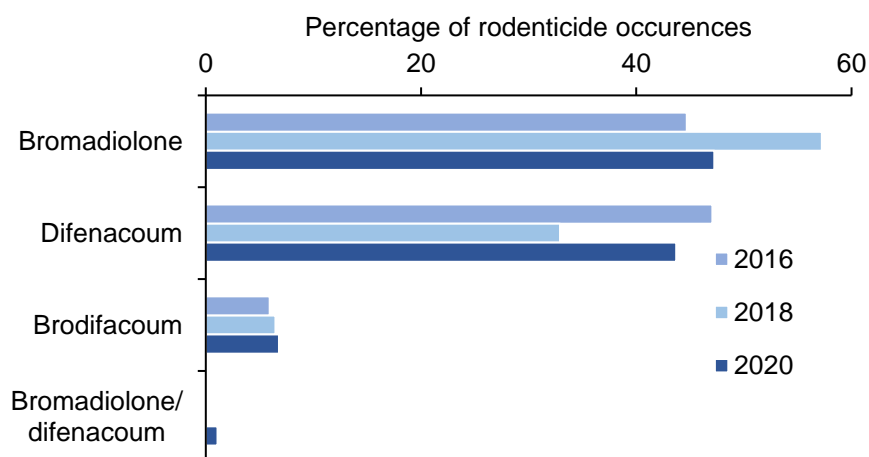


The combined use of bromadiolone and difenacoum has changed little over time, accounting for 92, 90 and 92 per cent of rodenticide occurrences in 2016, 2018 and 2020 respectively. However, the relative proportions of these two compounds have changed since the last survey. In 2020, the number of farms using bromadiolone was significantly lower (p-value 0.009) than in 2018. In contrast, significantly more farms used difenacoum in 2020 (p-value 0.002) than in 2018. However, the proportions of occurrences encountered in 2020 are similar to those encountered in 2016 (Figure 4). The mixed

formulation bromadiolone/difenacoum, which accounted for one per cent of all specified occurrences in 2020, is the first formulation containing more than one active substance recorded in this survey series since 2014 (possibly as part of resistant management programmes). The relative proportions of these compounds vary in the longer-term dataset (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⁽⁴⁾. It may also represent a response to differences in the range of approved products available and their marketing strategies over time.

The use of brodifacoum, the third most commonly encountered rodenticide in this survey (seven per cent), is very similar to that recorded in 2018 and 2016 (both six per cent).

Figure 4 Percentage occurrence of rodenticides on arable farms – 2016 to 2020



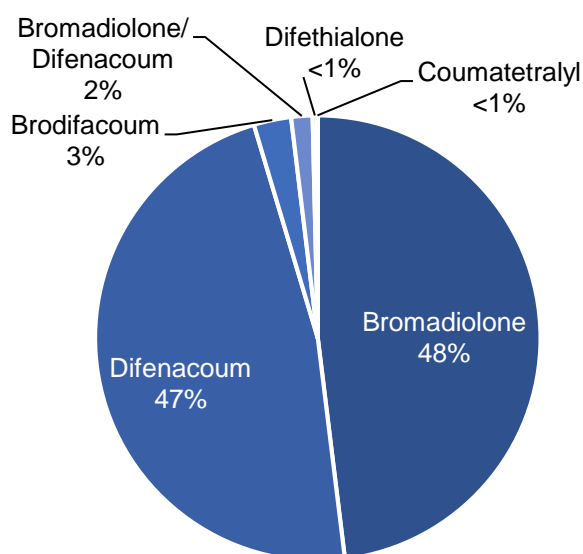
Note: Statistically fewer farms used bromadiolone in 2020 (p-value 0.009) than in 2018. In contrast, more farms used difenacoum (p-value 0.002). There was no significant difference for the proportion of farms using brodifacoum between 2018 and 2020.

Weight of rodenticides used

Approximately 62 tonnes of rodenticidal products are estimated to have been used on Scottish arable farms in 2020 (Figure 5, Table 2). More than 99 per cent of the total weight used was SGAR products. Products containing bromadiolone were the most commonly used (ca.30 tonnes), accounting for 48 per cent of total rodenticide use by weight. This was closely followed by difenacoum products (ca. 29 tonnes) accounting for 47 per cent of total use. Brodifacoum (ca. 2 tonnes) and bromadiolone/difenacoum (ca. 1 tonne) were the only other rodenticides frequently encountered, accounting for three and two per cent of total use respectively. 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. 62 tonnes of rodenticide product used on arable farms in 2020 contained only ca. 3.1 kg of active substance, the remainder of the product weight is almost exclusively food bait used to attract rodents. This is 47 per cent less active substance than in 2018 (5.8 kg of a.s. in 49 tonnes of product). This may have been influenced by the amount of unspecified rodenticide recorded during 2020 but also alphachloralose was recorded in 2018 but not in 2020. Alphacloralose products contain much higher levels of active substance (four per cent w/w) compared with anticoagulants (ca. 0.005 w/w).

Figure 5 Percentage weight of rodenticide product used on arable farms – 2020

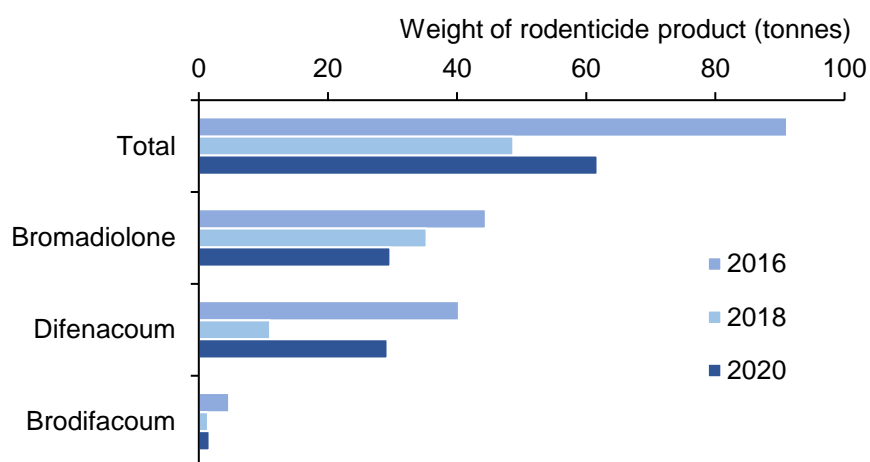


The estimated weights of the three main rodenticides recorded in the 2016, 2018 and 2020 arable crop surveys are presented in Figure 6. Overall rodenticide use in 2020 (ca. 62 tonnes) was 27 per cent higher than in 2018 (ca. 49 tonnes). However, this increase in use is the first for many years following a longer-term decline in rodenticide use in arable agriculture. Rodenticide use 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)⁽⁵⁾. This has partly been driven by a decline in the proportion of farms on which baiting is conducted (76 and 61 per cent in 2000 and 2020 respectively) and may also have been influenced by the greater use of PCPs.

At active substance level there was a large increase in the use of difenacoum in 2020 which was 165 per cent higher than in 2018. The use of brodifacoum also increased but the increase (20 per cent) was less marked. In contrast, the use of bromadiolone decreased by 16 per cent between 2018 and 2020. The use of all three of the main active substances were lower than in 2016 (brodifacoum 64 per cent, bromadiolone 33 per cent and difenacoum 27 per cent). The reasons for these changes are unclear and it should be noted that rodent populations, and thus rodenticide use, fluctuate over time. Prior to 2020, the decline in rodenticide use and increased use in PCPs, which were

detected in both arable and grass and fodder crop systems, were thought to have been influenced by the Campaign for Responsible Rodenticide Usage (CRRU) guidance for best practice⁽⁶⁾ and the 2015 launch of the UK industry led rodenticide stewardship scheme⁽⁷⁾. The increase in use recorded in 2020 and the slightly lower use of PCPs may be a one-off exception to this trend influenced by the impact of the pandemic or it could suggest that the impact of the stewardship scheme has plateaued. It is not possible at this time to establish the impact of COVID-19 on farmer baiting operations and to indicate whether the 2020 data is an outlier, however subsequent surveys (the next survey will cover 2022) will provide longer term context. The CRRU Code of Best Practice was revised and published in 2021 following a number of changes about the regulation and permitted practical uses of professional rodenticides (see rodenticide approval and stewardship section for further details). These changes could influence future rodenticide use.

Figure 6 Weight of rodenticide product used on arable farms – 2016 to 2020



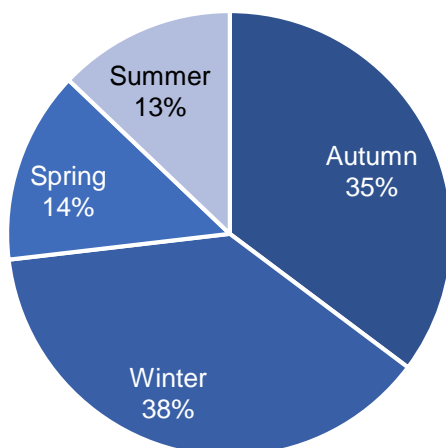
Note mixed bromadiolone/difenacoum formulated products are included in total.

Seasonal use of rodenticides

The season in which rodenticides were used was specified for all the rodenticides encountered in this survey. Forty five 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 a decrease from the level reported in 2018 in which 61 per cent of rodenticides were reported to be used throughout the year. However, similar levels of year-round baiting for anticoagulant rodenticides have been reported previously, with 46 per cent in 2016.

When the weight used, including year-round use, is separated into constituent seasons, the greatest use was in winter (38 per cent) and autumn (35 per cent), with lower use in spring and summer (Figure 7). This is a very similar seasonal pattern to that encountered in previous surveys.

Figure 7 Seasonal use of rodenticides on arable farms (percentage of total weight) - 2020



Rodenticide bait type and target

As with the previous survey, baits formulated with grain were the most commonly encountered in this survey, accounting for 82 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 (<1 per cent of total grain baits).

The other types of rodenticide products encountered included wax based baits, which accounted for 16 per cent of use. Ninety six per cent of wax baits were solid wax baits and four per cent were soft waxes. Pasta based bait contributed two per cent of total use, gel rodenticides and other paste baits (for which the type of bait was not specified) were both estimated to account for less than one per cent.

Grain baits also accounted for the majority of rodenticides used in the previous two arable surveys in 2018 (90 per cent) and 2016 (86 per cent).

Survey respondents were asked to state the target of their rodenticide baiting regimes (Figure 9) and this information was supplied for all estimated use by weight. The most common target was a combination of rats and mice (51 per cent), followed by rats (45 per cent). Only four per cent of rodenticide use was targeted at mice alone. In the previous survey in 2018 the principal target was also a combination of rats and mice (52 per cent). In 2016 the principal target was rats (58 per cent).

Figure 8 Type of rodenticide bait used on arable farms (percentage of total weight) - 2020

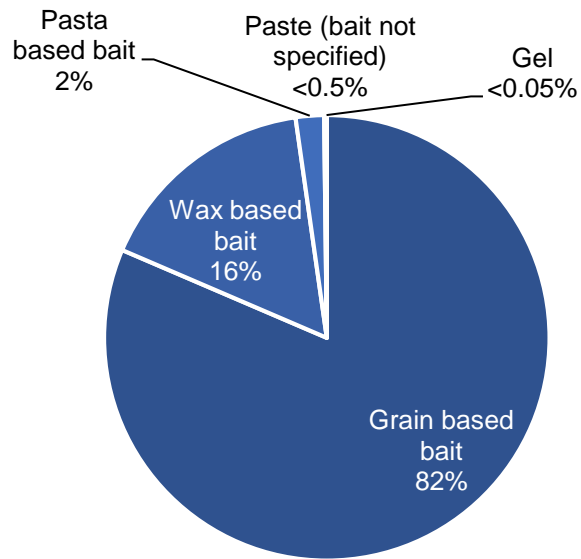
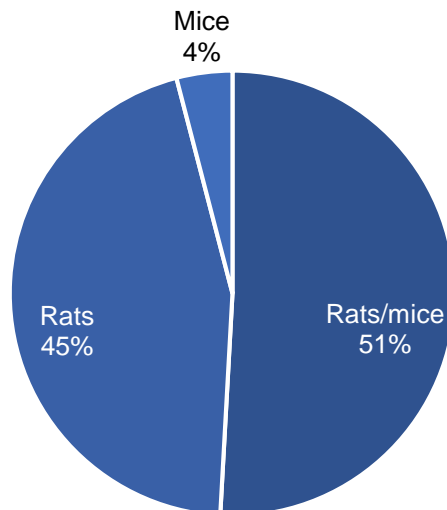


Figure 9 Target of rodenticide use on arable farms (percentage of total weight) - 2020



Supplementary data

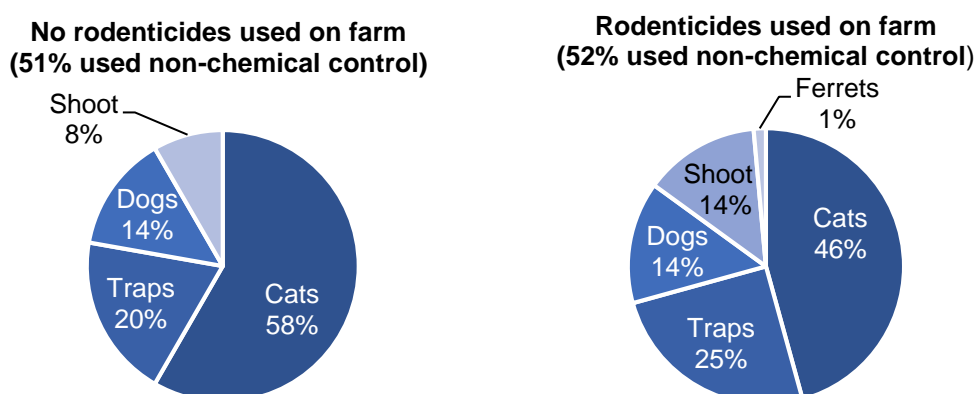
In addition to the collection of rodenticide usage data, farmers were also asked a series of supplementary questions relating to aspects of their farm operation, their use of non-chemical rodent control, rodenticide stewardship and their compliance with best practice in rodenticide use.

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 arable farms (percentage of total methods used) – 2020



On holdings on which rodenticides were not used (n=47), 51 per cent of the farmers reported using one or more non-chemical controls. The most commonly encountered methods were use of cats and traps (58 and 20 per cent of all methods reported respectively). Shooting and dogs were also used to control rodents. Whilst most traps used are concussive, respondents were not asked to provide information on trap type but this will be collected in future surveys.

On holdings using rodenticides (n=221), 52 per cent reported that they used additional non-chemical methods of rodent control. Again, the most common methods used were cats and traps (46 and 25 per cent of all methods reported respectively) with lower use of dogs, shooting and ferrets.

The number of farmers reporting that they employed non-chemical rodent control was greater in 2020 than in 2018 and 2016 on holdings where rodenticides were used (52, 46 and 26 per cent respectively). For holdings where no rodenticides were used the numbers reporting the use of non-

chemical rodent control was lower in 2020 than in 2018 and 2016 (51, 60 and 61 per cent respectively) but higher than that reported in 2014 (44 per cent).

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⁽⁶⁾ (Table 3).

These data are expressed as percentage of respondents giving a positive answer to each question. Not all of those surveyed provided this data, responses were provided by 78 farmers, representing 94 per cent of those farmers who conducted their own rodenticide baiting and 25 PCPs, representing 69 per cent of the contractors encountered during the survey. Where statistically significant differences in the response between farmers and PCPs were found these are noted.

All PCPs and 49 per cent of farmers had attended a training course on rodenticide use. The uptake of training was significantly different between farmers and PCPs ($P < 0.001$).

All PCPs and 99 per cent of farmers stated that they recorded the quantity and location of baits. All PCPs and farmers stated that these baits were protected from non-target animals. Bait was reported to be regularly inspected by all PCPs and farmers. Sixty-four per cent of PCPs and 65 per cent of farmers removed bait after targeted baiting periods. Therefore, levels of permanent baiting are similar to those recorded in 2018, although slightly higher for farmers (65 per cent of PCPs and 75 per cent of farmers removed bait after targeted baiting periods in 2018). The CRRU UK Rodenticide Stewardship regime published updated permanent baiting guidance in July 2019⁽⁸⁾ following changes to make the rules around permanent baiting more prescriptive.

Ninety-six per cent of PCPs and 91 per cent of farmers stated that they searched for and removed rodent carcasses. Many respondents stated they rarely saw carcasses. However, those farmers who did encounter carcasses employed a range of disposal methods; primarily burying and incineration, but also landfill and disposal in dung heaps (refer to table 3 for details).

Over half (56 per cent) of PCPs and five per cent of farmers used non-toxic indicator baits to monitor rodent activity on farm. This uptake in use of indicator baits was significantly different between farmers and PCPs (p -value < 0.001). This is the first time 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 very similar to those provided in the 2018 arable crop survey. The level of training and use of non-toxic indicator baits were the only questions where there was a significant difference between farmer and PCP response.

Farm operation data

Farmers were asked a series of questions relating to aspects of farm operation which might affect rodenticide use pattern (Table 4). Responses were provided by all 268 farms sampled.

The majority of respondents (96 per cent) were a member of a quality assurance scheme, similar to the 94 per cent recorded in 2018. 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. More farms that practised rodenticide baiting were members of a quality assurance scheme (99 per cent) than farms that did not use rodenticides (85 per cent) and this difference was significant (p -value <0.001).

Although all the farms surveyed grew arable crops, some were also mixed farms and 55 per cent of those surveyed kept livestock on their holding, compared to 59 per cent in 2018. Only two per cent of farms had a pig unit and four per cent had a poultry unit. 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.

Lastly, 62 per cent of holdings surveyed had an on-farm grain store, and a significantly greater number of farms using rodenticides had a grain store (67 per cent) than farms that did not use rodenticides (34 per cent) ($p < 0.001$).

In 2020, as in 2018 and 2016, statistically significant differences between those farmers using and not using rodenticides were only found in relation to quality assurance membership uptake and presence of a grain store.

Rodenticide approval and stewardship

EU and UK Regulatory risk assessments have concluded that the use of first and second generation anticoagulant rodenticides outdoors present 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, the 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)⁽⁶⁾, which was launched in 2015.

With the launch of the stewardship scheme providing environmental risk mitigation measures for rodenticide use, HSE has from 2016, re-approved

rodenticide product authorisations. As part of this re-authorisation the approval conditions for some products have been 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 permits these 'non-standard' scenarios specifically. 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 may influence rodenticide usage patterns. As discussed earlier, it is possible that decreased rodenticide usage and increased adoption of non-chemical control reported in 2016 and 2018 may have been influenced by the introduction of the stewardship scheme and increased adherence to best practice. The slight increase in rodenticide usage and similar levels of non-chemical control reported during 2020 may suggest that behaviour and patterns of usage are plateauing after 5 years of rodenticide stewardship.

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; responses were provided by 78 farmers, representing 94 per cent of those farmers who conducted their own rodenticide baiting.

Eighty seven per cent of farmers were aware of the rodenticide stewardship scheme's existence in 2020. Twenty eight per cent of the farmers surveyed had attended a stewardship compliant training scheme which provided certification acceptable for point of sale purchase of professional rodenticide products. In addition, nine per cent of farmers stated they intended to complete this training in future. In 2018, 86 per cent of farmers were aware of the scheme, 25 per cent had completed stewardship compliant rodenticide use training and 21 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.

Farmers were also asked how they last purchased rodenticides. The majority (72 per cent) obtained rodenticides by demonstrating membership of a

stewardship compliant quality assurance scheme (69 per cent in 2018), followed by production of a stewardship compliant training certificate (26 percent, 17 per cent in 2018). No farmers reported buying amateur products in 2020 (which accounted for four per cent of purchases in 2018).

Appendix 1 - Estimated rodenticide use and supplementary data tables

Table 1 Total estimated occurrence of rodenticide use on arable farms in Scotland - 2020

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

Formulation	Number of occurrences	Percentage of total specified occurrences
Brodifacoum	381	7
Bromadiolone	2,655	47
Bromadiolone/difenacoum ⁽¹⁾	61	1
Coumatetralyl ⁽¹⁾	28	<1
Difenacoum	2,455	44
Difethialone ⁽¹⁾	37	<1
Unspecified Rodenticide ⁽²⁾	1,610	
Total (excluding unspecified use)	5,618	
FGARs ⁽³⁾	28	<1
SGARs ⁽⁴⁾	5,589	>99

(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.

(3) First generation anticoagulant compounds: coumatetralyl.

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

Table 2 Total estimated weight of rodenticides used on arable farms in Scotland – 2020

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 specified use
Brodifacoum	0.07	1,675	3
Bromadiolone	1.48	29,659	48
Bromadiolone/difenacoum ⁽¹⁾	0.05	955	2
Coumatetralyl ⁽¹⁾	0.01	29	<1
Difenacoum	1.46	29,204	47
Difethialone ⁽¹⁾	0.01	202	<1
Total⁽²⁾	3.08	61,723	
FGARs ⁽³⁾	0.01	29	<1
SGARs ⁽⁴⁾	3.07	61,695	>99

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

(2) Not including unspecified rodenticides.

(3) First generation anticoagulant compounds: coumatetralyl.

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

Table 3 Farmer and PCP response to training and compliance questions - 2020

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

Question	Percentage yes response	
	Farmer (n=78) ⁽¹⁾	PCPs (n=25) ⁽²⁾
1) Have you attended a training course on rodenticide use? ⁽³⁾	*49	*100
2) Are quantity and location of baits recorded?	99	100
3) Are bait points protected from non-target animals?	100	100
4) Is bait regularly inspected?	100	100
5) Is bait removed after targeted baiting periods?	65	64
6) Are rodent carcasses searched for and removed? ⁽⁴⁾	91	96

(1) Not all farmers returned compliance data. These farmers represent 94 per cent of the 83 farmers who conducted their own rodenticide baiting during this survey.

(2) Not all PCPs returned compliance data. These 25 PCPs represented 69 per cent of the contractors encountered during this survey and collectively conducted baiting on 61 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) Seventy farmers gave a response in relation to carcass disposal method. The most common method was burying (56 per cent), incineration (29 per cent), others included landfill (nine per cent), and disposal in dung middens (one per cent). Twenty-four PCPs gave a response in relation to carcass disposal method. The most common method was incineration (46 per cent), burying (42 per cent), collection by a waste contractor (eight per cent) and landfill (four per cent).

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

Table 4 Farmer response to farm operation questions - 2020

Question	Percentage yes response		
	All farms (n=268) ⁽¹⁾	Farms using rodenticides (n=221)	Farms not using rodenticides (n=47) ⁽¹⁾
1) Is your farm a member of a quality assurance scheme	96	*99	*85
2) Is livestock kept on your farm?	55	57	45
3) Do you have a pig unit on your farm?	2	3	0
4) Do you have a poultry unit on your farm?	4	4	4
5) Do you have a grain store?	62	*67	*34

* Responses marked with an asterisk are significantly different between farms that did and did not use rodenticides (P<0.001).

Table 5 Farmer response to rodenticide stewardship questions - 2020

Question	Percentage yes response (n=78) ⁽¹⁾
1) Are you aware of the rodenticide stewardship scheme?	87
2a) Have you completed a stewardship compliant training course?	28
2b) If no, do you intend to complete a stewardship compliant training course in the future?	9
3) When you last purchased rodenticides did you:	
3a) Show a certificate of competence/training in rodenticide use	26
3b) Demonstrate membership of a compliant quality assurance scheme	72
3c) Purchase non-professional/amateur rodenticides (<1.5 kg pack)	0

(1) Not all farmers responded to stewardship questions. These farmers represent 94% of the 83 farmers who conducted their own rodenticide baiting during this survey.

Appendix 2 - Survey statistics

Census and sample information

Table 6 Distribution of arable holdings sampled in Scotland - 2020

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	7	0	4	1	1	0	2	15
20.00 – 49.99	1	5	10	7	1	4	7	35
50.00 – 99.99	2	9	15	15	12	5	7	65
100.00 – 149.99	1	7	8	17	9	3	9	54
150.00 +	2	13	10	31	16	3	24	99
Total	13	34	47	71	39	15	49	268

Table 7 Census distribution of arable holdings in Scotland - 2020

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	1,343	336	825	281	205	499	455	3,944
20.00 – 49.99	117	234	547	292	175	295	294	1,954
50.00 – 99.99	54	160	423	286	226	180	180	1,509
100.00 – 149.99	13	85	152	148	137	68	107	710
150.00 +	8	78	163	189	163	64	154	819
Total	1,535	893	2,110	1,196	906	1,106	1,190	8,936

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

Raising factors

Table 8 Raising and adjustment factors for arable holdings - 2020

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	191.86	117.00	27.00	13.00	4.00	1.0000
Moray Firth	NA	75.03	28.50	19.47	9.62	1.6032
Aberdeen	206.25	54.70	28.20	19.00	16.30	1.0000
Angus	281.00	41.71	19.07	8.71	6.10	1.0000
East Fife & Lothian	205.00	175.00	18.83	15.22	10.19	1.0000
Central Lowlands	NA	134.38	65.59	41.30	38.87	1.8221
Southern Uplands, Tweed Valley & Solway	227.50	42.00	25.71	11.89	6.42	1.0000

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 100-149.99 ha sized farms in Aberdeen would be multiplied by 19.00 (raising factor) and 1.00 (adjustment factor) to give an estimated rodenticide use in that region and size group of 190 kg. NA = not applicable.

Survey response rates

Table 9 Response rate for arable rodenticide survey - 2020

	2020	Percentage of total
Target sample	350	100
Total achieved	268	77
Total number of farms approached	474	
Total number of refusals/non-contact	206	

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 used non-visit methods of data collection such as email, post or telephone call.

To determine the total burden that the 2020 rodenticide use on arable farms survey placed on those providing the information, farmers were asked to estimate the time spent providing data. Ninety seven per cent of the farmers surveyed provided this information. The median time taken was two minutes.

In addition, PCPs were also asked to estimate how long they took to provide information. Eighty per cent of the PCPs supplying data provided this information. The median time taken was 25 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 £15.62⁽⁹⁾)

It is estimated that the total financial burden to respondents for the 2020 arable crop rodenticide survey was £240.03.

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 2020 survey period were: FGARs (coumatetralyl and warfarin), SGARs (brodifacoum, bromadiolone, difenacoum, difethialone and flocoumafen) and non-anticoagulant rodenticides (alphachloralose, aluminium phosphide, carbon dioxide and hydrogen cyanide). Cholecalciferol was authorised from October 2020, near the end of the survey period. The **rodenticides encountered** in this survey were; brodifacoum, bromadiolone, coumatetralyl, difenacoum and difethialone.

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. These farms may also grow other crop types and/or have livestock in addition to arable 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 2016⁽¹⁾ and 2018⁽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 **June Agricultural Census**⁽¹⁰⁾ 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**⁽⁷⁾ 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 2020 Agricultural Census⁽¹⁰⁾, 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.

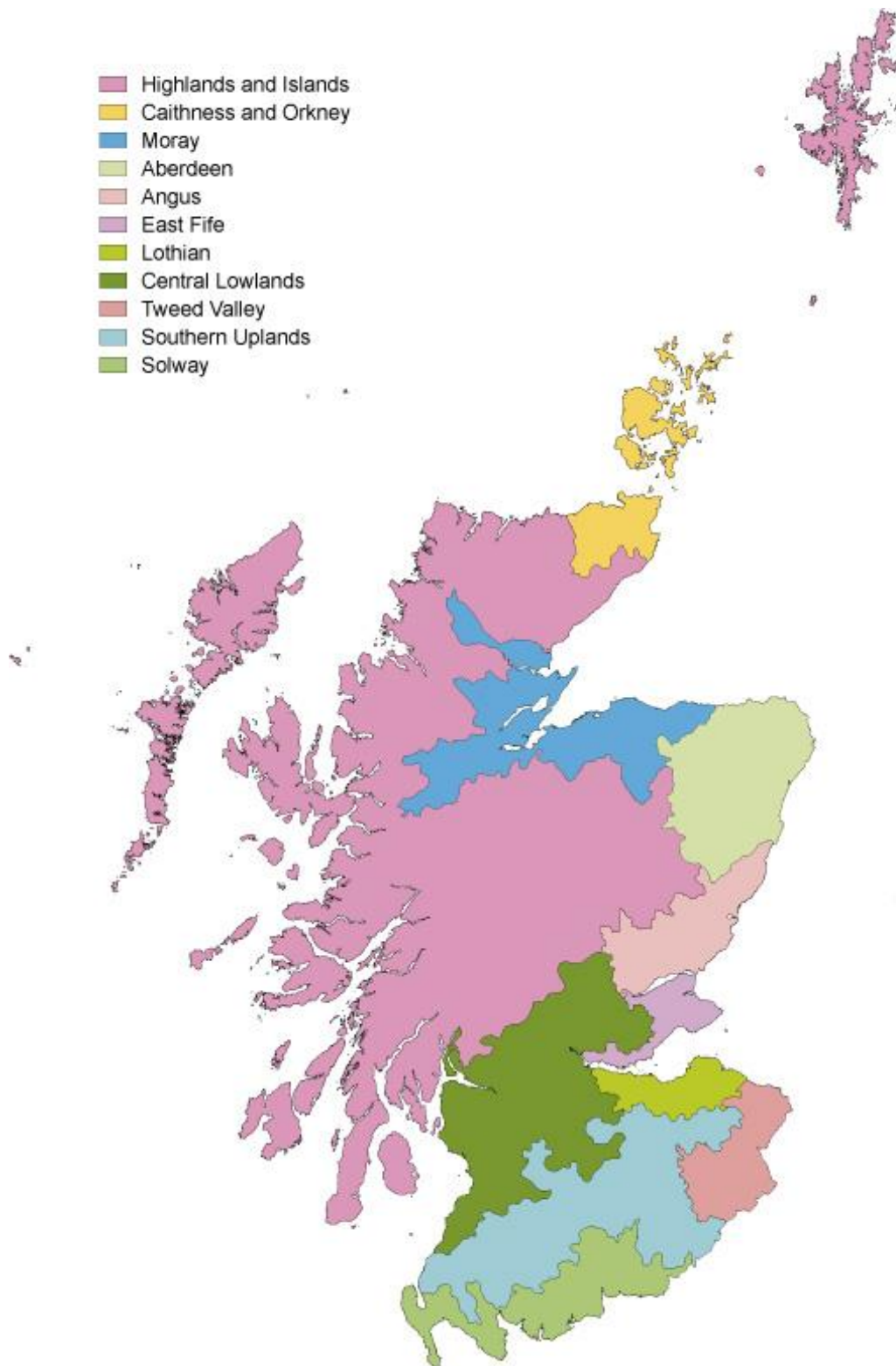
The survey covered rodenticide use during the 12 month period January to December 2020. Following an introductory letter and telephone call, data were collected by telephone interview, email or post. When rodenticides were applied by a pest control professional (PCP) the data were obtained from either 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 268 holdings (Table 6). These 268 holdings represent three per cent of the total arable holdings in Scotland (Table 7). The data collected were; who conducted the baiting, 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⁽¹¹⁾



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 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 8.

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

All data in 2020 had to be collected using non-visit methods such as by phone interview or by email due to restrictions imposed by the COVID-19 pandemic. In previous years data was collected by a combination of personal interview during a visit to the holding and/or by phone/email. This change in data collection method may have impacted the number and type of respondents. It should be noted, it is also possible that rat populations, farmer use of PCPs and as a consequence, bait volumes were impacted by COVID-19 restrictions during 2020. The impact of the pandemic on trends in baiting operations may be clearer in subsequent surveys. Every effort was made to achieve a robust sample. This additional effort and change in data collection method resulted in a delay to the publication date.

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 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 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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