

Attitudes of clients of Dutch pest controllers towards integrated pest management (IPM) and preventive measures in relation to rodent nuisance

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Abstract

BACKGROUND: Rodent management with lethal methods (e.g., rodenticides) comes with downsides for rodent welfare, the environment and non-target species. To reduce chemical use and prevent rodent nuisance, pest controllers in the Netherlands must work according to the principles of integrated pest management (IPM). A condition for the success of IPM is that there is sufficient engagement of all parties involved, including clients of pest controllers. The aim of this study was to gain insight into the attitudes of clients regarding rodent control, IPM and the application of preventive measures. Insight into their attitudes may contribute to a better implementation of IPM and with that to a more sustainable rodent management based on more effective prevention. An online survey among 248 clients of Dutch pest controllers from both the agricultural and other sectors was carried out.

RESULTS: Respondents from the agricultural sector had a relatively negative attitude towards IPM, the new IPM regulations in the Netherlands and had little confidence in prevention. In other sectors, respondents were more positive about IPM and had more confidence in prevention. The respondents from the latter subgroup had a similar attitude compared to Dutch pest controllers who participated in a previous survey.

CONCLUSION: The findings of the study provide information for the further development and practical implementation of IPM and preventive measures and with that a more sustainable and animal friendly rodent management. They can also be helpful for a better communication and cooperation between pest controllers and their clients.

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Supporting information may be found in the online version of this article.

Keywords: attitude; integrated pest management; mice; pest control; rats; rodent control; rodent management

1 INTRODUCTION

Commensal Norway and black rats (*Rattus norvegicus* and *Rattus rattus*) and house mice (*Mus musculus*) are controlled in many human-dominated locations because they may cause different forms of nuisance. This can include damage to human property, consumption or contamination of food and feed, spread of pathogens or simply being an unwanted presence. There are no precise figures about the different forms of nuisance caused by rodents in the Netherlands. In the agricultural sector presence of rodents is linked to the spread of different (zoonotic) pathogens^{1,2} and barn fires caused by gnawing of cabling.³ More general, rats and mice are mainly reported to pose a risk for the spread of (zoonotic) pathogens such as Leptospirosis, Salmonella, Campylobacter and Avian Influenza.⁴⁻⁷ The National Institute for Public Health and the Environment (RIVM)⁷ reported 49 incurred human infections of Leptospirosis in the Netherlands in 2022, from which

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70% occurred through contact with mud/surface water and 20% through (in)direct contact with rats and mice. For households, in a study by Lipman and Burt⁸ it was found that 62% of the 411 participants reported presence of rodents in their home in the past year, of which 35% reported this presence to occur more than once. In a study by RIVM⁹ it was found that 34% of the participants in a survey had mice in/around their house in 2019 and 10% had rats.

The management of rodents with lethal methods, such as rodenticides and trapping, comes however with different downsides for the environment, rodent welfare^{10–15} and other animals that become (in)direct victims of control methods.¹⁶ Especially rodent control with chemical methods, such as anticoagulant rodenticides, has a negative impact on the environment and other animal species,^{16–18} rodent welfare and effectiveness of control due to the increased rodenticide resistance in rodents.¹⁹

To reduce the use of chemical control methods and prevent rodent nuisance, a new system for professional rodent control has been developed over the years.²⁰ By working in accordance with the principles of integrated pest management (IPM) the control should be performed more sustainably and effectively²⁰ and with a lower negative impact on the welfare of both target and non-target animals.²¹

IPM consists of several phases: identification of possible pest species; determination of the threshold level for nuisance and/or presence of populations; prevention of nuisance and/or presence of populations; monitoring of nuisance and/or presence of populations; and control (for reviews, see Meerburg *et al.*¹⁵ and Van Gerwen and Meijboom²¹). Monitoring and prevention are important aspects of IPM. In the case of rodent management, prevention mainly focuses on eliminating access to and availability of food, measures for habitat management and preventing rodents from sheltering or housing. If nuisance does occur after applying prevention, the next step is to use non-chemical control methods, such as snap or cage traps. Only if these methods are not sufficiently effective, rodenticides can be used as a last resort.

Since 2023, rats and mice may in the Netherlands only be controlled with anticoagulants and cholecalciferol by professionals who have an IPM-licence and work in accordance with the principles of IPM.²² This means that private individuals are no longer allowed to use or buy these rodenticides. Farmers have the option to self-certify for IPM. Otherwise, they should contract a professional pest controller. From 2017 onwards, and at the time of data collection for this study, these regulations were already in place for the control of rats outside buildings.

Effects of the IPM regulations on the use of rodenticides are still not visible, but the possible effects can be significant based on studies into environmental effects^{17,18} and sales data. Private consumers in 2019 bought at least 350 000 of packages with rodenticides, with a package size varying between 10 and 100 g.⁹ Sales data of products do not tell what the actual product use is. In the study by RIVM⁹ of the people having rodents in their house, only 40% (for rats) and 47% (for mice) indicated to take action. In the case of mice control 44% of these persons used rodenticides and 69% mechanical traps. Half of them took preventive measures. More data about the sales of rodenticides and other control products in the Netherlands have not been published.

Prevention of rodent nuisance can be designed in many ways, by for example sealing off holes in buildings, removing waste and food resources or habitat management. A condition for the success of prevention is that there is sufficient knowledge and

awareness regarding factors to prevent nuisance from occurring among all those involved.

Dutch pest controllers who participated in an earlier survey study²³ also considered prevention of nuisance as a relatively animal-friendly, effective, and important method of rodent management. However, they indicated that clients who contract a pest controller do not always invest sufficient time and money in prevention. The majority of the problems faced in practice by the respondents in that study were client-related and had to do with clients that lacked the willingness to invest sufficient money in preventive methods and thereby lacked the willingness for a proper implementation of IPM principles. According to the respondents of that study, changes in client awareness, improved knowledge and willingness to invest in prevention are important factors to improve the implementation of preventive methods and to safeguard animal welfare in relation to rodent control.

Pest controllers may however also underestimate the actual knowledge of their (potential) clients. A study by Burt and Lipman²⁰ showed that Dutch members of the public had a reasonable level of knowledge about IPM and prevention. Thereby it showed that pest controllers underestimated the knowledge level of the general public when it comes to statements about IPM and preventive measures.

Understanding and acknowledging differences in attitudes and knowledge levels between professionals and their clients might be helpful for those that want to facilitate a better communication between pest controllers and their clients. It may furthermore facilitate joint decision-making and may help to ensure a better application of IPM and preventive methods. Hence, discussing the aims and expectancies of rodent management together is an important step in the protocol for IPM.

The aim of the current study was to gain insight into the attitudes of clients of pest controllers in professional sectors (e.g., organisations and companies that contract a professional pest controller), towards rodent control, IPM and the application of preventive measures. The study did not focus on the general public. This study forms part of a larger project that also looked at client attitudes towards the moral position and welfare of commensal rodents.²⁴ The complete study serves: (1) to verify the findings of the previous study among pest controllers²³; and (2) to explore whether the ideas of the pest controllers match client views. Furthermore, (3) the outcomes will be used to develop an assessment framework that can support ethical decision-making in the practice of rodent control and can be used by both pest controller and client. We consider the input of pest controllers and their clients to be important for the development and practical implementation of such a framework. Insight into opinions and attitudes of both pest controller and client may in this way contribute to a more ethical rodent management, that is, management where the application of preventive measures plays a central role and the moral position of rodents and their welfare is subject to greater care and consideration than currently.

2 MATERIALS AND METHODS

Data were collected by means of an online survey among professional clients of Dutch pest controllers. Clients could be affiliated to different sectors, including municipalities, food-processing companies, healthcare services, restaurants and hotels, zoos, and the agricultural sector (type of company within the agricultural sector was not further specified, but besides farms other

companies in the supply chain were included). The survey was set up in Dutch using Qualtrics software (Qualtrics, Provo, UT, USA). Answers were translated into English for the purposes of this article. The link to the survey, together with the call to take part, were placed on the website of Utrecht University and disseminated throughout the Netherlands via professional associations (newsletters and websites), personal networks and social media. It was explicitly stated in the invitation that respondents should be the persons overseeing rodent management and/or contacts with the pest controller.

The complete online survey consisted of eight sections, divided into a part (a) with animal welfare-related questions and a subsequent part (b) showing questions related to IPM and prevention of rat and mouse infestations. Both parts of the survey resulted in many relevant data. Therefore, in the present study, we focus on the questions related to IPM and only the data from part (b) were used (sections one to four and part of the data from section seven of the survey). The other results, containing data regarding animal welfare, are published in a separate article.²⁴ A complete and detailed description of the methods, including statistical analyses, can also be found in that article.

To compensate for the increased chance of a type I error due to multiple hypotheses testing, values of alpha were adjusted with the Dunn–Šidák correction. The adjusted alpha values for each test used can be found in Supporting Information Tables S1 and S2. Statistical significance represented by *P*-values may not necessarily confirm practical importance. Therefore, besides *P*-values, estimated effect sizes were calculated. In Van Gerwen *et al.*²³ the formulae for the correction of alpha values and thresholds for interpretation of effect sizes can be found.

The relevant survey sections relevant for and discussed in this article are:

Parts of sections one and two of the survey: with general background information about the company or organisation and reasons for hiring a pest controller. Based on answers in section two, respondents were selected for continuation of the survey. Only respondents working for a company or organisation that hired a pest controller for rodent control were selected. This was almost 61% of the total participants who started the survey (see also section three of the survey).

Section five of the survey: questions about the relation with the pest controller.

Section six of the survey: questions about the attitudes towards existing regulations, IPM, and the belief in prevention. The section consisted of five statements about regulations and IPM. It contained one open question about prevention where respondents were asked to indicate what percentage of nuisance could be solved by preventive methods only according to them. Furthermore, the section contained questions about the company budget available for prevention and ways to better implement prevention. Statement G about IPM refers to 'quality systems'. With quality systems, certain quality marks, standards or certification systems for pest controllers are meant, such as the European CEPA Certified® and the Dutch KPMB (Keurmerk Plaagdiermanagement Bedrijven).

Part of the date from section seven: questions about the experience and decisions in daily practice, for example about the importance of control of rats and mice on a 1 (very unimportant) to 10 (very important) continuous rating scale.

At the end of the survey (section eight), data relating to respondent demographics were collected, namely gender, age, level of education and pet ownership.

Since the number of respondents from the agricultural sector was relatively large (around 70% of the total) compared to all other sectors together, a new grouping variable 'subgroup' with two categories (subgroup *agri* and subgroup *other*) was created.

Furthermore, to ensure that any statistical findings were not wrongly attributed to the large group of respondents from the agricultural sector, analyses were also performed separately within both the respondents from subgroup *agri* and from subgroup *other*.

In total 248 respondents started the survey, 184 from subgroup *agri* and 64 from subgroup *other*. After the questions about the selection criteria (professional pest controller for control of rodents), 151 respondents remained. Of these respondents, 108 fully completed the survey. Results regarding general descriptives, respondent demographics and general effects of grouping variables can be found in Van Gerwen *et al.*²⁴

2.1 Ethical approval

The survey research reported in this article involved healthy human participants and did not make use of any invasive subjects, techniques, substance administration or psychological manipulations. Besides age, education level and pet ownership, the survey did not contain personal or sensitive information. Participants were recruited through newsletters and websites and included the link to the questionnaire. Respondents participated by clicking on the link and their answers were sent directly to the secured servers of the University to which only the involved researchers had access. All participants were informed about the purpose of the study and that participation was voluntary. Consent for participation and processing the data could be derived by starting the survey. Participants could withdraw at any moment in the process. Data that had been collected up to that point were stored and used for analysis. This approach was chosen in order to prevent loss of this data and on the assumption that participants would have already stopped at earlier questions had they not wanted to answer them. The research was conducted in accordance with the principles expressed in the Declaration of Helsinki and the General Data Protection Regulation.

3 RESULTS

3.1 Integrated pest management and the relation with the pest controller

The majority (48.3%) of all respondents (50.6% within subgroup *agri* and 43.2% within subgroup *other*) indicated that, in their company a rodent management plan is made together with the pest controller and discussed on a regular basis. For 39% of all respondents (35.8% within subgroup *agri* and 45.9% within subgroup *other*) the pest controller makes a plan, the company approves it, and the pest controller executes it. Only 7.6% of all respondents (6.2% within subgroup *agri* and 10.8% within subgroup *other*) indicated that the pest controller does his/her job, without the respondent knowing what is done exactly. In 4.2% of the cases (6.2% within subgroup *agri* and no respondents within subgroup *other*) the respondent tells the pest controller what to do and the pest controller does it.

Most respondents (83.1%) indicated that they never have been in a situation of disagreement with the pest controller regarding the need to kill rats and mice (Table 1, statement A). Half (50%) of all respondents and 60.4% of subgroup *agri* indicated that the company does never or seldomly ask about the possibilities for prevention (Table 1, statement B). In subgroup *other*, almost half of the respondents (48.6%) indicated that the company often or always asks about these possibilities.

Table 1. Amount of agreement with three statements (A–C) about the relation with the pest controller

Statement	Frequency of situation number (percentage)				
	Never	Seldom	Sometimes	Often	Always
A. I have been in a situation in which my company wanted rats and mice to be killed, but the pest controller was of the opinion that was not needed					
Total (n = 118)	98 (83.1%)	13 (11%)	6 (5.1%)	1 (0.8%)	0 (0%)
Subgroup <i>agri</i> (n = 81)	71 (87.7%)	9 (11.1%)	1 (1.2%)	0 (0%)	0 (0%)
Subgroup <i>other</i> (n = 37)	27 (73%)	4 (10.8%)	5 (13.5%)	1 (2.7%)	0 (0%)
B. My company asks the pest controller explicitly about the possibilities for preventive methods					
Total (n = 118)	45 (38.1%)	14 (11.9%)	32 (27.1%)	16 (13.6%)	11 (9.3%)
Subgroup <i>agri</i> (n = 81)	39 (48.1%)	10 (12.3%)	23 (28.4%)	5 (6.2%)	4 (4.9%)
Subgroup <i>other</i> (n = 37)	6 (16.2%)	4 (10.8%)	9 (24.3%)	11 (29.7%)	7 (18.9%)
C. I am familiar with the causes of nuisance by rats and mice in my company					
Total (n = 118)	2 (1.7%)	2 (1.7%)	12 (10.2%)	57 (48.3%)	45 (38.1%)
Subgroup <i>agri</i> (n = 81)	2 (2.5%)	2 (2.5%)	7 (8.6%)	39 (48.1%)	31 (38.3%)
Subgroup <i>other</i> (n = 37)	0 (0%)	0 (0%)	5 (13.5%)	18 (48.6%)	14 (37.8%)

Data were obtained through an online survey among professional clients of Dutch pest controllers. The number of respondents that indicates the option chosen most frequently is displayed in bold typeface.

The majority (86.4%) of respondents indicated that they are often or always familiar with the cause of nuisance caused by rats or mice (Table 1, statement C).

Figure 1 shows box plots with the responses of both the subgroup *agri* and the subgroup *other* to the five statements (D–H) about IPM. There was a significant difference between the scores

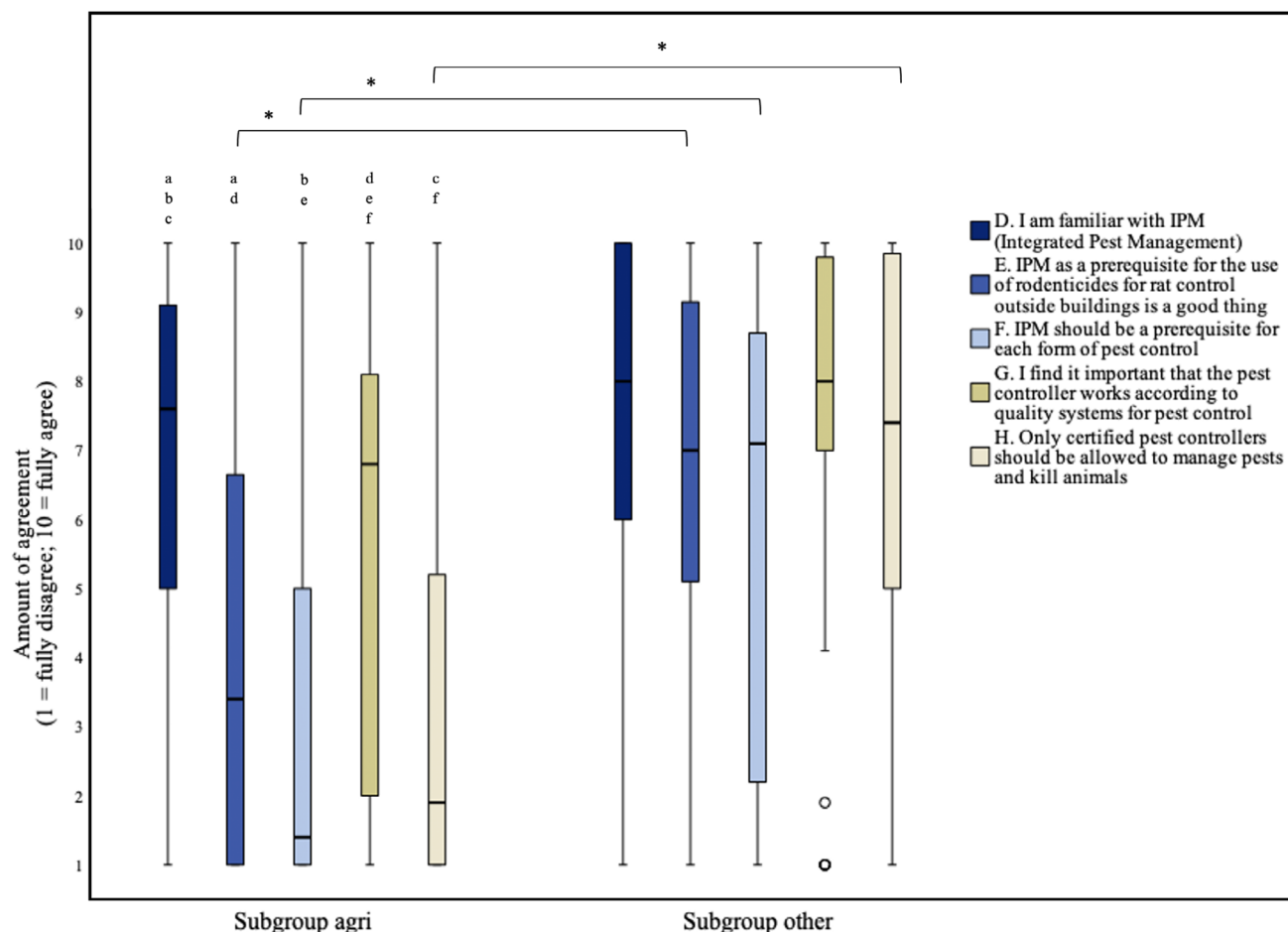


Figure 1. Box plots presenting the amount of agreement with statements D–H about integrated pest management (IPM). The amount of agreement could be indicated on a 1 (fully disagree) to 10 (fully agree) continuous rating scale. Data were obtained through an online survey among professional clients (n = 110) of Dutch pest controllers. Outliers are indicated with o. Differences between subgroup *agri* (n = 75) and subgroup *other* (n = 35) that are statistically significant are indicated with *. Differences between statements within subgroups that are statistically significant are indicated with lowercase letters above the bars.

of the five statements in the total group of respondents ($n = 110$, $df = 4$: $\chi^2 = 68.629$, $P < 0.0000005$, small effect, $W = 0.16$). The pairwise comparisons of the five statements showed that statement D was scored significantly different than all other statements, except for statement G. Statement G was scored significantly different than statements E, F and H. In Table S3 the medians, inter-quartile range (IQR), exact P -values and absolute effect sizes for the pair-wise comparisons can be found.

Most respondents disagreed with statement E ('IPM as a prerequisite for the use of rodenticides for rat control outside buildings is a good thing'), statement F ('IPM should be a prerequisite for each form of pest control') and statement H ('Only certified pest controllers should be allowed to manage pests and kill animals'). With median scores of 5, 2.4 and 4, respectively. Most respondents of subgroup *agri* agreed with statement D ('I am familiar with IPM'), with a median score of 8. Respondents tended to agree with statement G ('I find it important that the pest controller works according to quality systems for pest control'), with a median score of 7.2.

For statements E, F and H there was a significant difference between subgroup *agri* ($n = 75$) and subgroup *other* ($n = 35$) (see Fig. 1). For these statements, subgroup *other* agreed more than subgroup *agri*. In Table S4 medians, IQR, exact P -values and effect sizes can be found.

Within subgroup *agri*, there was a significant difference between the scores of the five statements about IPM ($n = 75$, $df = 4$: $\chi^2 = 76.934$, $P < 0.0000005$, small effect, $W = 0.256$). The pairwise comparisons of the five statements showed that statement D was scored significantly different than all other statements, except for statement G. Statement G was scored significantly different than statements E, F and H. Exact P -values and effect sizes per *post hoc* comparison within the subgroup *agri* can be found in Table S5.

Most respondents of subgroup *agri* disagreed with statements E, F and H, with median scores of 3.4, 1.4 and 1.9, respectively. Most respondents of subgroup *agri* agreed with statement D (median score of 7.6). Respondents of subgroup *agri* were neutral or tended to agree with statement G (median score of 6.8).

Within subgroup *other*, no significant differences were found between the statements.

The respondents from subgroup *other* mostly agreed with all statements, with median scores ranging from 7 to 8.

3.2 Attitudes towards prevention

Respondents were asked to indicate how much of the nuisance could be solved by preventive measures only (without any control). In the total group, respondents thought that on average 38.73% ($n = 106$) could be solved by preventive measures. In subgroup *agri* this was 32.51% ($n = 71$) and in subgroup *other* 51.36% ($n = 35$). Respondents from subgroup *other* had more confidence in preventive measures than respondents from subgroup *agri* ($P = 0.004213$, small effect, $|r| = 0.28$).

Most (over 80%) of all respondents indicated to have an annual company budget available for the prevention of nuisance caused by rats or mice. The amount of money available varies from less than 1000 euro per year to more than 10 000 euro a year, with the majority reporting a budget of up to a few thousands of euros per year. Approximately 10% of the respondents (and 25% within subgroup *other*) did not know if any budget is available and 8% indicated that no budget is available. Companies with the highest annual budgets of over 5000 euros available were from the agricultural, animal feed, food processing and zoo sector.

The majority of all respondents (62.7%) and of subgroup *agri* (72%) indicated that there is no need for more preventive measures in their company. Within the subgroup *other* a small majority of 57.1% thought there is a need for more prevention. Of all respondents 30.9% (21.3% of subgroup *agri* and 51.4% of subgroup *other*) thought there is a need for more prevention, and this should be done by the company and the pest controller together. Other respondents (5.5% of total, 5.3% within subgroup *agri* and 5.7% within subgroup *other*) thought more should be done by the company and only one respondent from the subgroup *agri* thought this should be done by the pest controller.

Respondents could indicate on a 1–10 rating scale what the added value of different potential measures for more and a better prevention of nuisance is (see Fig. 2).

Respondents (total group) saw differences in the added value of potential measures for more and better prevention ($n = 110$, $df = 6$: $\chi^2 = 132.779$, $P < 0.0000005$, small effect, $W = 0.20$).

'Awareness among employees of the company' was scored the highest of all possibilities with a median score of 7 and it was scored significant different from all other possibilities provided. The possibilities 'A decision tree that helps the pest controller and clients' and 'Adjustment of regulations or laws' received the lowest score for their added value for more and better prevention, with median scores of 1.8 and 1.7, respectively. Other potential measures had median scores ranging between 3 and 5. Medians, IQR, exact P -values and effect sizes can be found in Table S6.

Respondents from the subgroup *other* scored the added value for all possibilities, except for 'Awareness among employees of the company', 'More willingness by company to invest in preventive methods' and 'Governmental subsidies for preventive methods', higher than respondents from subgroup *agri* (see Fig. 2). The significant differences between subgroup *agri* and subgroup *other* are indicated with asterisks in Fig. 2. Medians, IQR, exact P -values and effect sizes can be found in Table S7.

Respondents from subgroup *agri* saw differences in the added value of measures for more and better prevention ($n = 75$, $df = 6$: $\chi^2 = 109.654$, $P < 0.0000005$, small effect, $W = 0.24$) (Fig. 2). The significant differences between possible solutions are indicated with the letters 'a'–'j' above the bars in Fig. 2. Exact P -values and effect sizes can be found in Table S8.

Respondents from subgroup *other* also saw differences in the added value of measures for more and better prevention ($n = 35$, $df = 6$: $\chi^2 = 38.576$, $P < 0.0000005$, small effect, $W = 0.18$). These respondents did however see fewer differences between the added values of the possibilities provided than respondents from subgroup *agri*. Significant differences are indicated with the letters 'x'–'z' above the bars in Fig. 2. Exact P -values and effect sizes can be found in Table S9.

3.3 Importance of control

Respondents were asked to indicate how important they find it that rats and mice are controlled at specific locations within their company or organisation on a continuous rating scale from 1 (very unimportant) to 10 (very important). Three locations within the company were presented: inside company buildings, outside company buildings, in the production room. For all these locations and for both rats and mice, respondents indicated that control is very important. Only for mice outside buildings (median of 7.5), control was scored somewhat lower than for the other situations (medians between 9.7 and 10). Significant differences in the importance of control were found between locations ($n = 109$, $df = 5$, $\chi^2 = 240.472$, $P < 0.0000005$). Pairwise comparisons showed that

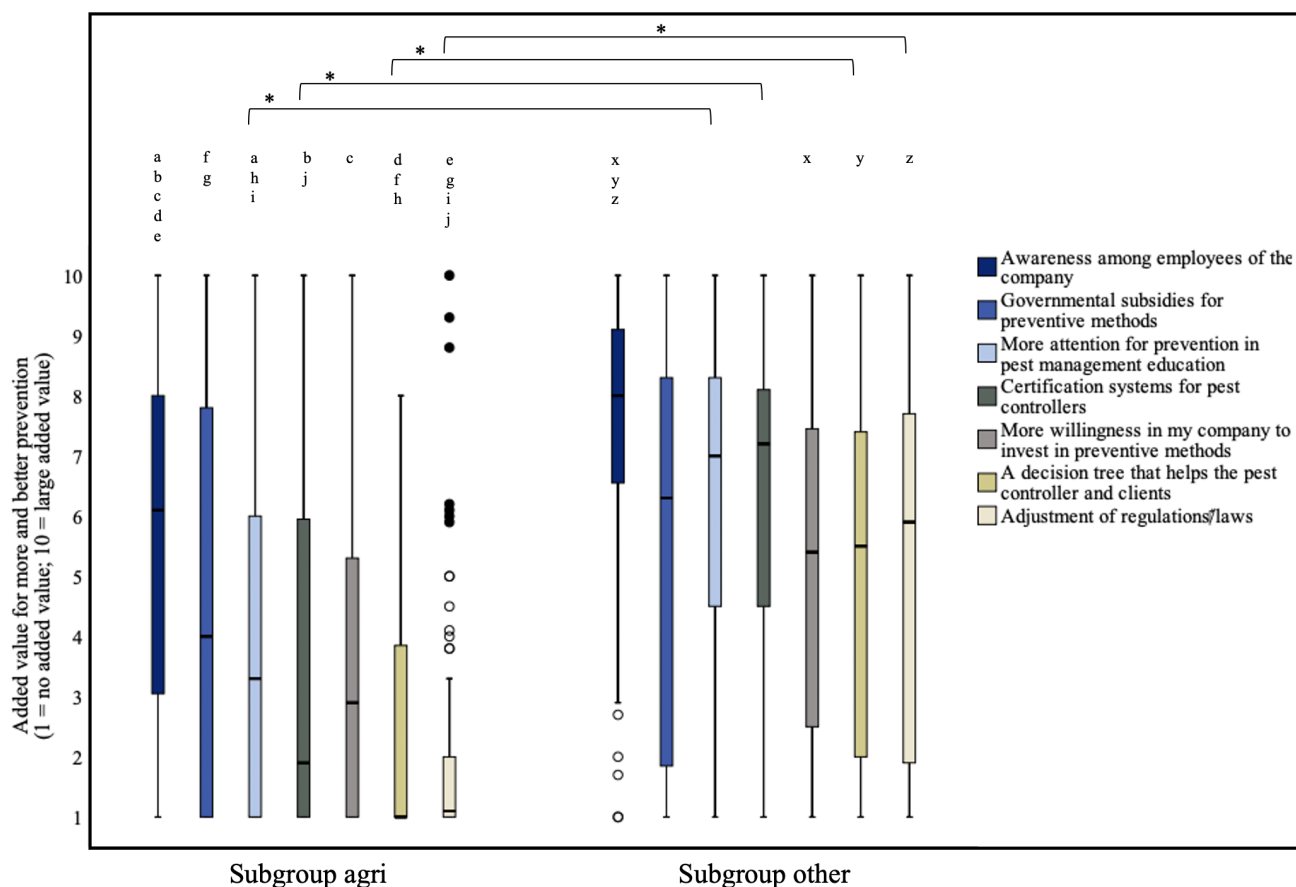


Figure 2. Box plots presenting the added value of potential measures for more and a better prevention of nuisance caused by rats (*Rattus rattus* and *Rattus norvegicus*) and mice (*Mus musculus*). The added value per measure could be indicated on a 1 (no added value) to 10 (large added value) continuous rating scale. Data were obtained through an online survey among professional clients ($n = 110$) of Dutch pest controllers. Outliers and extreme cases are indicated with o and •, respectively. Differences between subgroup *agri* ($n = 75$) and subgroup *other* ($n = 35$) that are statistically significant are indicated with *. Differences between statements within subgroups that are statistically significant are indicated with lowercase letters above the bars.

significant differences were found between all locations, except for: mice *versus* rats inside buildings, rats inside buildings *versus* mice in the production room, rats inside buildings *versus* rats in the production room and mice *versus* rats in the production room. Medians, IQR, exact P -values and effect sizes can be found in Table S10.

Differences in the importance of control were found between subgroup *agri* and subgroup *other* for ‘Mice outside buildings’ and ‘Rats outside buildings’. For both locations, the respondents from subgroup *agri* scored the importance for control higher than respondents from subgroup *other*. Medians, IQR, exact P -values and effect sizes can be found in Table S11. For the other grouping variables, no significant differences were found.

Within the subgroups, similar differences were found (subgroup *agri*: $n = 74$, $P < 0.0000005$, $df = 5$, $\chi^2 = 146.332$, moderate effect, $W = 0.40$; subgroup *other*: $n = 35$, $P < 0.0000005$, $df = 5$, $\chi^2 = 103.971$, large effect, $W = 0.59$) as in the total group of respondents.

Post hoc testing showed that within subgroup *agri*, the importance of control of ‘Mice outside buildings’ was scored significantly lower than all other locations. For subgroup *other* the importance of control of ‘Mice outside buildings’ was scored significantly lower than all other locations, except ‘Rats outside buildings’. Medians, IQR, exact P -values and effect sizes of all *post hoc* comparisons can be found in Table S12 for subgroup *agri* and Table S13 for subgroup *other*.

4 DISCUSSION

This research was performed with the aim of gaining an insight into the attitudes of clients of Dutch pest controllers towards IPM and preventive measures to manage rodent nuisance. The research served also to verify the findings of an earlier survey study among pest controllers²³ and to explore whether the perceptions of the pest controllers were in line with those of their clients. The study data can be useful in four ways. Firstly, through providing information for the further development and implementation of preventive measures in rodent management practice. Secondly, as input for the development of an assessment framework to support ethical decision-making in the management of liminal rodents. Thirdly, by improving the communication and cooperation between professional pest controllers and their clients. Fourthly, by offering insights into the attitudes towards the new Dutch regulations regarding rodent control and IPM.

4.1 Relation with the pest controller

Most respondents indicated that plans for rodent control in the company are made in consultation with the pest controller. The majority indicated furthermore that they have never had a disagreement with the pest controller about whether to kill rats or mice. For all company locations presented in the survey, control of rodents was found to be very important. Also, pest controllers

from the previous study²³ indicated that control of mice and rats inside buildings is important and that there is limited space to consider rodent welfare in these cases. While no disagreement about the killing of rodents was reported by respondents of the present study, pest controllers in the previous study²³ said to regularly face disagreements with clients regarding the implementation of preventive measures. Thereby adding, that this is the case because clients often lack the willingness to invest sufficient money in preventive methods and thereby lacking the willingness for a proper implementation of IPM principles. The disagreement about taking preventive measures may, based on the results of the current study, indeed be a challenge in practice.

4.2 IPM and prevention

Most respondents indicated that they are familiar with IPM, but not in favour of it. Especially in the subgroup *agri* the attitude towards IPM and prevention was quite negative, even though most respondents indicated that the company or organisation has an annual budget for prevention. The respondents of subgroup *other* had a more comparable attitude to pest controllers, who had quite a positive attitude towards IPM and showed quite a high level of trust in preventive measures.²³

The negative attitude and lack of trust in IPM and prevention form risks for the proper implementation of both IPM and prevention, especially within the subgroup *agri*. With the new IPM 2023 regulations in the Netherlands, one of the groups in which change is needed are farmers. In the past, they often used rodenticides themselves, but with the new regulations, this is no longer allowed. They now need to be certified through a 1-day course or hire a professional pest controller. With the negative attitudes towards IPM and a limited capacity for governmental enforcement, the question is how well this will actually be implemented in this group. Attitude is in the end an important aspect for performing behaviour and in this case applying IPM.²⁵

Burt and Lipman²⁰ showed in their study among households that the general public had sufficient knowledge about IPM and prevention. Based on this, you would expect that pest controller clients working in companies have a similar level of knowledge. Furthermore, respondents from the current study indicate that they are familiar with IPM. The negative attitude in the subgroup *agri* may therefore not be a result of a lack of knowledge about IPM in itself. It may rather be a result of insufficient knowledge on how exactly to implement prevention, a lack of confidence in prevention being successful or a lack of self-efficacy (an individual's belief in his or her capacity to execute behaviours necessary to produce specific performance attainments)^{26,27} to successfully implement prevention. Furthermore, applying preventive measures may in the short term be more expensive than application of lethal control methods. The answers of the respondents from the subgroup *agri* showed that they have little trust in the success of preventive measures (on average they thought that only one-third of the nuisance can be solved by prevention only), much less than other respondents (50% solvable by prevention) and animal pest controllers (two-thirds solvable by prevention).²³ The study by Rezaei *et al.*²⁵ found that trust in and knowledge about IPM are important factors for applying the necessary measures. The study found that farmers were especially likely to adopt IPM in crop protection when they believed it was actually beneficial and produced positive outcomes for themselves. This was also found by Stetkiewicz *et al.*,²⁸ who showed that 80% of farmers in that study were open to reduce fungicides if they could obtain the same yield and to be

cost-effective. Furthermore, in the adoption of decision support systems for IPM in crop production trust and a lack of knowledge were found to be important factors.²⁹

When it comes to knowledge about and confidence in IPM and prevention in rodent control, the problem may be that there is a lack of evidence, proof and experience of success from practice. Lefebvre *et al.*³⁰ also showed that within crop production there is a lack of quantitative evidence on the potential of IPM to improve economic sustainability and there is a so-called knowledge or experience gap. Knowledge and experience or engagement are important factors in the 'Theory of Planned Behaviour', which has been proven to be a viable predictor of farmer's behaviour.^{31,32} Lefebvre *et al.*³⁰ say that the risk perception of farmers plays an important role in the adoption of new technologies or principles, as pests can indeed reduce yields and impact product quality. From a conventional or traditional viewpoint, biocides have been an important tool to reduce those risks and therefore have gained confidence. Instead IPM and prevention might be seen as a risk by farmers. Another aspect that may influence the confidence in prevention within the subgroup *agri* is that open barns, with stores of animal feed or other edible items for rodents, can be more challenging locations for prevention than closed buildings.

For obtaining the necessary knowledge about the importance and application of preventive measures, the professional pest controller is the first person clients speak to. It may also be assumed that the animal pest controller is the one who has this (technical) knowledge about prevention and can convey it to his/her clients.²⁰

Since most respondents indicated to have good relations with the pest controller in which plans are made together, there seem to be opportunities for a proper implementation of prevention. However, negative attitudes and resistance against change may result in difficulties to engage clients in prevention. Besides this, pest controllers may experience clients searching for another pest controller who is less motivated for IPM. Furthermore, from the previous study²³ it became clear that pest controllers might experience a dilemma in relation to work motivation. On the one hand, the pest controllers want to assure client satisfaction, while on the other hand, they sometimes need to be critical of client behaviours and attitudes. This calls for strong communication skills.

If animal pest controllers would acquire more knowledge and skills for engaging their clients in this during their training, this could maybe improve implementation of IPM and prevention. Pest controllers from the previous study²³ and respondents from subgroup *other* in the current study also indicate that it is important to include experiences of and solutions for these type of dilemmas in pest controller education.

Those that already implement IPM and prevention might have a higher trust in the measures.²⁹ A way to provide farmers and other clients with the knowledge and trust necessary for proper implementation of IPM, is to make use of peer learning through for example 'farmer field schools'.^{33–35} The systematic review of Waddington *et al.*³⁴ showed that farmer field schools (FFS) are suitable for the adoption of 'beneficial' practices, including the implementation of IPM technology in crop production. Although most studies about FFS for a better implementation of IPM focused on short-term effects of pesticide reduction in crop farming, Van Den Berg and Jiggins³⁴ reported even positive effects lasting for more than 6 years.

For future studies focused on the topic of IPM in rodent control it may be useful to look at ways to engage farmers and other

clients in the application of preventive measures. This may be done by investigating reasons behind the lack of confidence in prevention and the effects of FFS for a better adoption of preventive measures related to pest control for example. Behaviour change is much more complex than what is touched upon in this article. We therefore recommend further research that is focused on behaviour change in the context of the implementation of IPM and prevention. This should look at attitudes, knowledge, trust, self-efficacy, and other factors influencing behaviour. Furthermore, in addition to pest controllers and their clients there are more stakeholders, including (local) governments, involved in IPM and rodent control.^{3,21,36} It may be good to investigate ways for those stakeholders to participate (more) in the implementation of IPM. Finally, better implementation of IPM, prevention and more ethical ways for rodent control within specifically the agricultural sector, could also be integrated in existing incentives for improved animal welfare and/or a more sustainable production, such as norms for organic farming or specific labels for higher animal welfare standards in livestock farming (e.g., the 'better life label' in the Netherlands). In a broader sense, it could be part of Corporate Social Responsibility.

4.3 Limitations of the study

Respondents of this survey did not represent the Dutch population of pest controller clients (this was also not aimed for). Results should therefore be used in an indicative way without generalising conclusions. Further research is needed to draw more general conclusions. There was an overrepresentation of respondents from the agricultural sector and therefore two distinct groups of respondents were analysed and compared. The overrepresentation of the subgroup *agri* may be due to a better distribution of the survey link within the agricultural sector. But it may also be due to a high degree of involvement and/or resistance in this group due to the new IPM regulations, that force a change in their management. Low respondent numbers in specific sectors such as health care, supermarkets and garbage processing may be due to limited survey distribution in these sectors or the start of COVID-19 pandemic in the period of the survey. For further research we would recommend distributing similar surveys wider and within a more diverse group of sectors.

In the survey no information on farm type was included (e.g., animal species, type of crops, open or closed barns). This information could however be relevant to have, since crop farmers might already be used to IPM related to pesticide use. Furthermore, type of farm and especially open *versus* closed barns. Open barns with a lot of animal feed present, may be more challenging locations for pest control and prevention compared to fully closed barns. Farm type may influence tolerance levels for rats and mice, attitudes towards IPM and levels of trust in prevention and with that implementation of prevention. For further discussion points about the limitations of the study we refer to Van Gerwen *et al.*²⁴

5 CONCLUSIONS

The aim of the current study was to gain insight into the attitudes of clients of pest controllers (e.g., organisations and companies that engage a pest control contractor), regarding IPM and the implementation of preventive measures in rodent control. Respondents from the agricultural sector have a relatively negative attitude towards IPM, the new IPM regulations in the Netherlands, and have little confidence in prevention. This may

result in challenges related to the proper practical implementation of IPM in relation to rodent control in the Netherlands. In other sectors, respondents are more positive about IPM and have more confidence in prevention. The respondents from the latter subgroup have a similar attitude compared to Dutch pest controllers who participated in a previous survey. The findings of the study may be useful for the further development and practical implementation of IPM and preventive measures. Firstly, they may provide useful insights for engaging farmers and other clients better in the application of preventive measures in rodent control. Secondly, a better understanding of both the attitudes of pest controllers and their clients may help to improve communication and cooperation between them and with that a better implementation of IPM. Finally, a better implementation of IPM and preventive measures may result in a reduced application of lethal control methods and thus lead to a more ethical rodent management, with less negative impact on rodent welfare, the environment and non-target species.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

SUPPORTING INFORMATION

Supporting information may be found in the online version of this article.

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