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INVASION NOTE

Exploring knowledge, perception of risk and biosecurity practices among researchers in the UK: a quantitative survey

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Abstract Accidental introduction and/or spread of invasive non-native species (INNS) can result from a range of activities including agriculture, transport, trade and recreation. Researchers represent an important group of stakeholders who undertake activities in the field that could potentially facilitate the spread of INNS. Biosecurity is key to preventing the introduction and spread of INNS. Risk perceptions are a fundamental component in determining behaviour, so understanding how researchers perceive the risks associated with their activities can help us understand some of the drivers of biosecurity behaviour in the field. The aim of this study was to investigate researchers' perceptions of risk in relation to their field activities and whether risk perceptions influenced behaviour. We gathered quantitative data on perceptions of risk and biosecurity practices using an online questionnaire. Only 35% of all respondents considered their field activities to pose some risk in terms of spreading INNS. Higher risk perception was found in those who undertook high risk activities or where INNS were known/expected to be present. However, whilst respondents with experience of INNS were more likely to report consciously employing biosecurity in the field, this did not translate into better actual biosecurity practices. Awareness of biosecurity campaigns did in fact increase perception of risk, perceived and actual biosecurity behaviour. However, there remains a disconnect between reported and actual biosecurity practices, including a lack of understanding about what constitutes good biosecurity practice. These findings should be used to improve targeted awareness raising campaigns and help create directed training on biosecurity practices.

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Introduction

As the rate of invasion increases, there is a growing need to prevent ecological, economic and social impacts. Management and prevention of the introduction and/or spread of invasive non-native species (INNS) is recognised as a global priority under the CBD and targets to achieve this have been transposed into recent EU legislation (EC Regulation 1143/2014). The EU Regulation aims to address the problems INNS can create by targeting intervention measures; prevention, early detection and rapid eradication and management. Once an INNS has become established, eradication is frequently difficult, economically costly and has a low rate of success (Dunn and Hatcher 2015). Methods to prevent the introduction and spread of INNS are increasingly being recognised as the most cost effective means of reducing the impacts of INNS and are central to the EU regulation and the Invasive Non-Native Species Strategy for Great Britain (Perrings et al. 2002; Dunn and Hatcher 2015). Biosecurity measures cover all activities aimed at preventing the introduction and/or spread of INNS. Biosecurity measures to reduce the introduction and/or spread of INNS on fomites (e.g. clothing or equipment) can involve simple practices such as employing cleaning measures (Anderson et al. 2015; Dunn and Hatcher 2015).

In the UK, the Department for Environment, Food and Rural Affairs (Defra) launched the first invasive species specific biosecurity campaign 'Check Clean Dry' in 2011, in response to the first reports of the invasive non-native killer shrimp (*Dikerogammarus villosus*). Freshwater ecosystems are disproportionately affected by INNS (Dudgeon et al. 2006) because of high anthropogenic activity including transport, recreation and research. The aim of the Check Clean Dry campaign was to reduce the risk of accidental introduction and spread of aquatic INNS by encouraging biosecurity best practice among water users. The campaign encourages people to check, clean and dry all equipment and clothing thoroughly to kill or remove any organisms that have the potential to survive while attached to equipment and be transported to a new location. Similarly, the 'Be Plant Wise' campaign was also launched in 2010 by Defra and the Scottish Government. This campaign targets gardeners, pond owners and retailers, providing resources and advice on the damage caused by invasive aquatic plants and how they can be disposed of safely. Additionally, the Great Britain Non-Native Species Secretariat also offers free biosecurity e-Learning courses on how to plan and practice Check Clean Dry in the field for anyone who uses the environment for work or leisure (GBNNSS 2015). Both campaigns and e-Learning resources aim to promote appropriate changes in perceptions and behaviours among individuals using the environment for recreation or research.

Researching stakeholder awareness, perceptions and practices in relation to biological invasions has been identified as a priority for the further development of targeted delivery of knowledge (Shackleton and Shackleton 2016). Researchers conducting fieldwork represent an important group of stakeholders in relation to INNS. They undertake activities in the field, such as surveying and sampling, that could potentially bring them into contact with INNS and facilitate their spread. However, while research has investigated the attitudes, risk perceptions and behaviours of anglers and recreational users (Drake et al. 2014; Anderson et al. 2014), gardeners, hunters (Prinbeck et al. 2011), tourists and conservationists (García-Llorente et al. 2011) we have yet to turn the spotlight on ourselves.

Researchers come with significant environmental knowledge, in addition to that gleaned from broader biosecurity campaigns (Shackleton and Shackleton 2016), although that knowledge will be framed and determined by the disciplinary background of the researcher. This knowledge has the potential to translate into good biosecurity practice. However, behaviour in relation to biosecurity will be determined by more than just knowledge (disciplinary or otherwise) and will be influenced by individual risk perceptions to INNS and biosecurity, and awareness about the risks related to activities carried out in the field (Ballantyne and Packer 2005; Delabbio et al. 2005; Estévez et al. 2015). Risk perceptions are particularly important because they are influenced by attitudes, beliefs and knowledge and can help predict behavioural intentions (O'Connor et al. 1999). Direct experience has also been found to be a major influence

on risk perception and action in relation to other environmental issues (e.g. climate change (Lorenzoni et al. 2007)) so experience of and exposure to INNS in the field may also significantly influence researchers' understanding of risk and so their biosecurity behaviour.

This study has two objectives: (a) to investigate the impact of academic discipline, exposure to INNS and information campaigns (i.e. knowledge) on risk perception and biosecurity practice; and (b) to explore the impact of field experience and activity on risk perceptions and biosecurity practice.

Methods

Survey design

An online questionnaire was created using Bristol Online Surveys software (https://www.onlinesurveys.ac.uk/) to gather information on knowledge, risk perceptions and biosecurity practices among researchers within the UK (Online Resource 1). A pilot study was conducted ($n = 7$) to ensure the online questionnaire worked effectively and to reduce ambiguity or misinterpretation of the questions. This pilot data was not used in the overall analysis. The online questionnaire was conducted between 12th June 2015 and 31st July 2015 and was designed to take 15–25 min. Using a multiple start point snowball sampling strategy (Miller and Brewer 2003), invitation e-mails were sent to researchers with the request that they complete the online questionnaire and forward the invitation to their colleagues and research groups. Reminder emails were sent out weekly during the survey period to encourage people to complete the questionnaire. A total of 65 questionnaires were completed.

The online questionnaire satisfied the University of Leeds' guidelines on ethical conduct (Ethics reference AREA 14-121) and all data was collected, stored and analysed anonymously. A definition of INNS was given at the start of the online questionnaire.

Demographic data

The first section sought two items of demographic data (gender and age) and the role of the respondent at their institution. Respondents could choose up to four disciplinary areas that best described their research/study.

Fieldwork

The second section gathered information about the locations where researchers had undertaken field research, both in the UK and overseas. Respondents could select more than one environment in which they carried out field activities. Respondents were asked to identify all the field activities they carried out (sampling, monitoring, conservation, etc.), these results were used to determine their field experience to address objective *b*. Using polar questions (yes, no), all respondents were asked whether they used equipment when undertaking fieldwork.

Actual biosecurity practices

The third section of the questionnaire focused on actual biosecurity practices undertaken by respondents. Respondents who answered yes to using equipment in the field were asked further questions including which items they used, what the equipment came into contact with, as well as further questions relating to how often they used equipment and their cleaning practices. If individuals did not use equipment in the field they were forwarded onto the next question. Respondents were asked how often they checked, cleaned and dried equipment and modes of transport (including the tyres/wheels or boat hulls) before, after and between visits and again for the use of footwear and outerwear during field research. The term biosecurity was not used when individuals were asked about general cleaning procedures to avoid prejudice for questions later in the survey and to determine whether what individuals *think*, say and what they do are consistent. These data were used to generate a quantitative 'actual' cleaning numerical score for each individual in the analysis. Respondents were scored on cleaning equipment, vehicle tyres/wheels/hulls and footwear/outerwear before arriving on site, before departing a site and drying thoroughly in between uses. Responses were scored from 0 to 4 (e.g. never = 0, rarely = 1, sometimes = 2, often = 3, always = 4), each respondent was given a mean score for each variable (equipment, vehicle and footwear/outerwear) and then a combined overall mean score. The higher the score the better the actual biosecurity

practice of the individual. Not all individuals completed all cleaning questions as many did not use equipment in the field and therefore did not receive a mean cleaning score for this variable; these individuals were given a mean score on the other two variables.

Awareness and perceptions of risk

Section four of the questionnaire investigated awareness of INNS issues and perceptions of risk of introducing/spreading INNS while undertaking fieldwork. Respondents were asked whether they considered their field activities to pose any risk in term of spreading INNS (yes or no). Respondents that answered yes were asked to estimate the risk their actions posed from low (1) to high (5). To measure exposure to INNS in the field, participants were asked whether they had ever carried out field activities in an area where they knew or suspected that INNS were present, participants were able to answer using yes or no.

Respondents were asked whether they were familiar with any biosecurity campaigns (yes or no) and could give further detail to what campaigns they had heard of.

Perceived biosecurity

The final section of the questionnaire asked all respondents to self-report on whether they consciously employed biosecurity measures in the field regardless of awareness of INNS and familiarity with campaigns/training (yes/no). Self-reports have been argued to be reflections of an individuals' beliefs or perceptions about behaviour (Corral-Verdugo 1997). Therefore, asking individuals to self-report enabled investigation of perceived biosecurity against actual reported cleaning (biosecurity) practices.

Statistical analysis

All statistical analyses were carried out in R version 3.2.1 (R Core Team 2015) with $\alpha = 0.05$. We grouped our explanatory variables into two categories: knowledge (academic discipline, exposure to INNS, and familiarity with biosecurity campaigns) and experience (sampling and aquatic activity), and tested for the influence of each category on risk perception (whether an individual perceived their activity to pose a biosecurity threat), reported biosecurity (whether respondents consciously employed biosecurity), and actual biosecurity scores, including relevant two-way and three-way interactions. Models investigating risk perception and perceived biosecurity were investigated using a binomial error structure. Models investigating actual biosecurity were investigated using a Gaussian error structure; data were normally distributed.

To identify significant explanatory variables, GLMs were simplified to minimum adequate models (MAMs) following Crawley (2007), discarding terms whose exclusion from the model did not significantly increase deviance. χ^2 and F tests of significance were employed for binomial and Gaussian models respectively.

Results

Return rate and demographics

The online questionnaire was completed by 65 respondents from a total of 12 different universities and research institutes, all based within the UK. A range of age groups were represented with most respondents aged between 26 and 35 (43%), with the second largest age group aged between 36 and 45 (20%). A smaller number of respondents were aged under 25 (12%) and the final quarter of respondents were aged over 46. A wide range of roles were represented (Fig. 1) with most respondents identifying as PhD students (29.2%), as post-doctoral researchers (13.8%) and lecturers (12.3%).

Each respondent could select up to four disciplinary areas to describe their study/research or teaching. The most frequently selected discipline was ecology, selected by 40% of the sample, followed by environmental science (23%), conservation (22%), soil science (14%), entomology (12%), environmental studies (12%), geography (12%), agriculture (11%) and biology (11%), with numerous other disciplines also selected by smaller numbers of respondents (these percentages sum to > 100 as respondents could choose more than one discipline) (Fig. 2). The sample was split into two groups according to whether respondents identified ecology and/or conservation ($n = 26$ ecology, $n = 14$ conservation) as one of their

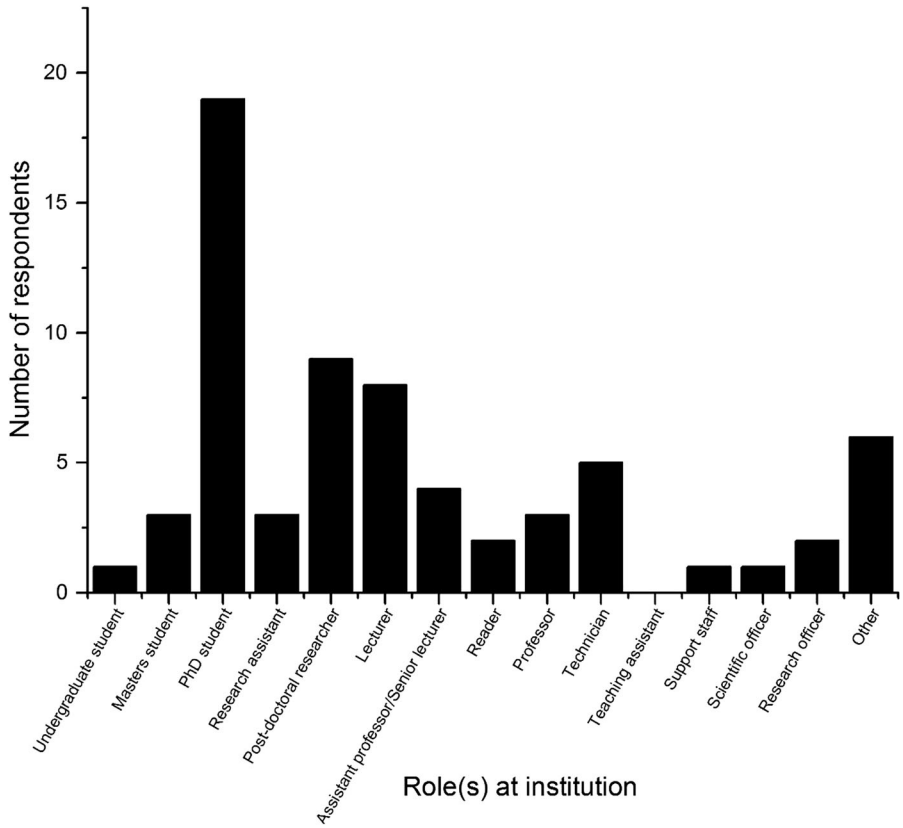

Fig. 1 Roles identified by researchers. A range of roles were represented, with most researchers identifying as Ph.D. students (n = 19)

disciplinary areas (we refer to these individuals as EcCon) or not (n = 35), in order to test the impact of academic discipline on risk perception and biosecurity practice.

Nearly half of respondents (n = 31) carried out fieldwork in woodland areas and 34% of respondents indicated that they carried out fieldwork in aquatic (combining marine and freshwater) environments (Fig. 3). The most common activity among respondents was monitoring/surveying (69%) but nearly 60% of respondents also carried out sampling in the field (these percentages sum to $>$ 100 as respondents could choose more than one activity).

Individuals were asked whether they considered their field activities posed a risk in spreading INNS, individuals that answered yes were asked to measure their risk from low to high. Thirty-five percent of all respondents perceived that their field activities posed a risk of spreading INNS. For the respondents that considered their fieldwork to pose some risk in terms of spreading INNS, most respondents (78.2%) considered their activities to be medium to low risk on the Likert scale.

Impact of academic discipline, exposure to INNS and familiarity with biosecurity campaigns on risk perception and biosecurity practice

There was no significant difference in perception of risk in the EcCon group (43% considered their field activities posed a risk of spreading INNS) compared to those from other non EcCon disciplines (29%) (Table 1). In contrast, researchers who reported exposure to INNS were significantly more likely to consider that their activities posed a risk of spreading INNS as were those who were familiar with biosecurity campaigns (Table 1).

For most respondents (55.4%), issues related to INNS never or rarely come up in relation to fieldwork. Respondents that had undertaken fieldwork in areas where INNS were suspected or known to be present (39%), were significantly more likely to perceive their field activities to entail risks of spreading INNS

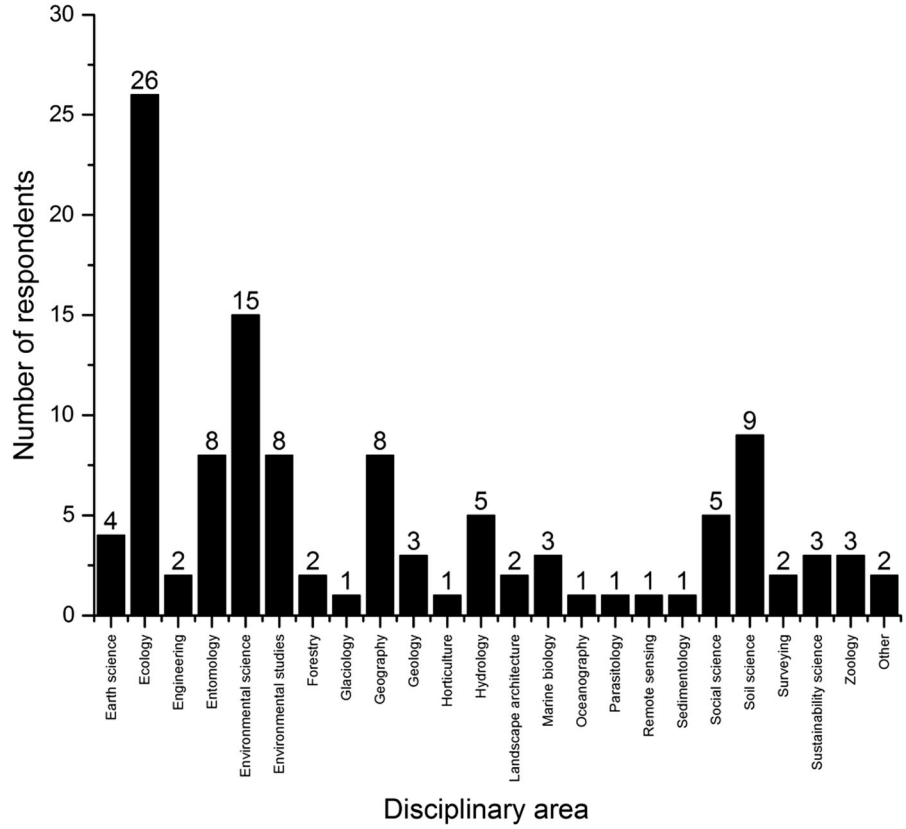

Fig. 2 Disciplinary areas identified by researchers. Respondents were able to select up to four disciplinary areas with 40% of researchers selecting Ecology (n = 26) and 22% conservation (n = 14)

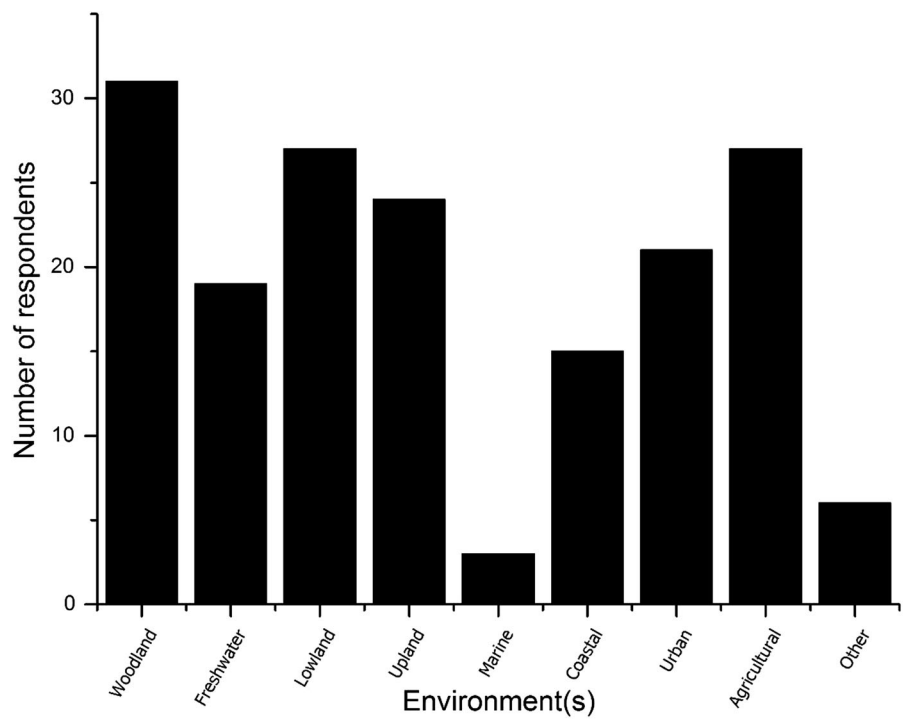

Fig. 3 Environments in which respondents carried out field activities (choice of four; these numbers sum to > 100 as respondents could choose up to four environments). Woodland areas were identified as one of the most common environments for respondents to undertake fieldwork ($n = 31$)

Table 1 Risk perception, perceived biosecurity and actual biosecurity cleaning scores for respondents from different disciplines (EcCon versus other); respondents exposed/not exposed to INNS; and respondents who were/were not familiar with biosecurity campaigns or guidance

	EcCon	Other	GLM
Risk perception (*considered to be a risk*)	43.3% (n = 30)	28.6% (n = 35)	X^2 = 0.012 d.f. = 1 p = 0.914
Perceived biosecurity (*consciously employing biosecurity*)	33.3% (n = 30)	22.9% (n = 35)	X^2 = 0.624 d.f. = 1 p = 0.429
Actual biosecurity (*mean cleaning score*)	1.40 ± SD 0.84 (n = 30)	1.61 ± 0.74 (n = 35)	F = 5.188, d.f. 1,61, p = 0.026
	Exposure to INNS	No exposure	GLM
Risk perception (*considered to be a risk*)	52% (n = 25)	25% (n = 40)	X^2 = 4.637 d.f. = 1 p = 0.031
Perceived biosecurity (*consciously employing biosecurity*)	52% (n = 25)	12.5% (n = 40)	X^2 = 12.271 d.f. = 1 p = < 0.001
Actual biosecurity (*mean cleaning score*)	1.56 ± SD 0.70 (n = 25)	1.48 ± SD 0.84 (n = 40)	F = 0.063, d.f. 1,62, p = 0.803
	Familiarity with campaigns	Not familiar	GLM
Risk perception (*considered to be a risk*)	53.84% (n = 26)	23.1% (n = 39)	X^2 = 6.448 d.f. = 1 p = 0.011
Perceived biosecurity (*consciously employing biosecurity*)	46.2% (n = 26)	15.4% (n = 39)	X^2 = 7.326 d.f. = 1 p = 0.007
Actual biosecurity (*mean cleaning score*)	1.77 ± SD 0.84 (n = 26)	1.34 ± SD 0.71 (n = 39)	F = 5.244, d.f. 1,63, p = 0.025

compared to those who had not undertaken fieldwork in areas where INNS were suspected or known to be present (Table 1). Forty percent of all respondents stated that they were familiar with biosecurity campaigns or guidance and of those that had encountered campaigns or guidance. Check, Clean, Dry and Be Plant Wise were mentioned, as were regulations on Japanese knotweed. Familiarity with biosecurity campaigns or guidance was significantly associated with risk perception, with 54% of those familiar with campaigns or guidance considering their field activities to constitute a risk in terms of spreading INNS, compared with only 23.1% of those who were not familiar with campaigns (Table 1). Risk perception was not significantly affected by the interactions between discipline, exposure to INNS, and familiarity with campaigns (two-way and three-way interactions, $P > 0.05$).

A total of 28% of all respondents reported consciously employing biosecurity practices in the field. Of these individuals, many stated that they often avoided contact with INNS in the field (40%), often challenged the risky practices of others (38%), and sometimes found out whether INNS were present at their field sites (44%). No significant difference was found between respondents from the EcCon group and those from other, non-EcCon disciplines when reporting consciously employing biosecurity practices in the field (Table 1). On the other hand, actual cleaning scores were significantly better among those from EcCon compared to those from other disciplines (Table 1).

Respondents who reported exposure to INNS and had carried out activities where INNS were suspected or known to be present were significantly more likely to report consciously employing biosecurity measures, as were those who were familiar with biosecurity campaigns or guidance (Table 1). Of the 25 respondents (39%) that had carried out activities in an area where INNS were suspected or known to be present, most (60%) said that they did not change anything about how they carried out their field activities. Nonetheless, respondents that had undertaken fieldwork where INNS were suspected or known to be

present were significantly more likely to report consciously employing biosecurity measures, with 52% doing so, compared with only 13% of the group that had not carried out fieldwork in the presence of INNS (Table 1). Those that did make changes to their activities because of encountering INNS in the field (40%), reported changing the order of sites visited, disinfecting equipment and following Check, Clean, Dry recommendations. Reported biosecurity was not significantly affected by the interactions between discipline, familiarity with campaigns, or exposure to INNS ($P > 0.05$ for all two-way and three-way interactions).

However, the increased awareness and reporting of biosecurity by those familiar with INNS did not appear to translate into actual biosecurity practices. There was no significant difference between mean scores of actual biosecurity practices of respondents that had carried out activities in areas where INNS were known or suspected and for those respondents who had not worked in these areas (Table 1).

In contrast, familiarity with biosecurity campaigns or guidance was significantly associated with both higher reported biosecurity and higher actual cleaning scores (Table 1). There was no significant effect of the interactions between discipline, exposure to INNS and familiarity with campaigns on cleaning scores (two-way and three-way interactions, $P > 0.05$).

Impact of field experience on risk perception and biosecurity practice

Respondents carrying out sampling in the field were significantly more likely to perceive that their field activities may constitute a risk of spreading INNS than those not carrying out sampling in the field (Table 2). Despite this higher reported perception that their activities pose a risk of spreading INNS, those undertaking sampling activities were not significantly more likely to report consciously employing biosecurity in the field. Nonetheless, respondents that took samples had higher mean cleaning scores than those that did not (Table 2).

In contrast there was no significant difference in risk perception, reported or actual biosecurity practices between those working in aquatic versus terrestrial environments (Table 2). There was no significant effect of the interaction between sampling and aquatic activity on risk perception ($p = 0.608$), perceived biosecurity ($P = 0.305$), or actual biosecurity ($P = 0.788$).

Discussion

This study provides the first test of key hypotheses, that knowledge and exposure determine behaviour surrounding the implementation of biosecurity measures by a neglected group of stakeholders: field researchers. We measured the perceptions of risk an individual associated with their field activities and their reported and actual behaviours in relation to biosecurity of INNS in the environment. This work shows both the importance of experience in the field (through taking samples) and information campaigns/guidance as key components for behaviour change.

Surprisingly, respondents to the questionnaire with ecology and/or conservation disciplinary backgrounds were not more likely to consider that their activities posed a risk in introducing and/or spreading INNS despite the likelihood that they would know more about INNS issues. There was also no association between disciplinary background and likelihood of reporting employing biosecurity however there was an association between disciplinary background and conducting better biosecurity practices. This suggests that knowledge seemed to have no impact on an individual's risk perception and reported behaviour but was associated with actual behaviour.

Although field experience and exposure to INNS was positively associated with perceptions of risk and reported behaviour, researchers with higher perceptions of risk were generally not found to be undertaking better biosecurity practices. On the other hand, knowledge, as indicated by awareness of campaigns seems to have a positive impact on an individual's awareness of INNS and behaviour. Whilst information campaigns are a relatively cheap method of communication and are somewhat successful in raising awareness of issues, they may not always lead to action (Collins et al. 2003; Lucas et al. 2008). Little is known about the success of campaigns targeting preventative behaviours in relation to INNS and the success of information campaigns in influencing behaviour is difficult to measure (Timlett and Williams 2008; Prinbeck et al. 2011). Our study reveals that awareness of campaigns and guidance led to both an increased perception of risk and to better

Table 2 Risk perception, perceived biosecurity and actual biosecurity cleaning scores for respondents undertaking different activities in the field: sampling versus not taking samples; and aquatic versus terrestrial/other field work

	Activity (sampling)	Other	GLM
Risk perception (*considered to be a risk)*	50% (n = 38)	14.9% (n = 27)	X^2 = 9.142 d.f. = 1 p = 0.002
Perceived biosecurity (*consciously employing biosecurity*)	28.9% (n = 38)	25.9% (n = 27)	X^2 = 0.072 d.f. = 1 p = 0.788
Actual biosecurity (*mean cleaning score*)	1.70 ± SD 0.70 (n = 38)	1.25 ± SD 0.84 (n = 27)	F = 5.362, d.f. 1,63, p = 0.024
	Activity (Aquatic)	Other	
Risk perception (*considered to be a risk*)	54.5% (n = 22)	25.6% (n = 43)	X^2 = 3.285 d.f. = 1 p = 0.069
Perceived biosecurity (*consciously employing biosecurity*)	36.4% (n = 22)	23.3% (n = 43)	X^2 = 1.149 d.f. = 1 p = 0.284
Actual biosecurity (*mean cleaning score*)	1.54 ± SD 0.70 (n = 22)	1.50 ± SD 0.84 (n = 43)	F = 0.091, d.f. 1,62, p = 0.764

biosecurity practice amongst researchers. These data are in accord with a study of recreational water users which found better biosecurity practice reported by canoeists who were aware of the Check Clean Dry campaign (Anderson et al. 2014).

Risk perceptions can be influenced by many variables including cultural background, personal values, attitudes and experience (Estévez et al. 2015). Drake et al. (2014) highlight the continued problem of human-mediated invasions, despite numerous outreach programs which aim to educate the public on the risks of introduction and spread, and encourage behaviour change among stakeholders. The broad range of incentives and motivations that determine behaviour need to be understood in order to devise and enforce targeted strategies (Perrings et al. 2002; Drake et al. 2014). In this study, we found that perception was associated with previous exposure to INNS and with undertaking field sampling, which carry a higher risk of accidental transfer of INNS. Although individuals who undertake sampling activities were not more likely to report consciously employing biosecurity practices in the field, their biosecurity scores indicated that these individuals did in fact employ better biosecurity practices than those that did not undertake sampling activities. This could be explained by the type of training they receive and knowledge that has been instilled in a "correct" way, which perhaps is aligned with better cleaning scores among people undertaking sampling activities. However, these individuals might not equate that with biosecurity and so may not report consciously employing better biosecurity practices. Surprisingly, individuals undertaking work in high risk, aquatic environments did not show higher risk perception, nor did they show higher reported or actual biosecurity practices in the field. Previous studies have found that whilst experience may have some impact on a person's perception of risk, it is only partly related to an individual's choice to make a conscious decision towards undertaking biosecurity practices (Perrings et al. 2002; Drake et al. 2014). Recent research on biosecurity with UK stakeholders has indicated that there are costs associated with implementing biosecurity, both monetary and in terms of time (Sutcliffe et al. 2017). It is likely that these costs might explain at least some of this disparity between recognition of risk and biosecurity action.

In our study, there is some mismatch between risk perception and perceived behaviour (individuals with field experience) and perceived and actual behaviour (individuals with previous exposure to INNS); in particular, individuals who had previous exposure to INNS considered themselves to be undertaking good biosecurity practices when in fact their actual cleaning did not reflect this. Other studies have identified that stakeholders can feel that they do not have enough clear advice on *how* to prevent the spread of INNS and that there is not enough evidence to suggest prevention methods are successful (Prinbeck et al. 2011; Sutcliffe et al. 2017), both of which will act as disincentives to changing behaviour. Infrastructure developments

could potentially address the issue surrounding *how* to prevent the spread of INNS. For example, Anderson et al. (2014) suggest that cleaning stations are needed at hot spot locations to encourage biosecurity among anglers. Several studies have identified a gap between perceived/reported and actual behaviour in relation to pro-environmental actions, such as recycling (Corral-Verdugo 1997; O'Connor et al. 1999; Steg and Vlek 2009). Corral-Verdugo (1997) found a low correlation between self-reported and direct observations of recycling, while Woollam et al. (2003) found that many people exaggerated their recycling behaviour when asked because they recognised recycling as a 'good' thing and therefore wanted to give the 'right' answer. This exaggeration gap could provide an explanation for why individuals in our study reported consciously employing biosecurity in the field, even though this was not reflected in their actual practice. An alternative possible explanation for this gap between perceptions and practice might arise from the overestimation of current biosecurity activities. Efforts must be made to increase the willingness of stakeholders, including researchers, to implement biosecurity practices as provision of infrastructure alone will not encourage stakeholders to manage, maintain and use it. What is needed is sustained education, communication, incentives and leading by example, alongside infrastructure provision (Sutcliffe et al. 2017). Without these, it will be difficult to create and maintain stakeholder buy-in for biosecurity. We must recognise that behaviours are determined by many factors, and all are necessary to trigger and sustain a change in behaviour.

Conclusion

There seems to be a gap between the risks people associate with their activities, and the measures they take to minimise this risk. Through application of quantitative research using an online questionnaire we were able to explore the relationship between risk perception and behaviour in relation to biosecurity among a sample of researchers within the UK. Our results suggest that awareness raising campaigns have been successful in targeting behaviour change, however there is a large proportion of field researchers who recognise their activities pose a risk to the introduction and/or spread of INNS but do not employ behaviours to mitigate this risk. As a result, this group requires a specific intervention approach to target their actions. We propose that awareness raising campaigns be coupled with better biosecurity guidance and training. Training and guidance should be clear and concise in order to explain and demonstrate what constitutes good biosecurity. For example, using real life examples of situations where people may encounter INNS and the measures they should put in place could help to address the gap between perceiving risks and actually employing biosecurity practices. Field training and demonstrating biosecurity in the field (in high risk environments including aquatic) could also target individuals that believe they are undertaking biosecurity practices but in fact are not employing 'good' cleaning practices. Raising awareness of the potential long-term consequences of undertaking poor biosecurity might also make stakeholders more aware of how significant the impacts of their activities can be. Training on *how* to do biosecurity should support campaigns that aim to raise awareness and advise people *what* to do. e-Learning courses have been used as a tool to reinforce and improve standards for good biosecurity in the field. Whilst these courses should not be used as a stand-alone method, taking advantage of new technology can help to improve the learning process in addition to information campaigns (Seixas et al. 2015). The Great Britain Non-Native Species Secretariat offers free biosecurity e-Learning courses on how to plan and practice Check Clean Dry in the field for anyone who uses the environment for work or leisure. In addition, the University of Leeds and Cefas have recently developed a free open access e-Learning module (https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_1189_1) which is aimed at field researchers. By targeting undergraduates, postgraduates and field staff, this e-Learning training aims to raise awareness and train individuals undertaking fieldwork in better biosecurity practices. Increasing education and awareness among these individuals will create a legacy, and train the next generation of academics, environmental managers and conservationists in better biosecurity. Individuals conducting research in the field still pose a risk to the introduction and/or spread of INNS into new environments, but with better communication on the *what* and training in the *how* the introduction and spread of INNS can be reduced.

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