2018

Public Perception of Invasive Amphibians: Using citizen science to inform management of invasive non-native species

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http://hdl.handle.net/10026.1/12824

http://dx.doi.org/10.24382/738
University of Plymouth

Public Perception of Invasive Amphibians: Using citizen science to inform management of invasive non-native species

By

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A thesis submitted to University of Plymouth in partial fulfilment for the degree of

Research Masters

School of Biological & Marine Sciences

2018

Acknowledgments

I would like to thank my supervisors, Dr Peter McGregor and Dr Robert Puschendorf for their help and support throughout this project.

I would also like to thank the residents of south east Cornwall for their ongoing support with my research and for taking the time to take part in the survey for this report.

Thanks also go to my family and colleagues for their understanding and support.

AUTHOR'S DECLARATION

At no time during the registration for the degree of Research Masters has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at University of Plymouth has not formed part of any other degree either at University of Plymouth or at another establishment.

Relevant scientific seminars and conferences were regularly attended at which work was often presented.

Presentation and Conferences Attended:

BHS/ARC Scientific Meeting, Bournemouth, December 2014; attendance

GBNNSS Local Action Groups Workshop, Preston Montford, January 2015; presentation

ARC/ ARG UK Herpetofauna Workers Meeting, Newcastle, February 2015; attendance

Cornwall College Research and Scholarship Day, Newquay, June 2015; presentation

Non-Native Species Secretariat Stakeholder Forum, Edinburgh, June 2015; attendance

GBNNSS Local Action Groups Workshop, Preston Montford, January 2016; poster and oral presentation

ARC/ ARG UK Herpetofauna Workers Meeting, Oxford, February 2016; attendance

State of the World's Plants Symposium, Royal Botanic Gardens Kew, May 2016; poster and oral presentation

Cornwall College Research and Scholarship Day, Newquay, June 2016; presentation

Non-Native Species Secretariat Stakeholder Forum, York, June 2016; poster presentation

BHS/ARC Scientific Meeting, Bournemouth, December 2016; attendance

Cornwall Invasive Species Forum, Bodmin, December 2016; Chair and presentation

GBNNSS Local Action Groups Workshop, Preston Montford, January 2017; presentation

ARC/ ARG UK Herpetofauna Workers Meeting, Nottingham, February 2017; Chair and presentation

South West Invasive Species Forum, Roadford Lake, March 2017; Chair and presentation

Research and Scholarship Day, Newquay, May 2017; presentation

Zebra mussel stakeholder meeting, Bude, May 2017; participation

Non-Native Species Secretariat Stakeholder Forum, Cardiff, June 2017; attendance

Cornwall Invasive Species Forum, Porthcurno, November 2017; Chair and presentation

BHS/ARC Scientific Meeting, Bournemouth, December 2017; Chair and attendance

Word count of main body of thesis: 17,935

Signed N.J. Morris

Date 23.01.18

Abstract

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Invasive non-native species (INNS) can cause problems - impacting the environment, economy and people's lives. Including the public in research through citizen science can engage communities and assist scientists in gaining access to sites for INNS management. Concerns have been raised regarding the validity of using citizen science data in research. This report aims to address those concerns to ensure that data of suitable quality is generated. A questionnaire conducted in an area known to have both invasive and native amphibians posed questions on participants connectedness to nature (using the NR-6 scale), their perception of INNS and opinions on INNS management (using the specially designed INNS perception scale). They also provided information on: ponds in their gardens; pond management; amphibian presence/absence; confidence in identification. Participants had NR-6 scores at the higher end of the scale, suggesting strong biophilic connections and environmental views and suggest respondents may exhibit more self-reported environmental behaviour. Respondents demonstrated good knowledge of INNS impacts. INNS perception scores were at the higher end of the scale and participants agreed that INNS should be controlled, though there was no significant correlation between these results and respondents' NR-6 scores. Connection to nature can improve species identification skills though confidence in amphibian identification was not significantly different whether or not respondents reported amphibians as present. Respondents' rural location suggests more frequent exposure to the natural environment and a stronger connection than those in urban areas. The older demographic implies more available time to connect with the environment than younger people not spending as much time outdoors. In summary, providing consideration is given to the target audience, framing of questions and data verification, citizen science can be a valuable tool in engaging communities and providing data for use in scientific research.

Contents

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17,935

1 Introduction

1.1 Overview of invasive non-native species

Invasive non-native species (INNS) are defined as a living organism introduced by humans, through accidental escape or deliberate release, outside their normal range which cause negative impacts (GB Non-Native Species Secretariat, 2015). These impacts can be widespread and include economic, environmental and in some cases human health and wellbeing impacts (Jeschke *et al*., 2014; Keller *et al*., 2011; Williams *et al*., 2010). Examples of damage include: invasive pests and pathogens, impacting on the world's ability to sustain sufficient agricultural production (Paini *et al.,* 2016); introduced freshwater aquatic plants, which impact on ecosystems (Hussner *et al.*, 2017); feral cats (*Felis catus*), a primary cause of island extinctions (Nogales *et al.*, 2013). Research has shown that INNS cost the United Kingdom in excess of £1.7bn annually (Williams *et al.,* 2010) with this ever growing figure now thought to be £1.8bn (Shaw *et al*., 2014). Whilst this figure appears high it does in fact only concern direct costs such as control and eradication, loss of crops and structural damage. To include indirect costs, such as soil erosion or recreational loss, as a result of direct effects would obviously see an increase in the annual figure (Williams *et al.*, 2010). With continued pressure to cut budgets and apportion the limited available funds to produce maximum efficiency both the UK and Europe are looking increasingly at the impacts of INNS and how best to limit these effects through control and mitigation (GB Non-Native Species Secretariat, 2015; European Commission, 2014).

INNS are one of the most important drivers of ecosystem decline (Pagad & Scalera, 2012; Nelson, 2005) and threats to biodiversity (Roy *et al*., 2014a). These claims have been challenged by some as over-exaggerated (Pearce, 2015; Thomas & Palmer, 2015). One study suggested that non-native plants do not pose a threat to native flora but add to diversity (Thomas & Palmer, 2015). Whilst the evidence provided appears to confirm this it should be remembered that this study examined effects of non-native plants across Britain as a whole. The authors acknowledge that if the survey had been carried out on a regional scale the results could show an impact on local flora though the emphasis here was on national scale impacts. The report also focuses on non-native plants and does not make clear the distinction between these and invasive non-native plants (Thomas & Palmer, 2015). This is a point which should be clarified to avoid confusion to the reader and has been made clear in other reports that INNS are

non-native species which have a detrimental effect (GB Non-Native Species Secretariat, 2015; European Commission, 2014). The data used for the 2015 study (Thomas & Palmer, 2015) did not include impacts to urban areas. Whilst the authors accepted that urban environments have shown an increase in non-native species this data was omitted from the study. Urban areas have been shown to have high levels of INNS causing changes to habitats and species diversity (Hayhow *et al*., 2016). The inclusion of data from urban environments has been supported in another study which looked at horizon scanning (Roy *et al*., 2014a). It was suggested that pathways such as the ornamental and horticultural trades provide a route for invasive plants to become established due to their having the ability to flourish in Great Britain (Roy *et al*., 2014b). It could be suggested that to discount data from urban environments creates a bias which might affect any results. The time lag which exists between the arrival of a vascular plant and its establishment in the wild has been acknowledged as a contributing factor affecting the invasion process (Roy *et al*., 2014b). This is supported in the work by Thomas and Palmer (2015) stating that longer term extinctions may indeed be possible. However, the emphasis their report places on the short term impacts suggests that these invaders do not pose a threat to native plants. This, along with the confusion which could occur through interchanging terms such as non-native and invasive non-native, suggests that reports such as these hold little credence and may be treated with caution (Hulme *et al.,* 2015).

Given the fact that conflict occurs amongst the scientific community regarding INNS and that anthropogenic factors have assisted the introduction and dispersal of INNS (Hayhow *et al*., 2016; Scalera *et al*., 2012; Skerratt *et al*., 2007) the need for research on current invaders is essential in order to help provide evidence of impacts and prevent the detrimental impacts INNS may cause (Scalera, 2009). This is also true for species identified during the horizon scan process, those which have the potential to invade but have either not yet done so or are currently benign under existing conditions (Roy, *et al*., 2014a). A collaborative horizon scan approach, initiated to effectively and accurately assess the impacts of existing and emerging invaders, affords those working in INNS control a cost-effective tool to aid management (Gallardo *et al*., 2016). This trans-national methodology enabled experts from four European countries to share knowledge on INNS and develop a framework to identify research and management priorities (Gallardo *et al.,* 2016). Whilst this is useful,

legislation can help to prevent further introductions of INNS (Hussner et al., 2017). Until 2014 there was no legislation at European level which dealt with INNS (Silva *et al*., 2014) though this has now been addressed.

1.2 Legislation relating to INNS

Legislation changes introduced in Europe in 2014 provide a means to regulate the introduction of invasive non-native species (European Commission, 2014). These rules are deserving of particular attention as they are designed to help prevent the introduction and spread of a number of animal and plant species and aid the management of these invaders (European Commission, 2014). Not surprisingly these changes have encouraged some to pass comment on the laws with the suggestion that rather than preventing releases of unwanted pests they could in fact promote them (Hulme, 2015). The implementation of these regulations may encourage those keeping species now banned from sale to release them into the wild under the misinformed impression that they are no longer able to keep them (Hulme, 2015). This is an interesting thought which deserves further investigation particularly as, due to its recent introduction, the impacts of this legislation are not yet known. Initially, 37 species were included on the list which identified them as species of concern within the European Union (European Commission, 2016). With an additional 12 species added in July 2017 (European Commission, 2017) the regulation allows for further additions as risk assessments on species thought to be problematic are completed (European Commission, 2014). Alongside this, species of regional concern will be identified which will allow the inclusion of species endemic to Europe on lists of regional concern (European Commission, 2014). The list of species of European Union (EU) concern cannot include any native European species but the detail in Article 11 of the Regulation allows for member states to identify species native elsewhere within the Union which are non-native and invasive in their country and seek agreement and cooperation with other member states to control such species at regional level (European Commission, 2014). Article 12 of the Regulation allows member states the opportunity to identify species of concern at national level (European Commission, 2014). This takes the scope of the regulation further by allowing individual member states to create a list of species of specific concern to them. From this it can be seen that there is a need to prioritise which species should be dealt with at EU, regional and member state level (European Commission, 2014)

and scientific evidence is needed in order to identify those species and establish which of those species should be prioritised (Scalera *et al*., 2012). This evidence is gained through a combination of consensus building exercises involving experts from across all taxonomic groups who, through their own knowledge and experience, alongside risk assessment, identify which species are of concern or potential concern (Roy *et al*., 2014a). There are species native in some European Union countries which are known to be invasive and non-native in others and so the fact that species of both regional and member state concern can be identified provides leverage to governments in that they can include them on their own lists (European Commission, 2014). To put this into context, Great Britain has the possibility to expand on the list of species of European concern to include species native in other parts of Europe on their own list providing the risk assessment procedure has been carried out (European Commission, 2014).

An example that shows how this aspect of the legislation could operate in the UK is the alpine newt (*Ichthyosaura alpestris*). Native to many parts of mainland Europe, though not naturally present in GB, it is known to be established in some parts of the country (Arntzen *et al*., 2009; Cunningham & Minting, 2008; Wilkinson *et al.,* n.d.; Winchester *et al.,* n.d.). The element of the regulation dealing with species of member state concern could prove to be invaluable and provide the means to prevent further invasions of the species (European Commission, 2014). Alpine newts were a commonly kept pet, it was introduced almost one hundred years ago (Bell & Bell, 1995). It has been identified as being of high concern and high research priority due to it being a vector for amphibian disease (Wilkinson *et al*., n.d.). Whilst pathogens which cause infections in animals are not covered under the EU legislation all other species considered to be invasive non-native, or alien, are included (European Commission, 2014) so the alpine newt could be included on a UK list. If Hulme (2015) is correct, laws which ban the keeping of recognised invasive species could lead to animals being released intentionally to avoid prosecution.

Public awareness campaigns can be helpful in providing targeted information for stakeholder groups, for example the Check, Clean, Dry campaign aimed at water sports and angling enthusiasts (GB Non-Native Species Secretariat, 2018b). Such campaigns are designed to help increase compliance of legislation and help prevent invasions. Recreational water sports participants who had heard of the Check, Clean,

Dry campaign have demonstrated higher biosecurity practice than those who had not (Anderson *et al.,* 2014). However, awareness of the campaign is low and in order to increase compliance of its principles specific methodologies relating to the principles of the campaign are suggested (Dunn & Hatcher, 2015). Increased understanding and interpretation of laws concerning INNS would seem essential and, in the case of *I. alpestris* and other invasive amphibians, the need to work closely with exotic pet enthusiasts is paramount (Langton & Herbert, 2011). One campaign aimed at exotic pet enthusiasts, the Be Pet Wise campaign, details considerations which prospective owners should consider before purchasing an exotic pet (Invasive Species Ireland, n.d.). The effectiveness of these campaigns with regard to changes in legislation may need evaluation as the implications of the laws become apparent.

At the time of writing this thesis the political and legislative uncertainties surrounding Britain's decision to leave the European Union has led to delays in the implementation of a review of British Wildlife Law (The Law Commission, 2014) commissioned by the Law Commission (The Law Commission, 2015a; The Law Commission, 2015b). Undertaken before the referendum on membership of the European Union the review included an entire section devoted to dealing with invasive non-native species and with consultation from stakeholders (The Law Commission, 2014). Some of the suggested reforms have been made, such as the banning of some invasive aquatic plants (*The Wildlife and Countryside Act 1981 (Prohibition on Sale etc. of Invasive Non-native Plants) (England) Order 2014*;) and the introduction of Species Control Orders (Defra, 2017). These species control provisions provide environmental authorities with powers to work with landowners to make species control agreements or orders (GB Non-Native Species Secretariat, 2015). This helps to ensure landowners take action to control INNS on their land or allow others to enter their premises to allow such works to be carried out (Defra, 2017). However, the decision was made to delay parliamentary discussion on the full proposed Act until after the implications of the exit from the European Union is known (The Law Commission, 2017). Whilst the European Directive on invasive species will continue to apply to the UK until the process of leaving the EU is complete (Defra, 2018) it has been suggested by the British Ecological Society that the legislation covering EU countries within the Directive may be transposed to British law and adopted thereafter (Morrison-Bell, 2016). The Great Repeal Bill should ensure that as soon as the process of leaving

the European Union is complete EU laws which are relevant to the UK will be converted to UK laws and there should be no gaps in statue (Department for Exiting the European Union 2017). With regard to the EU legislation, the UK, as a European Union member state, had involvement in the EU legislation process and the detail within it and so could be adopted by the UK government. Considering that the current legislation, aside from some amendments (*The Wildlife and Countryside Act 1981 (Prohibition on Sale etc. of Invasive Non-native Plants) (England) Order 2014*;), was passed in 1981 (Wildlife and Countryside Act, 1981) this legislation is considered to be outdated (The Law Commission 2015a).

The review of existing UK legislation concerning invasive species called for evidence from stakeholders to support the proposed changes (The Law Commission, 2014; The Law Commission, 2015a). Comprehensive stakeholder consultations were undertaken with scientists, local action groups, wildlife organisations and government (The Law Commission, 2014). Feedback provided by stakeholders at consultations was used to help inform the Law Commission report which was presented as a draft Bill in 2015 (The Law Commission, 2017). Once again this demonstrates a clear need for stakeholder and citizen involvement in the legislative process.

Alongside stakeholder feedback evidence of impacts of INNS is necessary to aid decision making (Williams *et al*., 2010). Though often debated it is generally accepted that invasive non-native species cause more harmful than positive impacts *(*Hulme *et al*., 2015). There are however, a minority of people who question the reasoning behind such claims and argue that the impacts are perhaps exaggerated or untrue (Davis *et al*., 2011; Pearce, 2015; Thomas & Palmer, 2015). This viewpoint should be considered alongside more widely heard opinions as it raises questions regarding not just the validity of the science surrounding invasion biology but also the definitions of terms used when discussing invasive species. The term invasive species is regularly used to describe problematic species with no clear definition of or attempt to separate the terms native, non-native and invasive non-native species (Jeschke *et al*., 2014). It is perhaps this lack of conciseness which leads to confusion by the general population and provides credence to those with opposing opinions (Hulme *et al.,* 2015). It has been acknowledged that, whilst it is vital to define terms used in invasion biology to assist policy makers, land managers, scientists and the general public in the their understanding of the issues, the language employed on a global scale should be

unambiguous and explicit (Essl *et al*., 2018). It is hoped that the adoption of a new assessment scheme taking into account the following criteria: - "(a) acknowledging the role of assessment uncertainty, (b) incorporating time since introduction, (c) considering infraspecific taxonomic ranks, and (d) differentiating between alien species whose survival depends on explicit human assistance from those that survive without such assistance" (Essl *et al*., 2018) may provide clarity on definition of terms. Another contention regards the supposed and actual threats which INNS may pose and this is linked to the ambiguity surrounding terminology (Davis *et al*., 2011; Thomas & Palmer, 2015). Despite comments which suggest that the large number of non-native plants included in lists of invasive species could be disproportionate compared to the actual threats which these species pose to native species (Thomas & Palmer, 2015), scientists continue to provide counter arguments (Simberloff, 2011) and publish evidence of negative impacts (Simberloff *et al*., 2013; Kumschick *et al*., 2015; Scalera *et al*., 2012; Jeschke *et al*., 2014). It is hoped that a protocol devised in 2014, when applied practically by scientists and stakeholders, will not only provide more evidence of impacts but also better inform policy makers on legislative changes (Jeschke *et al*., 2014). The main objectives of this protocol is to explicitly define impacts with the aim of prioritising management and conservation alongside informing policy changes (Jeschke *et al*., 2014). Given this approach the necessity to conduct rigorous scientific study on species which could be listed for control at regional level is essential in order to justify the need for funds to carry out possible eradication and to provide detailed information on prioritisation of such species (Roy *et al*., 2014a). By utilising evidence gained through using the methods described, alongside the practical opinions which stakeholders and members of the public could provide, legislation may help to prevent introductions and aid the control and management of INNS (European Commission, 2014).

So it would seem that, in order to fully understand not only the impacts of INNS but also how to go about addressing the problems, cooperation of all stakeholders is essential. In order for this to be achieved large amounts of information are needed and one way in which this can be collected is through means of citizen science (Bonney *et al*., 2009).

1.3 Citizen science and its place in conservation

Citizen science can be defined as the participation by members of the general public in research with scientists (Raddick *et al*., 2013; Swanson *et al.*, 2016). The sheer amount of data required by scientists to conduct rigorous research has reached such a level that for many projects it has become necessary to source data from a wider source than has historically been used (Dickinson *et al*., 2010; Kobori *et al*., 2016; Swanson *et al*., 2016). Results obtained from scientific research can be enhanced and built upon using data generated by members of the public (Tulloch *et al.,* 2013). Whilst this form of data collection is not new, people have been working with scientists for centuries (Silvertown, 2009), the application and inclusion of citizen science in research has evolved into what has become a popular and generally accepted manner of data collection (Blaney *et al.,* 2016; Branchini *et al*., 2015).

Despite its rise in popularity there are reservations amongst some members of the scientific community regarding the quality of, and validity of using, such data (Dickinson *et al,* 2010). For example, analyses of results from a project in the US recording birds feeding at bird tables stated that 30% of records were unable to be verified due to lack of evidence needed to confirm the reports (Dickinson *et al*., 2010). However, many researchers are adopting methods of validity in order to ensure that the data provided by citizens is of the highest quality with some projects even making use of citizen scientists further by inviting them to become involved in the validation process of data recorded by participants (Swanson *et al*., 2016; Newman *et al*., 2012). Swanson *et al*., (2016) identified ways of quantifying and validating citizen science data through means of volunteer analysis of images of wildlife. This method can also be seen in the popular Zooniverse project (Lintott *et al*., 2008), which, at the time of writing this thesis, has 76 projects ranging from the highly successful Galaxy Zoo project, which asks volunteers to classify galaxies through image observation to those looking at wildlife and even analysis of literature (Zooniverse, 2017).

As the use of citizen science increases in popularity it becomes clear that some measure of accuracy of the results of such data is necessary (Conrad & Hilchey, 2011). It is recognised that scientists ought to adopt realistic expectations and accept that with any form of data collection there will be limits to what information can be gained through research and this is also true of using citizen science as a method of data collection (Riesch & Potter, 2014). By addressing these limitations, through

means such as ensuring there are appropriate validity checks in place, standardising methods of data collection of this type of study can afford greater reliability (Ottinger, 2010). The need to validate data has been alluded to as being an essential component of research using citizen science (Dickinson *et al*., 2010). For a number of years the use of protocols to avoid bias have been suggested, such as those employed to prevent under or over reporting common species in bird surveys (Bonney *et a*l., 2009). It has also been reported that methods of data collection should be rigorously tested and standardised and that protocols should be explicit to avoid confusion on the part of the citizen scientist (Silvertown, 2009). Anyone working in science would agree that these principles are not exclusive to citizen science but must also form part of any scientific research and it should be remembered that the level of accuracy required will depend very much on the research being conducted (Crall *et al*., 2011). As technology has become more a part of daily lives so citizen science has adopted means of not only engaging more members of the public in research but improving accuracy of results (Kobori *et al.,* 2016). For example, studies which involve location data can employ the use of smartphones to obtain accurate GPS locations (Adriaens, 2015). There are many other ways to validate data such as requesting samples in the form of photographs or specimens for identification, using trained validators, inviting professionals to conduct data collection and comparing professionals results to those of the volunteers and validators (Jordan *et al.,* 2012). Whichever validation tools are employed, standardisation of data collection is important to improve accuracy and aid validation of data (Crall *et al.*, 2011; Lewandowski & Specht, 2015). With regard to evaluating the human-nature connection, an important consideration of this thesis and of working with members of the public during INNS research, a standardised and widely accepted method of evaluating likely behaviour and attitude is the Nature Relatedness (NR) Scale (Martyn & Brymer, 2016; Nisbet *et al.,* 2009). This thesis explores the potential for citizen scientists to become involved in projects which look to control INNS. Given the need to engage people with a topic which can prove controversial, many people find control of INNS distasteful (Bremner & Park, 2007), it is essential to assess the attitudes of potential volunteers to such research and gauge the best approach to employ to increase engagement (Niemiec *et al*., 2016).

1.4 Public perception of and connection with wildlife

The NR scale (Nisbet *et al*., 2009) provides a score for individual participants which relates to their connection to nature and the natural world in a broad capacity. This questionnaire asks for information on three factors:- self – how an individual identifies with nature; experience – how an individual connects with nature; perspective – the attitude of an individual towards nature (Nisbet *et al*., 2009). The NR scale is used as a predictive tool to assess an individual's likely behaviour with regard to environmental issues and is also used as a measure of psychological health and well-being (Nisbet *et al*., 2009). Given the breadth of information and length of this 21 question survey a shorter form was needed in order to embed into other studies and the NR-6 was developed (Nisbet & Zelenski, 2013). This shorter version of the NR Scale takes 6 questions from the "self" and "experience" sections of the original questionnaire and, whilst more concise, has proven to perform well in experiments (Nisbet & Zelenski, 2013; Zelenski & Nisbet, 2014). Four studies focusing on demographically distinct groups revealed consistently comparable results with those of the longer NR-21 questionnaire. Whilst the NR-6 is considerably shorter than the NR scale the NR-6 showed statistical reliability and provided data which is no less valid than that generated from the longer NR scale. The authors concluded that the NR-6 is suitable for inclusion as part of longer questionnaires where time or space may be limited (Nisbet & Zelenski, 2013). Participants scoring highly on the NR and NR-6 survey have shown a greater willingness to participate in positive environmental action, show greater environmental concern or become more proactive in supporting environmental programmes (Nisbet *et al*., 2009; Nisbet & Zelenski, 2013). With this in mind it would seem sensible to utilise these surveys when assessing an individual or communities willingness to participate in citizen science projects, particularly when dealing with INNS management and control which can be the cause of contention amongst the general public (Estévez *et al.,* 2015). The NR-6 scale offers a robust framework (Nisbet & Zelenski, 2013) with which to compare the research reported in this thesis in an attempt to provide validity and accuracy of data provided by the general public. In addition it is hoped to provide information on the best approach to take when planning management of INNS and working with citizens scientists.

The involvement of all stakeholder groups is important when making decisions which affect everyone (See 1.1) and practical environmental management is no different. In

order to carry out environmental work, such as habitat management and species control, public cooperation with scientists and practitioners is essential (Kapler *at al.*, 2012). The approach which is taken in order to gain access to sites and carry out work should be both cautious and informed in order to achieve the environmental goals of a project (Restall & Conrad, 2015).

Understanding the relationships people have with wildlife in their gardens and further afield may help inform environmental researchers and practitioners (Petts, 2007) on how best to manage the environment and in particular how to approach the sensitive topic of INNS control, something which has in the past been relatively understudied (Sharp *et al*., 2011). Previous studies have shown that, in order to avoid conflict regarding invasive species management, decision making should be a joint process and information regarding the risks should be communicated effectively to all parties involved (Estévez *et al*., 2015). One way of assessing the manner in which to approach citizens is to question them on their perception of wildlife and a previous study showed that generally people see wildlife as an asset and something which contributes positively to their experience when outdoors (McGregor *et al.,* 2013). Asked to put a cost on various species of animal and plant, participants valued all species positively. After being provided with information regarding impacts of half of those species, all INNS, respondents re-evaluated the previous values they had given and their revised costs were significantly lower (McGregor *et a*l., 2013). This suggests two things. First, that participants had limited knowledge on INNS and their impacts and secondly, after being given additional information they considered those problem species less valuable than native comparatives, implying a need for an increase in public awareness of the issues (McGregor *et al.,* 2013). A study of public perceptions of INNS management in Scotland (Bremner & Park, 2007) demonstrated a need to increase understanding of the threats posed by INNS in order for citizens to accept their management. Given greater knowledge, people were more likely to support management programmes (Bremner & Park, 2007).

Public perception of invasive non-native amphibian species (hereafter referred to as INNS amphibians), is often affected by the misconception that they do not pose the same high level of ecological threat as some other taxonomic groups such as plants and mammals (Kraus & Campbell, 2002). This could easily lead to the threats posed by INNS amphibians, such as the alpine newt (*I. alpestris*), being overlooked. Using

just one example, that of the spread of novel disease, the implications of this oversight should not be dismissed and further collaborative research in this area is vital (Garner *et al*., 2016). In order to work with citizen scientists and generate valuable data which could aid the control of INNS amphibians, or disease often associated with these introduced species, members of the public should be made aware of the issues relating to INNS amphibians and the spread of novel disease to native amphibian populations. Given the strong evidence which links the global trade in amphibians to that of amphibian diseases, such as chytrid (Fisher *et al.,* 2009), information regarding both INNS amphibians and introduced disease should be effectively disseminated to the general public. The alpine newt (*I. alpestris*) is a species often used in science (Arntzen *et al*., 2009) and kept as an exotic pet by enthusiasts (Fisher & Garner, 2007). It is also a species which has been identified as of high concern in the UK due to it being a vector for disease (Wilkinson *et al*., n.d.). Without the knowledge of potential impacts and threats which introduced species could pose, members of the public might provide a vector for these amphibian INNS by introducing them unwittingly (Bell & Bell 1995). In contrast and given the facts, people have been shown to be concerned about the impacts INNS pose (McGregor *et al.*, 2013). This thesis aims to show that whilst some people who are prepared to take part in citizen science research may demonstrate a high nature relatedness, or connection to the environment, the knowledge they have with regard to INNS and their impacts may mean that they are also prepared to agree with control of those INNS. Cooperation in these projects is important in terms of data gathering and success of INNS control projects and greater knowledge has been shown to lead to greater cooperation (Bremner & Park, 2007).

1.5 Status of *Ichthyosaura alpestris* in its native range

The IUCN Red List assessment of the alpine newt (*I. alpestris*) states it is of least concern (Arntzen *et al*., 2009). Whilst initial interpretation of this status may lead to the belief that the species is not under any particular threat, closer examination of the facts reveal that, though endemic to large parts of mainland Europe, many sub-species of alpine newt face a number of threats including habitat destruction and changes in farming methods (Arntzen *et al*., 2009). It has also been identified as being under threat from the introduction of exotic fish species leading to predation of paedomorphic populations by the invader (Denoël *et al.,* 2005). Altered behavioural patterns, particularly in relation to breeding activity has also been observed in populations with

introduced ornamental fish (Winandy & Denoël, 2013). Alongside this, the species has been traded for the pet industry and for scientific purposes (Fisher & Garner, 2007) and, whilst it is now bred in captivity, previous wild captures have led to a depletion of native populations in some of its native range (Arntzen *et al*., 2009). Despite the IUCN status of least concern for this species it has been suggested that techniques to determine patterns of species decline could be flawed (Denoël, 2012). Including assessment of guilds into surveys may help more accurately assess distribution and decline and prevent, what are thought to be, inaccurate reports of population stability when in fact regional declines are likely (Denoël, 2012). When considering the status of a species it is suggested that, rather than simply looking at atlases of distribution, studying species at the population level alongside atlases provides more accurate data in quantitative terms (Denoël, 2012). This method showed evidence of decline in *I. alpestris* (Denoël, 2012) which indicates that reassessment of status may be necessary based on a more inclusive approach.

Amphibians have suffered mass population declines worldwide due to a number of contributing factors such as habitat degradation, introduced species and emerging disease (Beebee & Griffiths, 2005; Cunningham & Minting, 2008). Of these factors disease is one of the main drivers of amphibian decline (Price *et al*., 2014). *I. alpestris* are considered a “silent carrier” of the infectious amphibian fungus *Batrachochytrium dendrobatidis* (Bd) (Cunningham & Minting, 2008; Arnold & Ovenden, 2002). High loads of Bd experienced by its amphibian host can lead to the disease chytridiomycosis (Garner *et al*., 2005). Since the 1990s amphibian chytridiomycosis has contributed to the worldwide decline of amphibians, and in some cases extinction, to such an extent that it has been acknowledged as the primary cause of such tragedies (Daszak *et al.,* 2003). In more recent years *I. alpestris* has also been identified as a carrier of an emerging ranavirus, common midwife toad virus (CMTV) (Balseiro *et al*., 2010). What makes this virus potentially more of a threat than Bd is that not only is *I. alpestris* a vector for this ranavirus but the species has also suffered severe declines in populations as a result of the infection (Price *et al*., 2014). Additionally, common toad (*Bufo bufo*), common frog (*Rana temporaria*) (Teacher *et al.,* 2010) and smooth newt (*Lissotriton vulgaris*) are also experiencing declines as a result of infection with CMTV (Price *et al*., 2014; Robert, 2010).

1.6 Invasion history of *Ichthyosaura alpestris* in Great Britain

Historically, research on the impacts of introduced herpetofauna in the UK has been lacking (Bell & Bell, 1995) and to date this situation has changed little. Of all amphibian species in the UK 57% are non-native and it is thought that although some are as a result of accidental escape most are considered to be from deliberate releases (Pimentel, 2011).

Despite the threats to the species in its home range *I. alpestris* has also become a threat itself as one of the INNS amphibians known to be a problem to native species, in countries outside its native range including the UK (Arnold & Ovenden, 2002; Wilkinson *et al*., n.d.). As with other INNS kept as pets *I. alpestris* have established in the UK through accidental escape or deliberate release from captive collections (Bell & Bell, 1995). First recorded in the 1920s in Surrey (Winchester *et al.,* n.d.), there are now a number of populations across Britain (Winchester *et al*., n.d.). Whilst there has been little research carried out on the impacts these newts might be having on native amphibian populations it was suggested over 20 years ago that a precautionary approach be adopted citing competition as a possible issue (Bell & Bell, 1995). This same report stated that there was no apparent evidence of any detrimental impact on native amphibian species (Bell & Bell, 1995) so this cautious approach seems to be a premeditated attempt to prevent potential problems. It must be remembered though that the study carried out in Shropshire in 1995 (Bell & Bell, 1995) focused on an area where, in addition to *I. alpestris, Lissotriton vulgaris* (smooth newt) and *Triturus cristatus* (great crested newt) live alongside the invader but *Lissotriton helveticus* (palmate newt) is not present. In Cornwall the only endemic newt species is *L. helveticus* (ERCCIS, 2018) and whether or not the absence of the larger *T. cristatus* has any bearing on the success or failure of *I. alpestris* has not been recorded.

Efforts to reduce the actual and potential spread of disease by means of stricter trade and import controls and reducing the risk of further spread in existing populations should be paramount (Fisher & Garner, 2007; Scalera *et al.*, 2012). Invasive species are driving forward the spread and new emergence of invasive pathogens within naive host organisms through expansion of range and host switching which presents yet further cause for concern (Peeler *et al*., 2011).

As *I. alpestris* is known to be a vector for ranavirus as well as Bd (Cunningham & Minting, 2008) there should be evidence enough for the need to control this invasive

species. Whilst disease is of obvious concern and could have severe implications for native populations (Arntzen *et al*., 2009) there are other possible factors which could cause further negative impacts by introduced populations.

Research conducted in New Zealand on an introduced population of *I. alpestris* found evidence that the species may pose threats to native and endangered frog species (Arntzen & King, 2016). The study suggests that not only are endemic species at risk due to *I. alpestris* having the potential as a vector for disease but they are also at risk more directly through predation and competition (Arntzen & King, 2016). In south west Cornwall, UK, a high mortality rate of common frog (*Rana temporaria*) frogspawn was reported at a pond containing a population of introduced *I. alpestris* (Morris, 2014). After recording 30% coverage of common frog spawn in early February just one tadpole was caught during surveys at the end of March when conducting a trial removal of *I. alpestris* (Morris, 2014). The palmate newt (*Lissotriton (*formerly *Triturus) helveticus*) is the only Urodele species endemic to the county of Cornwall, the area in the south west of England where the research for this thesis was carried out (ERCCIS 2018). The smooth newt (*Lissotriton (*formerly *Triturus) vulgaris*) and great crested newt (*Triturus cristatus*) are naturally absent (ERCCIS 2018). The Anuran species naturally present are the common toad (*Bufo bufo*) and common frog (*Rana temporaria*) (ERCCIS 2018). Whether the limited range of native amphibian species has a locally specific bearing on the population density of *I. alpestris* has not yet been studied. Though the absence of the much larger *T. cristatus* implies fewer predatory limitations for *I. alpestris* and a larger trophic niche for the invader (Covaciu-Marcov *et al*., 2010).

1.7 Linking science to the citizens

Anthropogenic factors, such as scientific research and trade in amphibians, are identified as a causal element in the spread of Bd (Daszak *et al*., 2003; Fisher & Garner, 2007). Ponds in Great Britain containing non-native amphibian species are significantly more likely to test positive for Bd than those with just natives present (Cunningham & Minting, 2008). When presented with these details a link between human aided dispersal of amphibians through the scientific community and pet trade and the subsequent diseases which are carried by these animals becomes clear (Keller *et al*., 2011). Whilst this is an issue human intervention can also help prevent the spread of invasive disease, the resulting impacts and subsequent effects on the

wildlife in gardens through their pond management practices (North *et al*., 2015). Knowledge of the potential risks and an increase in communication between landowners, government, breeders, scientists and other stakeholders is essential in order to control these infectious diseases and prevent further impacts (Cunningham & Minting, 2008). This thesis aims to provide an overview of the perception of both native amphibians and INNS by members of the general public and gain insight into the best approach to take in order to move research in this area forward.

Without stakeholder engagement and action invasive species control can be limited (Bremner & Park, 2007; Niemiec *et al.*, 2016). But by utilising the valuable knowledge and data which citizen scientists can provide (Adriaens, 2015; Roy *et al*., 2015) scientists can continue to advance their own research and achieve more successful and long-lasting positive results such as increased outreach and awareness opportunities (Silvertown, 2009), the ability to collect data over a broad geographical range (Zapponi *et al*., 2017) and project longevity (Riesch & Potter, 2014). Project continuity has been of concern to some working with citizen scientists (Vann-Sander *et al.,* 2016) though some related their concerns more to funding issues than to maintaining volunteer enthusiasm (Adriaens, 2015; Geoghegan *et al.,* 2016). The need for greater knowledge and understanding amongst citizen scientists has been suggested as important in citizen science projects though this must be combined with feedback to the participants and ongoing communication in order to maintain retention (Vann-Sander *at al.,* 2016). This two way exchange of knowledge is vital in order to maintain good relations between all involved parties in order for control and mitigation projects to succeed (Peel *et al.,* 2012).

Given the complexities of invasion biology, the implications of the existence of INNS in the environment (Gallardo & Aldridge, 2013) and the inclusion of anthropogenic factors, participation by citizen scientists in locally based INNS control projects must be approached carefully and with consideration (Fischer *et al*., 2014). Whether or not cooperation is essential is not in question here, the fact that landowner permission is required to carry out control of INNS necessitates some form of collaboration. What is needed is some clarity on how scientists might be able to make use of citizen science data to help inform them on the approach to take regarding INNS control (Crall *et al*., 2011). With the ever increasing use of this form of data gathering the needs of the environment, the volunteers and the scientist should be taken into account (Kobori

et al., 2016) and this thesis explores some of these points with the aim of identifying how best to utilise the valuable resource we know as citizen science.

2 Methods

2.1 Participants

Individuals were invited to take part in an online questionnaire using SurveyMonkey via social media, through contacting local wildlife and gardening groups listed online, and as a result of the survey being shared by participants who were invited to do so during the introductory paragraph of the questionnaire. The survey was available to complete during the summer of 2016 and was open to all residents in the study area aged over 18 years for ethical purposes. An ethical review was carried out and advice sought from the University of Plymouth Ethical Review Committee. Respondents ages ranged from 20-76 years (Mean = 46.04, SE = 2.37 (n = 83)). The target audience was residents of south east Cornwall, an area known to have both native and invasive amphibians, though the extent of distribution of invasive amphibians is not fully known and existing sites with INNS amphibians is not publicised. Questions were answered anonymously but with the option to provide contact details for more information on the study if the participant wished. Contact details were not associated with answers during analysis. Not all questions were applicable to all participants, so the number of responses for each question varied from 8-83 due to the specificity of the question.

A high proportion of respondents (73%) stated that they were members of one or more wildlife, conservation or gardening groups (3.12).

Information relating to how often respondents used different forms of media was not analysed in this study but again may be revisited as part of future research.

2.2 Study area

The survey area was an area of south east Cornwall where a number of ponds are known to have native palmate newts (*Lissotriton helveticus*), the only newt known to be endemic to Cornwall (ERCCIS 2018), and the invasive non-native Alpine newt (*Ichthyosaura alpestris*), identified during past research (Morris, 2014). Using areas known to have both native and invasive newts meant that participants were likely to have come into contact with a variety of amphibians both native and invasive non-native. This was felt important so as to gain insight into the opinions of residents who have first-hand experience of these animals in their ponds and gardens. As the survey was distributed by a variety of means (2.1) and was shared by local residents the responses came from a wider area than was first envisaged. The south east Cornwall

area is not specifically defined and so many respondents may live outside the area known to have INNS amphibians. Due to the need to maintain the anonymity of participants it was not appropriate to insist on the location of each to be revealed so it was not possible to include only data from participants in the area known to have INNS amphibians. Although this meant that participants may not have knowledge or contact with INNS amphibians the opportunity to extend the survey to cover a broader reach of respondents increased opportunities to engage with a wider audience and gain a broader perspective of opinions on INNS in general.

2.3 Questionnaire design

The questionnaire was divided into five sections with each relating to a different aspect of the project; Connection with nature, Public perception of INNS, Information about ponds in south east Cornwall, Amphibians living in your pond or garden and Information about you (see Appendix 1). A total of 14 questions were asked with the option made available of providing an email address for further information or to find out more about the study. Participants had the option of skipping questions which were not relevant to their situation.

Participants were first asked to complete the shortened version of the Nature Relatedness scale (NR-6) (Nisbet & Zelenski 2013). This brief method (1.4 & Fig.2.1), based on the longer 21-point scale (NR-21) (Nisbet et al. 2009), provides a measure on an individual's connection with nature and has been shown to provide valuable and insightful data which can be used as a measure of reliability when discussing attitudes towards environmental issues (Nisbet et al. 2009; Nisbet & Zelenski 2013; Zelenski & Nisbet 2014).

Connection with Nature

These questions will help us understand how connected you feel to nature.

* 1. Please indicate how much you agree/disagree with the statements below.

	Disagree strongly	Disagree a little	Neither agree or disagree	Agree a little	Agree strongly
My ideal vacation spot would be a remote, wilderness area	○	○	○	○	○
I always think about how my actions affect the environment	○	○	○	○	○
My connection to nature and the environment is a part of my spirituality	○	○	○	○	○
I take notice of wildlife wherever I am	○	○	○	○	○
My relationship to nature is an important part of who I am	○	○	○	○	○
I feel very connected to all living things and the earth	○	○	○	○	○

Figure 2.1. Section 1 of questionnaire; Connection with nature (taken from SurveyMonkey questionnaire).

This scale was chosen due to it being already proven to provide measurable and accurate data (Nisbet & Zelenski 2013; Nisbet et al. 2009). The NR-6 results in this survey were compared to those of other studies in order to assess the degree of connectivity to nature of participants and therefore the level of environmental concern of people in the survey area (1.4). This vital knowledge must be gained when dealing with the public on an emotive issue such as control of vertebrate invasive non-native species in order to gain access to sites and to encourage cooperation of landowners.

Respondents were asked to rate each question using a five point Likert scale. Each answer was allocated a score (Table 2.1). The NR-6 score for individuals was calculated using the mean of the total for all items.

Table 2.1. Scores given to each answer on question 1 Connection with nature.

Item	Disagree strongly	Disagree a little	Neither agree or disagree	Agree a little	Agree strongly
Score	1	2	3	4	5

The next section asked three questions and employed two styles of questioning to collect the respondent's perception of INNS (Fig 2.2).

Question two asked for opinions on the damage caused by INNS and gave a choice between four possible answers which gave respondents the option to provide negative, positive and neutral opinions.

Question three employed a Likert scale to evaluate responses on questions regarding respondents' perceptions on native species and INNS in order to assess likely reactions to possible management and control of INNS. From this a scale similar to the NR-6 scale (Nisbet & Zelenski 2013) was devised in order to calculate an overall INNS Perception Score for each respondent.

Question four asked for a value to be attributed to the cost of INNS in Great Britain.

Public Perception of Invasive Non-Native Species

This section will help us to understand how you feel about invasive non-native species

* 2. Invasive non-native species are introduced by man to areas outside their natural range. Such species then spread causing: -

- ◯ no impacts to the environment, the economy, our health and the way we live
- ◯ beneficial impacts to the environment, the economy, our health and the way we live
- ◯ harmful impacts to the environment, the economy, our health and the way we live
- ◯ I don't know

* 3. Please indicate how much you agree/disagree with the statements below

	Disagree strongly	Disagree a little	I don't know	Agree a little	Agree strongly
Native amphibians are an important part of pond ecosystems	◯	◯	◯	◯	◯
Invasive non-native species can be a threat to native flora and fauna	◯	◯	◯	◯	◯
Invasive non-native amphibians can spread disease to native amphibians	◯	◯	◯	◯	◯
Management of invasive non-native species is important to protect our environment	◯	◯	◯	◯	◯
Invasive non-native plants should be controlled	◯	◯	◯	◯	◯
Invasive non-native animals should be controlled	◯	◯	◯	◯	◯

* 4. The total annual cost of invasive non-native species to the British economy is estimated at: -

- ◯ £0
- ◯ £1.7K
- ◯ £1.7 Billion

Figure 2.2. Section 2 of questionnaire; Public Perception of Invasive Species

Section four asked about ponds in the survey area (Fig 2.3). If respondents answered "Yes" to question five they were asked to continue on to questions six, seven and eight. If the answer to question five was "No" they were asked to continue to the next section as the remaining questions in this section did not apply. These questions aimed to gain an insight into the existing management of ponds in the survey are with

the view to aiding future control of INNS and establish potential pathways of introduction.

Information about ponds in South East Cornwall

We would like to understand more about the ponds in the South East Cornwall area. By answering these questions you will help us build a good picture of this type of habitat.

* 5. Do you have a pond in your garden?

- ◯ Yes (Please continue to question 6)
- ◯ No (Please click NEXT at the bottom of this page and you will be directed to the next relevant part of this survey)

6. How would you describe your pond? Managed indicates regular maintenance such as cleaning and using filters. Unmanaged indicates no maintenance or very occasional such as yearly clearance of leaves.

- ◯ Managed fish pond
- ◯ Unmanaged fish pond
- ◯ Managed wildlife pond
- ◯ Unmanaged wildlife pond

7. Please indicate the way you are most likely to get aquatic plants for your pond or have done in the past.

- ◯ Garden centre
- ◯ Online
- ◯ Friends or neighbours
- ◯ I have not planted aquatic plants in my pond

Information about ponds in South East Cornwall cont.

8. If you have never planted aquatic plants in your pond please indicate how you think plants have arrived.

- ◯ Planted by previous owner
- ◯ Natural colonisation
- ◯ There are no plants in my pond
- ◯ I don't know

Figure 2.3. Section 3 of questionnaire; Information about ponds in south east Cornwall

The next section required respondents to answer questions on the amphibians in their pond or garden and was open to all regardless of whether they had a pond or not (Fig

2.4). Question nine required respondents to say whether or not they had seen five named amphibian species in their pond or garden. They were provided with photographic images of each species and also a link to the Amphibian and Reptile Conservation Trust (ARC Trust) amphibian guide (see Appendix 2), an illustrated descriptive guide, to help. They were also asked to rate the confidence they had in their own identification skills and a five point scale was used to assess this.

Question 10 asked whether using the ARC Trust ID guide had helped them with identification or if they hadn't used the guide at all. Question 11 gave the opportunity for respondents to provide location details of their pond and was optional.

Amphibians living in your pond or garden

Please help us to identify the amphibians which you have in your pond or garden. The link below will help you with identification if you are not sure. The scale will help us get a clearer idea of how confident you are in your identification. Remember all information will be very helpful to us.

http://www.arc-trust.org/amphibians.html This link will open in a new window. Just click to download the amphibian identification guide.

9. Please indicate which of the following amphibians you see in your pond or in your garden(Images courtesy of http://www.froglife.org/)

	Have you seen this amphibian in your pond?	How confident are you that you are able to identify this amphibian correctly?
Common frog		
Common toad		
Palmate newt		
Smooth newt		
Alpine newt		

Other (please specify species and how confident you are that you can identify it correctly as with your previous answers)

10. Did using the identification guide (on the link to the ARC Trust website) give you more confidence identifying which amphibians you have in your pond or garden?

- Yes
- No
- I didn't use the identification guide

11. In order to get a good idea of the amphibian population it would help us to know where your pond or garden is. If you are happy to provide this information please use the following link to get the grid reference of your pond or garden. http://gridreferencefinder.com/

Please remember that your details will not be shared with any third parties without your permission and you are not obliged to provide this information but by doing so it will help us with our conservation work.

Figure 2.4. Section 4 of questionnaire; Amphibians living in your pond of garden.

This final section gave the respondent opportunity to provide information about themselves (Appendix 1). Whilst these details provided information about the demographic of the participants surveyed this was not included in analysis for this project but may be used for future work.

3 Results were analysed using the statistical package AQB (Asking Questions in Biology) (Barnard *et al.*, 2017).Results

3.1 Perception of INNS impacts

Of all respondents (n=74), most (89%) chose the generally accepted definition (harmful impacts to the environment, the economy, our health and the way we live) of invasive non-native species from 4 alternatives (Fig 3.1), significantly different from a random choice (χ^2 = 163.51, d.f. = 3, p < 0.00005), showing that most respondents were informed on this topic.

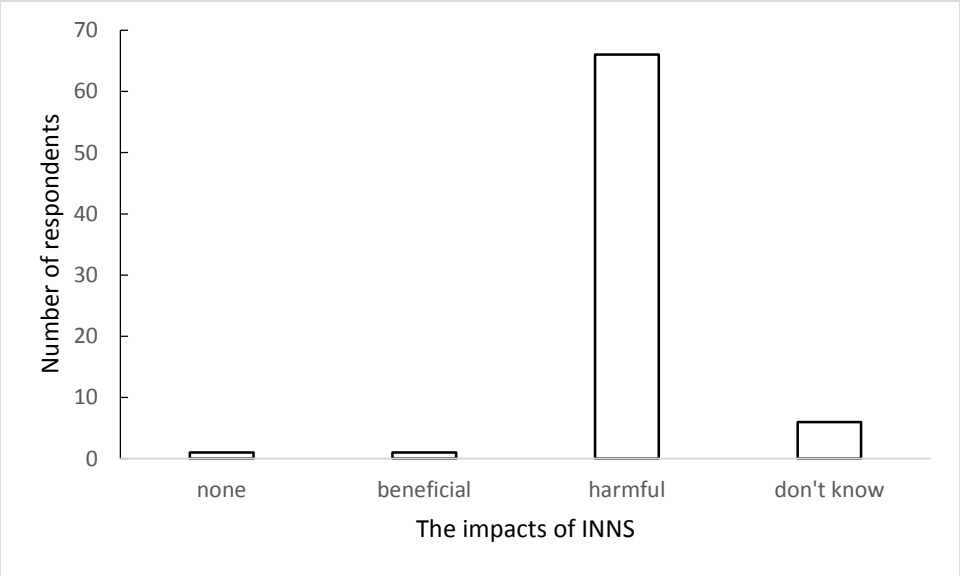


Figure 3.1 Number of respondents choosing from 4 options of INNS definitions. Responses to Question 2 (Fig 2.2).

3.2 INNS perception scores

All respondents (n=73) scored between 3.5 and 5 on the INNS Perception Scale (Fig 3.2) with 72.6% of respondents scoring 5.

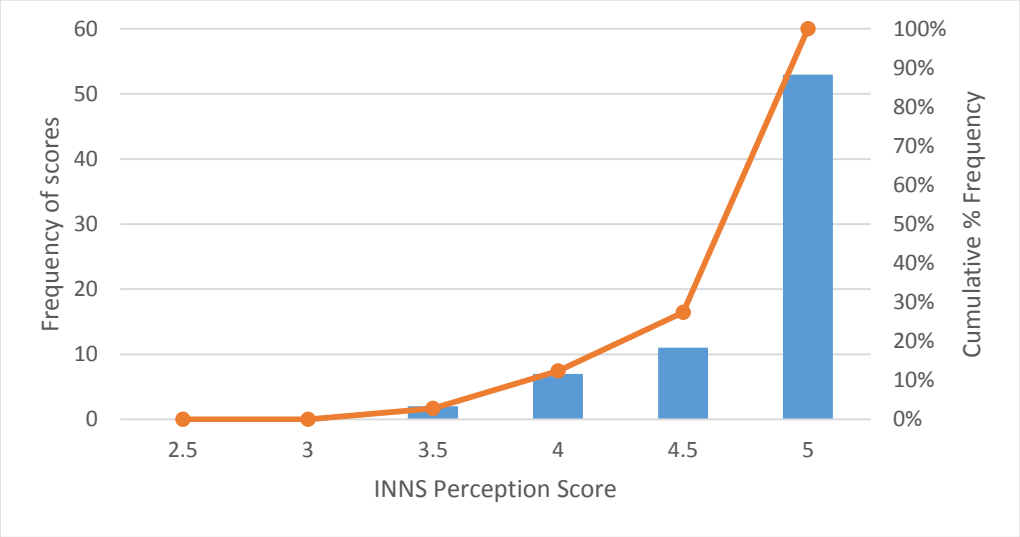


Figure 3.2 Frequency distribution of respondents' INNS Perception scores (bars, frequency; line, cumulative frequency). Response to Question 3 (Fig 2.2).

3.3 NR-6 scores

All respondents (n=73) scored between 2.33 and 5 on the NR-6 scale (Fig 3.3) with over 45% scoring 5.

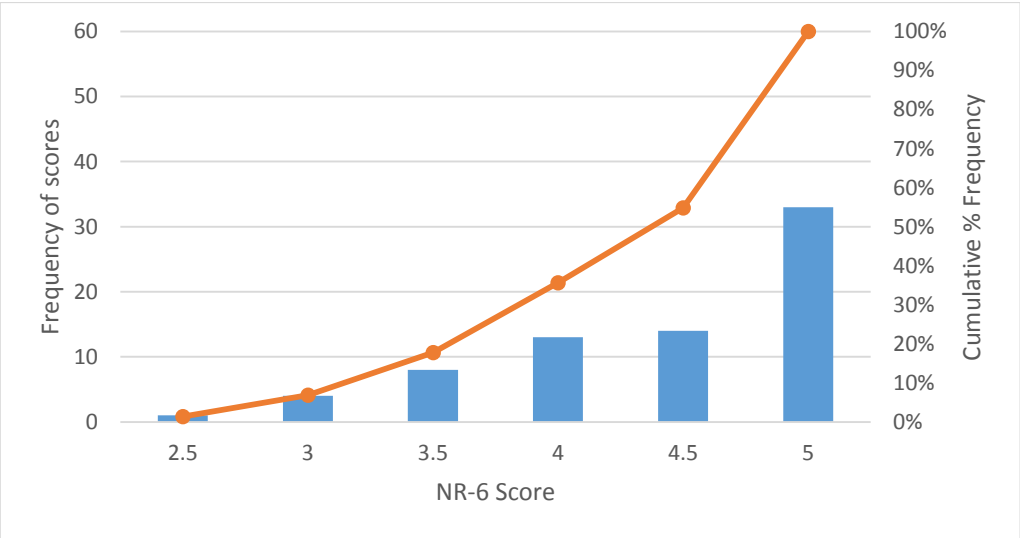


Figure 3.3 Frequency distribution of respondents' NR-6 scores (bars, frequency; line, cumulative frequency). Responses to Question 1 (Fig 2.2).

3.4 Comparison of NR-6 and INNS perception scores

There is no significant correlation between NR-6 and INNS perception scores (Fig 3.4; $r_s = 0.17$, df = 71, $p = 0.155$) and there is a significant difference between the frequency

distributions (Fig. 3.2, Fig. 3.3) of these two scores (Kolmogorov-Smirnov D = 0.28, $p < 0.01$). These results suggest that the scores are measuring different aspects of perception.

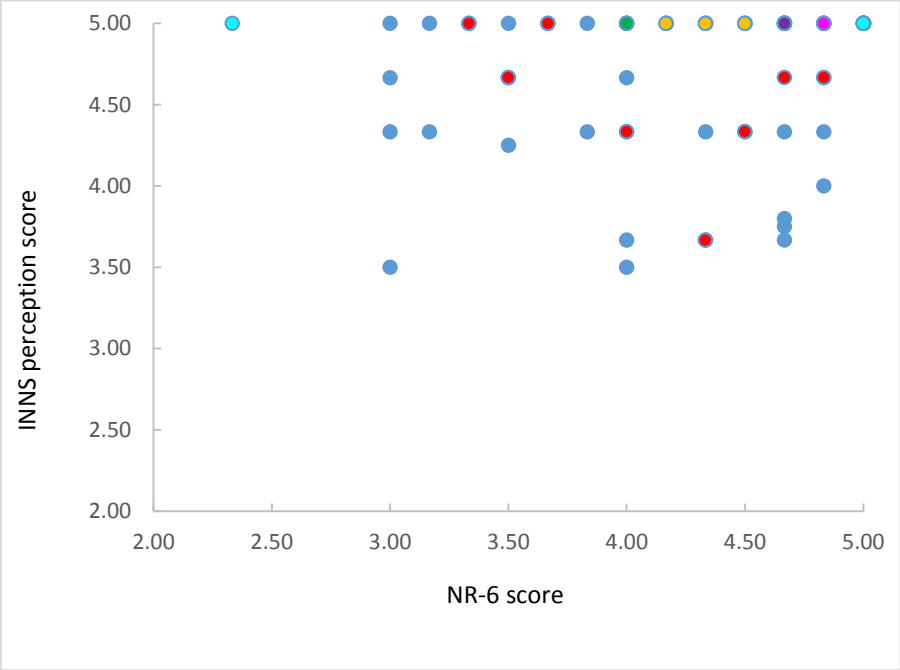


Figure 3.4 Relationship between NR-6 scores and INNS perception scores of respondents. Some dots represent multiple data points (blue, 1 data point; red, 2; yellow, 3; green, 4; pink, 5; purple, 7; light blue, 12).

3.5 Management of INNS

All respondents (n = 74) thought that management of INNS was important to protect our environment. There was no significant difference in NR-6 scores between those strongly agreeing with INNS management and those agreeing a little (U = 299.5, p = 0.1438) (Fig 3.5).

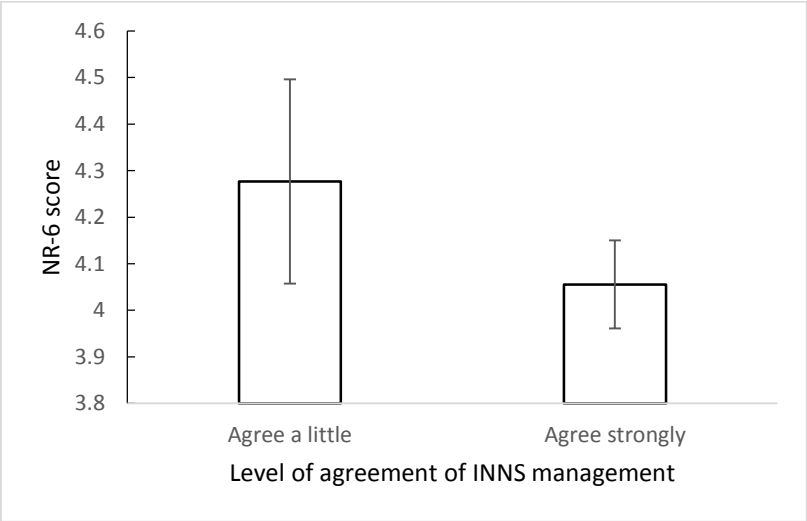


Figure 3.5 Mean (± se) NR-6 scores for respondents who agreed a little (n = 12) or agreed strongly (n = 62) that INNS management was important. Responses to Question 3 (Fig 2.2).

Almost all respondents (n = 74) agreed that INN plants should be controlled. One said they didn't know. There was no significant difference in NR-6 scores between those strongly agreeing with INN plant control and those agreeing a little. (U = 356.5, *p* = 0.3145) (Fig 3.6).

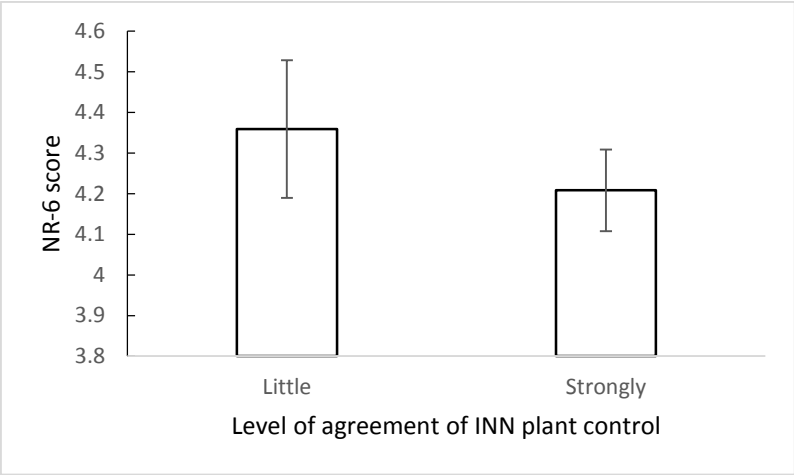


Figure 3.6 Mean (± se) NR-6 scores for respondents who agreed a little (n = 13) or agreed strongly (n = 60) that INN plants should be controlled. Responses to Question 3 (Fig 2.2).

Almost all respondents (n = 74) agreed that INN animals should be controlled. One said they disagreed a little and four didn't know. There was no significant difference in NR-6 scores between those strongly agreeing with INN animal control and those agreeing a little (U = 446.5, *p* = 0.2825) (Fig 3.7).

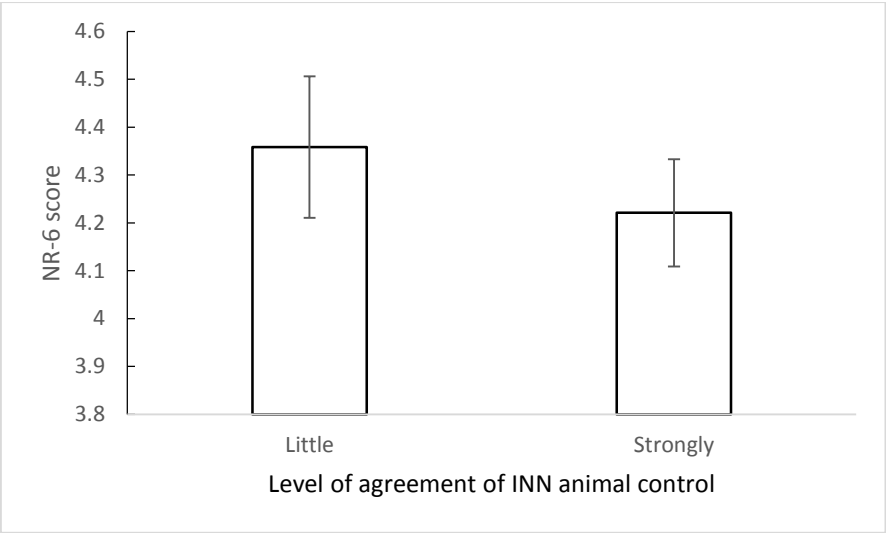


Figure 3.7 Mean (± se) NR-6 scores for respondents who agreed a little (n = 20) or agreed strongly (n = 49) that INN animals should be controlled. Responses to Question 3 (Fig 2.2).

3.6 Knowledge of INNS annual cost

Of all respondents (n=74), most (73%) chose the correct (£1.7 billion) estimated annual cost of INNS (Fig 3.8), significantly different from a random choice ($\chi^2 = 58.89$, d.f. = 2, $p < 0.00005$), showing that most respondents were informed on this topic.

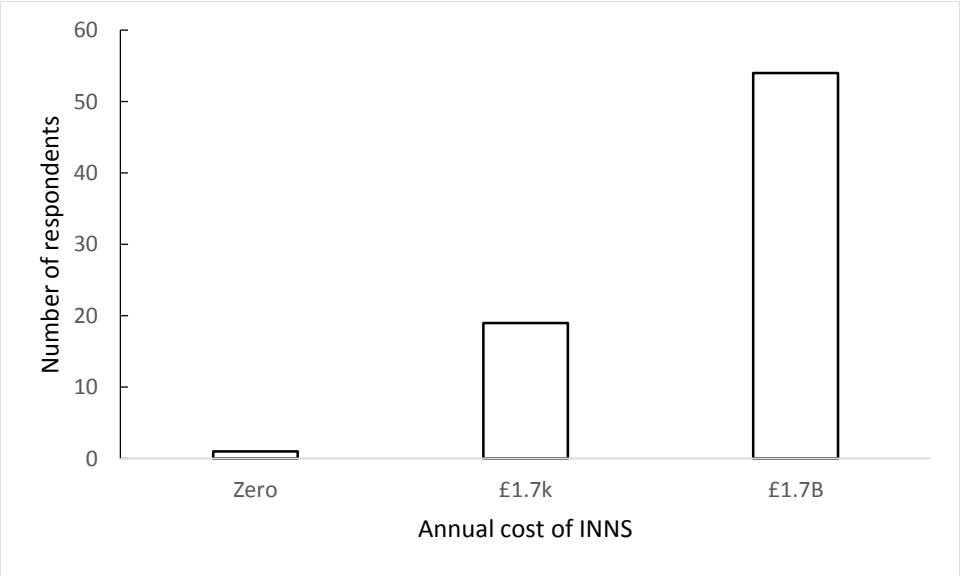


Figure 3.8 Number of respondents choosing from 3 estimates of annual cost of INNS. Responses to Question 4 (Fig 2.2).

3.7 Pond ownership

About half (54%) of respondents (n = 74) had a pond in their garden.

3.8 Pond management

The type of pond and its management regime differed significantly across respondents with ponds (χ^2 = 19.59, d.f. = 3, p < 0.0002) (n=41); most (83%) had wildlife rather than fish ponds and of those 59% were unmanaged (Fig 3.9).

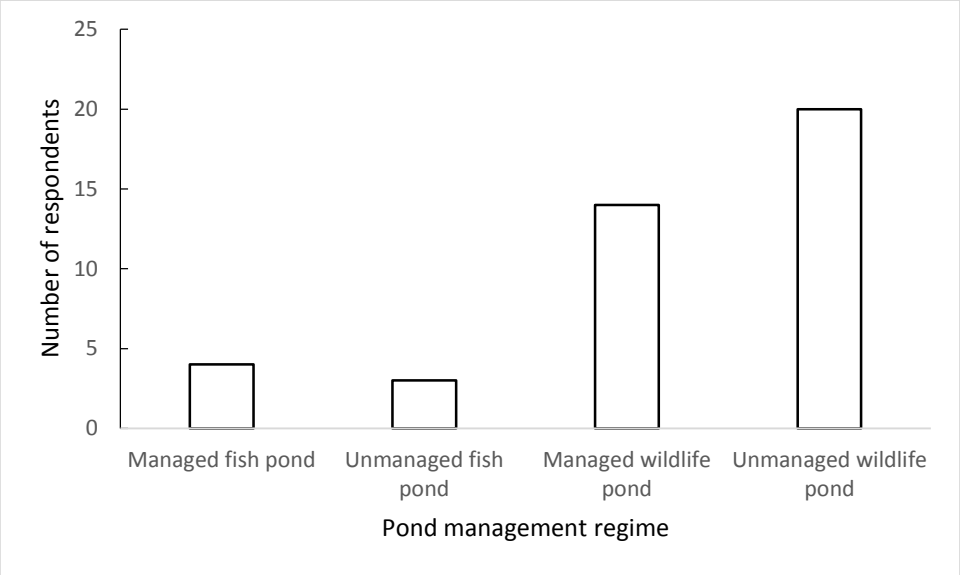


Figure 3.9 Number of respondents reporting use of 4 different pond management regimes. Responses to Question 6 (Fig 2.3).

3.9 Pond plant acquisition

The route through which aquatic plants were acquired differed significantly across respondents (χ^2 = 11.52, d.f. = 3, p < 0.0092) (n=42); almost half (45%) bought plants from garden centres and just over a quarter acquired them from friends (Fig 3.10).

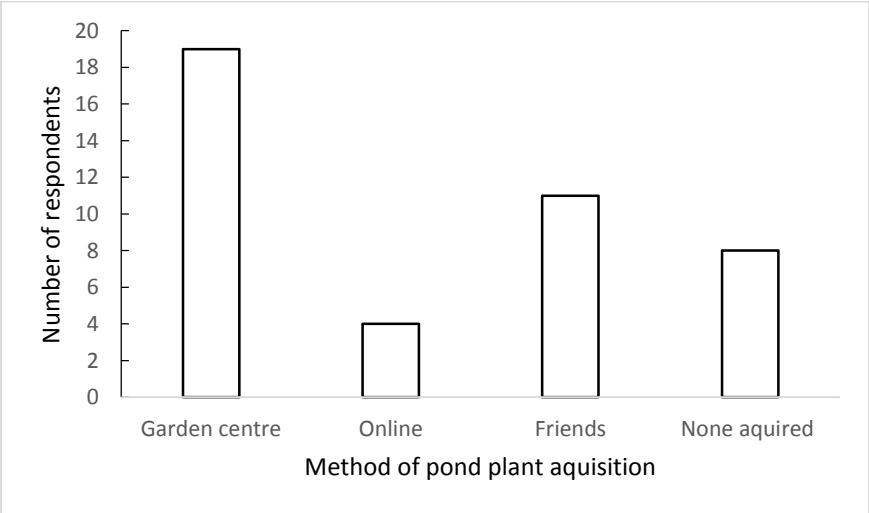


Figure 3.10 Number of respondents reporting use of 4 methods of pond plant acquisition. Responses to Question 7 (Fig 2.3).

Of those who had not acquired aquatic plants 57% of respondents (n=8) said that pond plants had colonised naturally with 43% stating that they had been planted by the previous owner.

3.10 Amphibian presence, identification and confidence in identification

There was no significant difference in the level of confidence respondents had in their amphibian identification skills whether they had them present in or absent from their garden or pond (note that χ^2 was calculated after categories with no respondents in present and absent were excluded (see Appendix 3 for data)).

Table 3.1 Level of confidence in amphibian identification by respondents who reported this species as either present or absent from their pond or garden.

Species	χ^2	d.f.	*P*
Common frog	1.91	2	< 0.3852
Common toad	0.24	1	< 0.624
Palmate newt	2.49	4	< 0.646
Alpine newt	1.84	3	< 0.606
Smooth newt	1.2	4	< 0.8788

3.11 Use of ARC amphibian identification guide

The majority (78.9%) of respondents (n=38) did not use the ARC amphibian identification guide (see Appendix 2) on the link but solely used the images provided on the questionnaire to aid them in identifying amphibians in their pond or garden. Of those who did use the guide (21%) half of them said using the guide gave them no more confidence in their identification of amphibians (Fig 2.4).

3.12 Membership of wildlife, conservation or gardening groups

Almost three quarters (73%) of respondents (n=55) were members of at least one wildlife, conservation or gardening group. Of those who did belong to a group there were approximately equal numbers belonging to one, two or three or more groups (χ^2 = 3.05, d.f. = 2, p = 0.2716) (Fig 3.11).

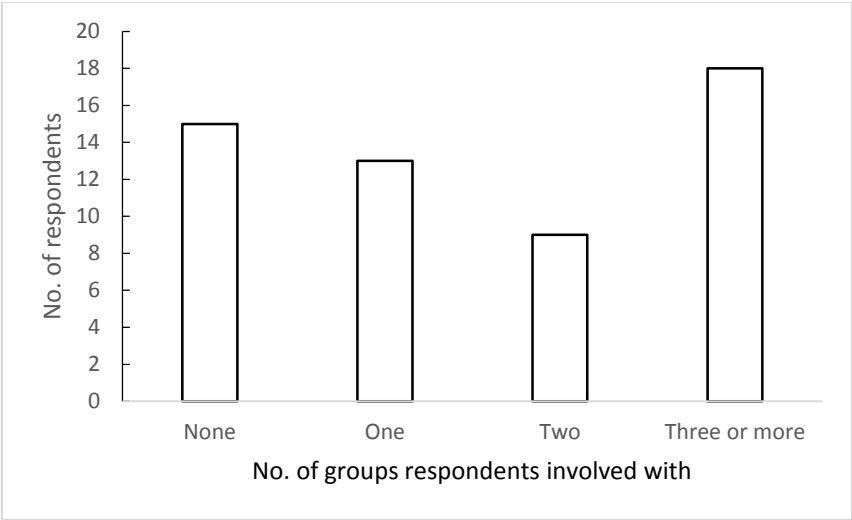


Figure 3.11 Number of respondents involved with wildlife, gardening or conservation groups. Response to Question 13 (Appendix 1).

4 Discussion

The aim of this thesis is to gain insight into the public's perception of INNS and their opinions on the practical management of such species. It also aims to identify the factors which might influence their opinions on both points with the view to informing future control work. The case for public involvement in the management of INNS will be discussed with the key findings examined in detail in each section of this discussion.

4.1 Public perception of INNS

The high number of respondents to the questionnaire in this thesis who described INNS as having harmful impacts to the environment, the economy, our health and the way we live (3.1) supports the generally accepted view (Roy *et al*., 2012b). There are some members of society who have an opposing opinion of INNS and argue that the harm which they cause is far less than reported in scientific literature (Pearce, 2015; Thomas & Palmer, 2015). However, a number of invasion biologists and other scientists have provided evidence to support the view that INNS are harmful and have shown that the aforementioned authors have ignored research which disagrees with their own point of view rather than attempting to back up their opinions with evidence (Hulme *et al*., 2015). Respondents to this thesis questionnaire significantly chose the accepted view (that INNS have demonstrated adverse impacts – 3.1) and therefore could be considered to be citizens operating with the same perception as mainstream scientists. This result supports the notion that, providing proper checks of validity are in place (Joyce, *et al.,* 2013), citizen science data could be of a suitable quality to inform INNS management.

A high volume of data can be generated by involving members of the public in research (Lintott *et al*., 2011) and the breadth of knowledge which can be captured enables projects such as the GB NNSIP (Great Britain Non-Native Species Information Portal) (Roy *et al*., 2015) to succeed. This online information, recording and alert system provides information on INNS and encourages people to send in records of species which are of concern to the GB environment. It has proven to be an invaluable source of information much of which was generated by citizen scientists many of whom are considered experts (Roy *et al*., 2015). In contrast, a study involving Portuguese students aged 13-15 years showed a lack of knowledge of some of the most basic concepts of INNS which was addressed after having taken part in workshop activities

(Schreck Reis *et al.*, 2013). This thesis did not ask for participants to have any previous knowledge on INNS though they displayed good knowledge nonetheless. This result could be explained by the age demographic of the group, the participants were all over 18 years old and those in the Portuguese study were children (Schreck Reis *et al*., 2013). As people get older they may be exposed to an increasing number of outdoor experiences which may also increase their knowledge on environmental issues (Lindemann-Matthies, 2016). This may explain the greater knowledge demonstrated by participants in this study (3.1).

An important consideration for public engagement which should be highlighted is the emphasis which the media puts on certain INNS. Species featured in the media tend to be those which the public then become aware of, though these species are not necessarily those which have the highest ecological impact (Gozlan *et al.*, 2013). The killer shrimp (*Dikerogammarus villosus*) is a case in point. This species has had a large amount of media attention both before its initial invasion and since it first being recorded in GB (Gozlan *et al*., 2013). However, the media attention has been sensationalist, perhaps due in part to the common name of this species (Gozlan *et al*., 2013). Whilst the threats this species pose are significant and include both ecological and economic issues (Gallardo & Aldridge, 2013) it has only been recorded in three locations in Great Britain (Aldridge, 2015). Media exposure has possibly meant that the public and stakeholders have helped to limit the spread of this freshwater invader; these points have been acknowledged by the GB Non-Native Species Secretariat (Roy *et al.,* 2012a). However, the extent of this effect is not known and this point is worthy of further examination and could assist with management of problem species.

The species which are the focus of scientific research are not necessarily those which are perceived as high priority by the public in terms of the threats posed or profile (Gozlan *et al*., 2013). For example, the signal crayfish (*Pacifasticus leniusculus*) and harlequin ladybird (*Harmonia axyridis*) have been the subject of large amounts of scientific research but have not received a proportionate amount of public attention (Gozlan *et al*., 2013). The more interest the public take in a species the more media attention is given to that species which encourages a cycle of reporting and subsequent knowledge on familiar topics (Gozlan *et al*., 2013). This point is one which ought to be considered in more depth regarding the detail of this thesis as whilst respondents had a high level of knowledge on INNS in general the specifics of their

knowledge was not examined and might prove to be crucial when dealing with a control programme for a specific INNS. It has been difficult to achieve a high level of interest amongst the public on specific issues regarding INNS (Roy *et al.,* 2012a*)*. However, if the subject is a species which has public appeal such as those with names that attract interest, like the killer shrimp, interest is higher (Gozlan *et al*., 2013).

4.2 INNS perception scores

INNS perception scores, in which the higher the score the more the individual considered control of INNS to be important, were all between 3.5 and 5 indicating that participants considered management of INNS and protection of our native species important. This is contrary to a study carried out with visitors to a national park in the U.S. (Sharp *et al.,* 2011). Visitors voluntarily visited the area, so it could be assumed that they had an existing interest in the environment (Sharp *et al.,* 2011). It could be considered likely that this group might also display a high familiarity of INNS and their impacts when in fact they showed a limited knowledge of such factors (Sharp *et al*., 2011). Education has been shown to be an important factor when dealing with INNS control (Caffrey *et al.,* 2015; Gozlan *et al*., 2013; Niemiec *et al*., 2016) as increased knowledge has been shown to generate greater support for INNS control and eradication (Bremner & Park, 2007; Verbrugge *et al.,* 2013). If we are to assume that nature relatedness follows with an interest in the environment then the thesis respondents and the national park visitors would have similar levels of familiarity of INNS. The results of this thesis suggest that further research could be carried out to investigate the background of participating groups in order to ascertain what influences peoples knowledge and subsequent acknowledgement of the issues posed by INNS.

4.3 NR-6 scores

The respondents in this survey demonstrated a higher NR-6 score (3.3, Fig 3.3) than those in previous studies (Nisbet & Zelenski, 2013). Respondents being based in a predominantly rural area may have influenced the results as people who have access to natural environments have been shown to display higher levels of biophilia, or an innate need to seek out and connect with wildlife, than those who live in urban environments (Zhang *et al.,* 2014). However, a study focusing on rural and urban residents found that there was no significant difference between those groups when posed similar questions (Bremner & Park, 2007). Another study found that people were not influenced by the amount of natural environment available to them rather it

was the frequency with which they were exposed to nature which proved the biggest influence (Soga *et al.,* 2016). Daily contact with nature was found to be important in shaping positive environmental opinions (Soga *et al*., 2016). The high NR-6 scores amongst the participants of the research for this thesis may be explained by the close proximity to wildlife which residents in the area experience though as this conflicts with the study in Scotland (Bremner & Park, 2007) other factors may have influenced overall results such as sample size. The study in Scotland had a higher sample size (n=248) compared to the number of participants in this study in Cornwall (n=73).

4.4 Comparison of NR-6 and INNS perception scores

The NR-6 and INNS perception scores show different distributions of responses (compare Fig 3.2; Fig 3.3); most respondents (72.6%) had a score of over 4.5 for INNS perception whilst only 45.2% scored over 4.5 on the NR-6 scale (Fig 3.2; Fig 3.3). The NR scale was developed to evaluate an individual's relationship with the environment, in particular their own connectivity (Nisbet *et al.,* 2009). The NR-6 scale (Nisbet & Zelenski, 2013) took questions from two dimensions of the original NR scale, those being "self" and "experience". These six questions relate very much to a person's feelings and emotions regarding the environment and how important nature is in their life. Given that the INNS perception questions deal with opinions on species which most respondents had thought to be problematic (4.2; 4.3) there may have been other factors which they considered during their answers such as financial or health impacts. These factors do not necessarily relate directly to how emotional or connected an individual might feel to the environment but may be equally as important to them or more so if they feel the impacts are great. That said the NR-6 scale is still a reliable and proven scale (Nisbet & Zelenski, 2013) which can be used in order to gain an insight into the expected environmental behaviour of an individual. Whilst a longer questionnaire such as the NR Scale (Nisbet *et al*., 2009) might provide more comprehensive results the inclusion of a shortened version was considered a more appropriate action so as to keep the time taken to complete the questionnaire to a minimum. The high NR-6 scores of the participants in this study suggest that any management plans of INNS which might be developed could be well received.

4.5 Management of INNS

If members of the public are aware of the issues posed by INNS they may be more likely to support control of them (Gozlan *et al*., 2013). This was the case in a study in

the U.S. which examined factors which influence INNS management preferences of visitors to a national park (Sharp *et al.,* 2011). However, whilst knowledge of INNS was important to these visitors it was environmental attitudes which most strongly influenced their decisions to support control of INNS or not (Sharp *et al*., 2011). The question on management or control of INNS in this thesis provided surprising results in that all respondents either agreed a little or strongly that such measures were important in order to help protect our environment (Fig 3.5). With no significant difference in NR-6 scores between those who agreed strongly or a little (3.5) it would suggest that the respondents overall high NR-6 scores could be indicative of an agreement to control INNS. One explanation is that whilst people may have a strong connection with nature they see INNS as an unnatural element of the landscape and as such should be controlled in order to protect the environment (Verbrugge *et al*., 2013).

Interestingly a U.S. study (Sharp *et al*., 2011) found that whilst all visitors to the park felt that nature should be protected it was a particular group of visitors, those classified as “adaptive ecocentric”, typically older more educated individuals with experience of wildlife, who agreed most strongly to control of INNS. The younger less educated group with limited experience of wildlife, the “absolute ecocentric” visitors, were less likely to support control and eradication and felt that all living things deserved to live (Sharp *et al*., 2011). This supports the findings of this thesis in that almost three quarters of respondents were members of a wildlife or gardening group (3.12) indicating an interest in the outdoors. Whilst the age range was 20-76 years the mean was 46. The U.S study found that the adaptive ecocentric group were older than the adaptive ecocentric group with 62.06% over the age of 40 (Sharp *et al*., 2011). Whilst this could be investigated further it suggests that an older demographic might be more willing to support control of INNS.

All respondents agreed that management of INNS was important to protect the environment (3.5). Almost all respondents agreed either a little or strongly that INN plant species should be controlled with just one responder saying they didn’t know (3.5; Fig 3.6). Similar results were gained from the question regarding the control of animal INNS (3.5; Fig 3.7). There was no significant difference between the NR-6 scores and any of these results suggesting that the high NR-6 score might be indicative of a tendency towards agreement of INNS control. The thesis questionnaire

did not identify specific INNS for potential control. If respondents had a connection with plant INNS used as examples for control they may have answered differently. A study in Scotland revealed that respondents favoured control of rhododendron (*Rhododendron ponticum*) less than Japanese knotweed (*Fallopia japonica*) and giant hogweed (*Heracleum mantegazzianum*) (Bremner & Park, 2007). Another study showed similar results with a reluctance expressed towards control of Buddleia (*Buddleja davidii*) (Lindemann-Matthies, 2016). In both cases the suggestion has been made that a connection exists between plants which people are familiar with as ornamental and aesthetically pleasing garden plants and a possible disconnect with those plants which are more widely known to be either harmful to the economy or human health (Bremner & Park, 2007; Lindemann-Matthies, 2016). This could be an important consideration when forming a management plan as if the stakeholder considers the species has some value or is thought to play a positive rather than a negative role then cooperation may be less likely.

The results of a study by Bremner & Park (2007) found that 25% of respondents disagreed most with using herbicides for plant control; the two alternative control methods for plants were digging up and cutting down. It was stated that people disagreed with using both poison and herbicides for animal and plant control as they disliked the idea of killing anything (Bremner & Park, 2007). Whilst the other two controls for plants might also involve the death of the treated plant it might be that people perceive these controls as less damaging though this was not discussed. These points suggest that it might be necessary to employ non-chemical control methods of INNS where possible.

The majority of respondents in this study supported the idea of controlling animal INNS (3.5; Fig 3.7), which is contrary to other studies which found that control of species considered endearing, such as mammals and birds, was opposed or less well supported than other taxa (Verbrugge *et al*., 2013; Bremner & Park, 2007). The fact that many participants in the research for this thesis were those living in areas with the invasive alpine newt may have influenced their answers. Previous research in the study area (Morris, 2014) has shown that householders are aware of the environmental impacts caused by this amphibian and are keen to cooperate in removal projects to help protect the native amphibian populations. This supports the points

made in 4.3 regarding education and awareness and their role in active participation in INNS control (Caffrey *et al.,* 2015; Gozlan *et al*., 2013; Niemiec *et al*., 2016).

Disregarding the specificity of the control methods, participants in this study were in favour of unspecified control methods, though opinions may have differed if control methods had been specified. However, the eradication of vertebrate species is a necessity in order to protect native species and habitats (Keitt *et al.,* 2011) and in some instances help to prevent extinctions which have been predicted if control measures are not implemented (Nogales *et al*., 2013). This strengthens the argument for increasing awareness of the issues of INNS amongst the public in order to increase action.

4.6 Knowledge of INNS annual cost

The high number of people choosing the accepted figure of £1.7 billion as the cost for annual control of INNS in the UK (Williams *et al*., 2010) shows that respondents are well informed on the subject or at least have knowledge enough to know that INNS have a significant financial impact. Although the general public generally engage well with awareness projects and often choose to participate in control programmes (Caffrey *et al*., 2015) in some instances their knowledge on INNS has been reported as being rather limited (McGregor *et al.,* 2013). A study undertaken in a different location in Cornwall found that visitors to a recreational trail had little knowledge of INNS and their impacts though their perception changed once they had been given information on the species featured in the study (McGregor *et al*., 2013). Further increasing the need for education on this topic leading to increased engagement in control of INNS. In this thesis, knowledge of INNS was found to be good (3.1; Fig 3.1), this could be explained by the fact that the group taking part were residents rather than visitors so may have a better knowledge of the wildlife in the area. Also, people have a higher awareness of INNS impacts in areas where INNS control projects have been carried out than areas where they have not (Bremner & Park, 2007). Some residents in the study area are aware of the impacts of INNS as practical removal work has been carried out in some parts of the study area previously (Morris, 2014). It is acknowledged that if the study were to be replicated elsewhere then the results may have been different and there would be merit in expansion of the study area for this reason.

Given that people generally support eradication of those INNS which are known to cause severe financial and other impacts (Lindemann-Matthies, 2016; Bremner & Park, 2007) it isn't surprising that participants supported control. However, in instances where people may not necessarily support projects the high financial costs identified could be used to help persuade residents in control areas rather than relying purely on ecological impacts.

4.7 Information about ponds in south east Cornwall

Just over half (54%) of respondents had a pond in their garden (3.6), 3-5 times higher than the national average of 10-16% (Thompson & Head, n.d.; Pond Conservation, 2011). The rural setting of this study could explain some of this difference but one factor which must not be overlooked is the fact that the population in Cornwall continues to be dominated by a predominantly ageing demographic (Cornwall Council, 2012). With this knowledge and the fact that 70% of people aged 65-74 years reporting gardening as an activity regularly carried out in their spare time (Buck, 2016) the high numbers of ponds isn't as surprising as the data first suggests. This information implies that any future research on aquatic invasives could be carried out in this area given the large number of potential research candidates and sites. Gardeners who have a pond in their garden see more wildlife generally in their gardens (Thompson & Head, n.d.). This fact suggests that either the pond attracts an increased abundance of species or that the owners spend more time in their gardens. Either way, these residents would be good candidates to engage in further research. However, despite the fact that the mean age of respondents in this study was 46 (± 2.37 (se), n = 83), the ageing population may be more inclined to engage with citizen science research in other ways such as face-to-face or via post.

Wildlife ponds made up the significant proportion of ponds in the study area (3.8; Fig 3.9). This is not just a positive sign for wildlife locally but, with 86% of the UK's ponds being garden ponds (Thompson & Head, n.d.), it is vital that these ponds be retained and used to encourage native wildlife to flourish. One individual's value of wildlife may differ from another's (Teel & Manfredo, 2010) and with opinions which may be contrasting it is difficult to ascertain what the motivations behind owning a pond might be. On the matter of the management employed by residents in their wildlife ponds, first impressions might imply that regardless of the techniques used a wildlife pond is a valuable resource regardless of any management or not. A mutualistic attitude

towards wildlife may encourage a more hands off approach to pond management in an attempt to encourage diversity but those with a more dominant approach are seen to favour more intensive management in order that the wildlife suits their own needs better (Teel & Manfredo, 2010; Verbrugge *et al*., 2013). The former approach might appear to be more suited to professional conservation motivations and actions though when dealing with INNS it is sometimes necessary to take a more drastic approach involving control and eradication. Without management INNS displace native species and can lead to a mono-culture (Scalera *et al.,* 2012), the opposite of what the mutualistic gardener hopes to achieve. The discussion surrounding rewilding has caused further confusion due to the misinterpretation of the concept of rewilding. Often the term is thought to relate to non-management of an environment rather than "the reorganisation of biota and ecosystem processes to set an identified social–ecological system on a preferred trajectory, leading to the self- sustaining provision of ecosystem services with minimal ongoing management" (Pettorelli *et al*., 2018). The misinterpretation goes further than suggesting non-management and some have even implied that rewilding means introducing novel species to manage the landscape (Bowman, 2012). The latest initiatives using rewilding as a method of land management involve the restoration of habitats and promotion of native species employing sustainable techniques (Pettorelli et al. 2018). Considering these targets it is essential that INNS would need to be removed as a part of any rewilding project (Pettorelli et al. 2018). The mismatch between concepts, approach and objective may be overcome with education though the style of knowledge exchange should be carefully considered due to the widely different motivations individuals have for taking part in INNS control programmes (Niemiec *et al.,* 2016).

Perhaps a realistic approach to encouraging residents to manage their ponds more sympathetically towards wildlife yet remaining mindful to the potential need to control some species would be to encourage greater knowledge of INNS through improved media reporting (Gozlan *et al*., 2013), in this case with particular attention to aquatic INNS, and improvements in public awareness and education campaigns (Reis *et al.,* 2013; Roy *et al*., 2015). Whilst the respondents here appear to be well educated on the subject this can't be assumed for all groups (Verbrugge *et al*., 2013) so going back to basic principles and guidelines may benefit both wildlife and gardeners who don't want to find themselves battling to combat introduced INNS. It appears that

consumers can't rely solely on the reliability of traders to inform them on the subject as often they are unaware themselves of the issues posed by INNS (Humair *et al*., 2014) and in some cases actively flaunt legislation (García-Díaz *et al.,* 2016). As trade is known to be one of the main routes of dispersal for INNS (Chapman *et al.,* 2017; Hulme *et al*., 2017) it seems sensible to educate the consumer so they are armed with the necessary knowledge to avoid unwise and ill-informed purchases.

Gaining knowledge of the way in which people acquire pond plants could be helpful in order to target awareness campaigns and aim educational materials at the correct audience. With over half of respondents buying plants from garden centres it should be acknowledge that this is where efforts should be focused. It has been acknowledged that DEFRA's "Be Plant Wise" and "Check, Clean, Dry" campaigns (GB Non-Native Species Secretariat, 2018a; GB Non-Native Species Secretariat, 2018b) have been successful in helping to educate consumers and retailers on the impacts of INNS (Caffrey *et al*., 2015). Though as previously mentioned the message doesn't always reach its intended target (Humair *et al.*, 2014). With over a quarter acquiring plants from friends a campaign targeted at not just retailers but also consumers such as the "Be Plant Wise" campaign may be helping to inform people on the consequences of planting INNS in their gardens. That said, some respondents said that the plants in their pond colonised naturally and the approach suggested would not assist those people in identifying newcomers to their pond. With regards to citizen science projects involving recording INNS, verification of records would be necessary to enable the data to be used in research (Pocock *et al.,* 2015). Given the fact that many people are unable to accurately identify plants (Muratet *et al.,* 2015) this would need to be addressed by scientists or competent wildlife experts in order for the data to be useful.

Very few respondents said that they purchased pond plants online which is a little surprising considering that the global trade of plants through e-commerce is a growing industry (Humair *et al.,* 2015). Despite the low numbers of online shoppers in this study this method of acquiring plants needs to be monitored carefully as the horticulture trade continues to grow and is the main source of horticultural invasions (Humair et al. 2015; Hulme et al. 2017).

4.8 Amphibians in respondents' ponds or gardens

Results showed no significant difference in confidence of respondents' identification skills regardless of whether they reported them in their pond or garden (3.10; Table 3.1). This could be the result of relatively low numbers of responders reporting some species, such as the alpine newt. However, if we are to assume that a connection to nature must involve close contact and that this leads to increased confidence in identification then it might also be assumed that those who had amphibians in their garden would have more confidence in their identification skills. This was not the case here which is contrary to previous work which showed that people who have greater exposure to wildlife have more confidence in their identification ability (Chizinski *et al.,* 2014). Greater self-confidence in identification ability on the part of the respondent may not naturally lead to confidence by the researcher in the record but with verification of some of those records the validity of records might be assessed more accurately. Regardless of any conjecture here it must be remembered that confidence in identification skills could be subjective and without definitive checks the results cannot be confirmed.

One factor which was considered important was the way in which respondents were asked to identify species. Photographs were included in the questionnaire as identification aids and a link provided for a more comprehensive guide to amphibians (Amphibian and Reptile Conservation & Holmes, 2014). Interestingly, over three quarters of respondents (78.9%) chose not to make use of the ARC amphibian guide to help with their identification skills (3.11). These respondents just used the photographic images provided on the questionnaire. Whether this affected the accuracy of results would need further investigation though a study in Ireland found the use of photographs, along with species facts, to be valuable tools as part of a project on invasive aquatic species (Silva *et al*., 2014). With the large variation in colouration of some amphibians, such as tree frogs (Brenes-Soto *et al*., 2017), reported it is understandable that members of the general public might experience some confusion over species or even misidentify them. This could be overcome by using a smartphone app which the participant could use to send in photographs for verification such as has been used with recent citizen science projects involving INNS (Starr *et a*l. 2014; Adriaens 2015), thus ensuring that only accurate data is used for analysis, improving data quality (Crall *et al*. 2011).

One point which deserves mention is that of the respondents who did use the guide half of them said that they gained no more confidence in their identification skills as a result of using it (3.11). This suggests the need to evaluate the effectiveness of using identification guides or the review of their content.

One way to overcome misidentification is to use multiple citizen scientists at each site as has been used effectively on other projects (Swanson *et al.,* 2016). Whilst this method has been helpful in obtaining accurate data from citizen science projects which are geographically distant from the citizens, such as identifying animals on the Serengeti (Swanson *et al*., 2016), or identifying galaxies (Lintott *et al*., 2008), it may not be appropriate in a more localised setting. However, it is something worth considering for future projects.

4.9 Generalising from thesis results

With the increasing need to protect native species and habitats from the threats posed by a growing number of INNS (Roy *et al.,* 2014b) the engagement and active participation in INNS management by members of the public is inevitable given that many urban and garden species, particularly plants, are known to be non-native (Štajerová *et al*., 2017). Any control work necessitates the cooperation of landowners and householders by allowing access to land for control and eradication programmes aimed at reducing the impacts of INNS. Species Control Orders allow for this by working with landowners to ensure that they carry out control themselves or allow environmental authorities to enter the property to carry out necessary works (Defra, 2017). However, it is suggested that a more favourable approach to take would be for all parties involved to agree to a less formal arrangement (Defra, 2017) in which landowners voluntarily agree to control problem species or allow access for others to carry out controls as has happened routinely in the past and now covered under formal Species Control Agreements (Defra, 2017). This arrangement is usually effective, mutually less onerous in terms of paperwork and would be the first line of approach (Defra, 2017). Though in cases where voluntary agreements cannot be made a formal Species Control Agreement or Species Control Order may be necessary (Defra, 2017). Cooperation on the part of the landowner and authorities is the most sensible approach but in order to reach cooperation this approach should be carefully assessed in order to achieve agreement between all parties involved (Defra, 2017). The current EU legislation on INNS states that the public should be given the opportunity to

participate in consultations concerning the implementation of action plans involving management of INNS (European Commission, 2014). With both UK and EU legislation in mind the need to foster good relations with landowners is essential and should be maintained throughout control projects and beyond to ensure long-term successful control (Wittenberg *et al*., 2005). The attitudes of landowners towards the species on their property may not match those of conservationists and land managers. People who consider species as beautiful or desirable are less likely to agree to their control unless they have prior knowledge of the impacts of INNS or are provided with information in a manner which encourages positive action to control them (Lindemann-Matthies, 2016). Education and awareness programmes can help better inform the public on issues surrounding INNS and lead to greater cooperation and action (Niemiec *et al*., 2016; McGregor *et al*., 2013).

The information gained from this thesis is intended to help in identifying the level at which to pitch education and outreach projects and when planning INNS control programmes. It assesses the participants' knowledge of their own properties and the wildlife utilising its resources which could provide an insight into the extent of the distribution of INNS. It may also help as an introduction to landowners of the issues posed by INNS and provide an opportunity for them to gain an increased knowledge of them and how they might affect their own lives which has been shown to lead to practical action (Niemiec *et al*., 2016).

Participants in this study were volunteers from the south east Cornwall area, some of which is known to have both native and invasive non-native amphibians. Due to the need for respondents to retain anonymity, should they wish, it was only possible to check the exact location of respondents who included their location data as additional information. Some respondents came from the area with alpine newts and provided positive sightings some of which were verified where location data was provided. This has addressed the issue of having confidence in respondents' answers, something which has been of concern to some in the scientific community (Crall *et al*., 2015). Given that this study was designed to assess the possibility of using citizen science data to help inform general management of invasive non-native species, not necessarily specific to the invasive non-native alpine newt, the broader than expected reach of the survey provided an opportunity to connect with participants living in areas of potential future invasion by alpine newts The information gained and contacts made

could provide a means of expanding current practical research and disseminating important information to residents particularly if the alpine newt does expand its existing range.

For safeguarding reasons participants over the age of 18 were invited to take part. Other than location there were no other limitations on who could participate. If the general public are to be included in INNS management, which they must be, given the large number of gardens with alien plants (Smith *et al.,* 2006), then householders must be encouraged to engage with citizen science projects. For people to engage with these projects they must have an interest in the subject of the research (Jennett *et al*.,2016). No reward was offered to respondents to the thesis questionnaire and so the curiosity and interest of participants was relied upon to engage them. Interaction with potential participants was through email, links on an invasive species project website (Morris, 2016) and social media, the survey was posted on Facebook and Twitter. These platforms were chosen in order to reach a larger audience than would have been achieved through face-to-face surveys and have become commonly used methods of data collection for citizen science projects (Atchison *et al.,* 2017; Ganzevoort *et al*., 2017). A project in Italy aimed at conserving the red squirrel (*Sciurus vulgaris*) has had some opposition due to the necessity to cull the invasive grey squirrel (*Sciurus carolinensis*) (Silva *et al*., 2014). Utilising social media the project engaged a large number of participants and it also provided a platform for those working on the project to pass factual information to participants in an accessible manner to help counteract those opposing the work (Silva *et al*., 2014).

One point which may be important is the fact that whilst 89% of the population of Great Britain are users of the internet only 41% of users are aged 75 or over (Office for National Statistics, 2017). With the average age of residents in Cornwall increasing (Cornwall Council, 2012) this should be addressed and one way to do this would be to conduct postal and face-to-face surveys alongside those on online platforms.

Social acceptance and reciprocity are important to community members implying that people are more likely to take part in INNS management if they know someone who has done so already (Niemiec *et al.,* 2016). In contrast, a Dutch paper noted that an individual's personal connection with nature is more important than social bonding (Ganzevoort *et al.,* 2017*)*. Though, there is some disparity within the same paper as

citizens from urban areas felt that a sense of community was an important contributing factor in their deciding to take part in wildlife activities (Ganzevoort *et al*., 2017). It could be that, despite the relatively rural location of the survey for this thesis, some participants live in small towns and so a strong community spirit may well be present which could influence decisions, though care must be taken not to make assumptions regarding communities and their priorities (Ann Waylen *et al*., 2013) and should be explored in more detail in order to draw firm conclusions on this point

The survey for this thesis was shared further by participants with their friends and contacts. An email was also sent to gardening clubs, wildlife and conservation groups based in the study area and also to individuals who have participated in previous studies. Several respondents who provided identifying information had taken part in previous studies and also expressed an interest in finding out further information on the survey results, supporting the Biophilia Hypothesis (Wilson, 1984; Kellert & Wilson, 1995). Individuals who have direct experience of and interaction with wildlife and nature are more likely to have a desire to protect and conserve nature than those who do not (Zhang *et al*., 2014). This may of course have unintended adverse impacts in that the desire to protect wildlife may extend to all flora and fauna regardless of the consequences of this. This could be thought of as limiting the target audience; those selected were likely to have a strong interest in wildlife and conservation. However, citizen science relies on people being willing to participate in surveys and interactive projects and volunteers who have already been involved in citizen science projects are more likely to participate in further work (Martin *et al.,* 2016). People with little or no interest in wildlife and conservation may be unlikely to participate in citizen science projects of this nature (Ganzevoort *et al*., 2017). This creates an unavoidable bias as the attitude of the participants, whether optimistic or pessimistic about conservation issues, will undoubtedly influence their answers (Blaney *et al.,* 2016). A previous study looking at nature relatedness and anxiety reported that participants were self-selecting and as such had a tendency towards being interested in nature (Martyn & Brymer, 2016) supporting the suggestions in this thesis. As such there is no reason to suggest that the results in this thesis are any more biased than those of other studies of a similar nature.

Citizen science volunteer motivations have been analysed and motivation for initial participation has been identified as being: - curiosity; interest in science; desire to

contribute to research (Jennett *et al*., 2016). Socio-ecological issues should not be overlooked here and the connection which people have with different taxonomic groups and with scientists and decision makers can be hugely influential when it comes to that persons opinions on invasive species and their control (Estévez *et al.,* 2015). Education has been shown to be an essential component of best practice in successful INNS research and management (Hussner *et al.*, 2017; Caffrey *et al*., 2015; Newman *et al*., 2012). Combined with the fact that citizens consider education a motivational factor in deciding whether or not to participate in research (Geoghegan *et al.,* 2016) then the fact that the target audience in this study appears to be limited is understandable and unavoidable.

One of the reasons highlighted as being a major factor for lack of continuing participation in citizen science projects is lack of time (Jennett *et al*., 2016). The questionnaire was designed to be completed in the minimum time to encourage participants to take part. Questions were designed to be straightforward and easily understood by members of the general public who might not have any knowledge of scientific terminology and questions were tested during pilot studies with non-biologists. The research aims were linked to the questions to ensure that the simplification of questions did not remove the possibility of gaining useful information and that the focus remained on the aims of the project (Burgess, 2001). The questionnaire was split into five sections: - Connection with nature; Public perception of INNS; Information about ponds in south east Cornwall; Amphibians living in your pond or garden; Information about you (Appendix 1). The decision to use these section themes was made after studying existing research on perception of both wildlife and more specifically invasive species which provided a broad view of the topic whilst remaining concise (Fischer *et al.,* 2014; Nisbet & Zelenski, 2013; Nisbet *et al*., 2009; Zhang *et al*., 2014). Some of the questions were compulsory though others were not as they may not have applied to all respondents. Whilst this meant that respondents could skip those questions which were not relevant it also meant that some respondents did not continue to the end of the survey. This could be overcome by including additional logic to remove the opportunity to skip questions which might otherwise have been answered. Despite this the questions regarding perception of INNS were all compulsory thereby ensuring that all respondents did answer questions in that section. From a management perspective this information is vital in that control

work can only be carried out with landowner permission (Williams *et al*., 2010) and the approach taken to raise the subject with landowners is dependent on the current perspective individuals have of INNS (Niemiec *et al.,* 2016).

The NR-6 scale was used as it is a tried and tested method of evaluating nature relatedness (Nisbet & Zelenski, 2013) and as such question 3 followed a similar format again using a Likert scale (Fig 2.2). The use of Likert scales has proven controversial due to the possibility of misinterpretation or misunderstanding of the results generated (Carifio & Perla, 2008) and as such has been avoided on occasion (Chizinski *et al*., 2014). However, many researchers find this method of data collection useful and able to generate large amounts of data particularly when dealing with environmental and ecological issues (Gray *et al*., 2017; Kapler *et al.,* 2012; Nisbet & Zelenski, 2013; Nisbet *et al*., 2009; Restall & Conrad, 2015; Rohrschneider, 1990; Zelenski & Nisbet, 2014). The majority of questions employed a closed question single answer format or multiple choice to provide clarity and conciseness of answers and to aid analysis of results (Burgess, 2001) and this helped prevent misinterpretation of the answers provided by the author.

The considerations above suggest that the results of this thesis could be applied to comparable populations in rural communities comprising predominantly older residents with an existing interest in and connection with wildlife and the environment. As a first step towards management of INNS the suggestions for gaining insight into public perception of these species could be instrumental in gaining cooperation of landowners and the approach needed to carry out control.

5 Conclusion

The impacts which invasive non-native species (INNS) have on the environment, the financial implications associated with them and the effects they have on daily life have a high cost attached. With damage and control alone costing £1.8 billion each year in Europe, excluding environmental costs where no financial costs are attached, it is essential that attempts are made to limit the damage INNS cause and educate stakeholders in an attempt to prevent further introductions.

Working alongside scientists the general public have engaged in citizen science including environmental projects for many years. This study aimed to determine whether they might also assist in projects involving the control and management of INNS. Concerns have been expressed regarding the validity of data generated using citizen science. This questionnaire based study demonstrates how effective citizen science can be in gathering data suitable for scientific research and how willing people are to engage in and support INNS control programmes.

Encouragingly respondents had a high level of awareness of the financial costs associated with INNS. Coupled with more direct questioning on the control of INNS the study suggests that control and management projects in the study area in south east Cornwall may be supported and engaged with. Further evidence of support is apparent with the high NR-6 and INNS perception scores reported. Previous studies have shown that high NR-6 scores indicate a connection with nature and proactive environmental behaviour. High INNS perception scores are indicative of an understanding of INNS and their impacts and all respondents agreed that INNS should be controlled. This is vital information to be gathered before attempting any control work as without local support and engagement access to sites would not be possible and control work could not take place.

The confidence which participants had in their identification skills requires further investigation in order to use this kind of data in scientific research without the need for comprehensive validation by experts. Some records in this study were verified and found to be accurate. A strong connection with nature suggests the individual has contact with nature. However, though these respondents had high NR-6 scores many did not report amphibians in their garden. As respondents' confidence in their identification skills was not affected whether or not the species was present in their

garden it leads to questions regarding the importance of nature relatedness in this instance. The relatively rural location of this study could account for the high NR-6 scores. Further research could focus solely on an individual's ability to identify species from a variety of media forms and additional expert record verification would help to determine the accuracy of respondents' identification skills.

The basic information participants in this study provided relating to pond ownership is helpful. If a control programme involving freshwater aquatic INNS, such as the alpine newt, were to be undertaken then the site location of the study areas would be gained without the need to knock on doors to determine pond presence.

Information provided on pond management is also useful. In order to carry out awareness campaigns the means by which people obtain their pond plants must be known so that a targeted campaign can be implemented. The fact that most people either buy plants at garden centres or are given them by friends suggests that further work could be carried out to raise awareness of invasive aquatic plants in the retail sector and perhaps increase the profile of native species better suited to our environment. The respondents were mostly older people and this detail could be used to further target awareness-raising materials to ensure the audience which is most likely to spend time outdoors and engage with the environment around them is most informed on matters relating to INNS. It may be necessary to re-evaluate campaigns and the target audience regularly as though most respondents did not purchase plants online this trend may alter in future years as the trend for online purchases increases. Again, this could be related to age demographic and must be considered in future research.

Providing careful consideration is given to the target audience and the nature and framing of questions, useful citizen science data can be generated and if necessary verified by the researcher. Whilst citizen science is just one method of data collection it is one which, when used alongside more traditional scientific methods, can be a useful tool in engagement and data gathering.

Appendices

Appendix 1 – Copy of survey from SurveyMonkey (excluding images in “Amphibians living in your pond or garden”).

Welcome to My Survey

Thank you for participating in this survey which should take just 5-10 minutes and should be completed only by those over 18 years old. This survey is a research project being carried out as part of a Research Masters degree at Plymouth University. It is part of a long term project being carried out by SINNG (Student Invasive Non-Native Group) which many people living in the South East Cornwall area have been kind enough to assist with. The aim of this survey is to gain a good picture of the current amphibian population and how best to protect our native amphibians from threats such as disease and invasive non-native species.

It would be much appreciated if you could share the link for this survey with your friends and neighbours who live in the South East Cornwall area.

By participating you agree to sharing basic information with the researcher. Personal information will not be shared with any third parties without your permission. Your responses will be treated in confidence and your identity will not be connected with any published data.

If you submit an email address to request more information about this project you will be contacted to invite your questions. Your details will not be used for any other purpose. If you decide that you do not wish your questionnaire responses to be used in the study, please email nicola.morris@cornwall.ac.uk and ask for their removal. If you are dissatisfied with the way the research is conducted, please contact Nicola Morris in the first instance. If you feel the problem has not been resolved, then please contact the secretary to the Faculty of Science and Engineering Human Ethics Committee, Plymouth University: Mrs Paula Simson 01752 584503

Connection with Nature

These questions will help us understand how connected you feel to nature.

* 1. Please indicate how much you agree/disagree with the statements below.

	Disagree strongly	Disagree a little	Neither agree or disagree	Agree a little	Agree strongly
My ideal vacation spot would be a remote, wilderness area	○	○	○	○	○
I always think about how my actions affect the environment	○	○	○	○	○
My connection to nature and the environment is a part of my spirituality	○	○	○	○	○
I take notice of wildlife wherever I am	○	○	○	○	○
My relationship to nature is an important part of who I am	○	○	○	○	○
I feel very connected to all living things and the earth	○	○	○	○	○

Public Perception of Invasive Non-Native Species

This section will help us to understand how you feel about invasive non-native species

* 2. Invasive non-native species are introduced by man to areas outside their natural range. Such species then spread causing: -

- ◯ no impacts to the environment, the economy, our health and the way we live
- ◯ beneficial impacts to the environment, the economy, our health and the way we live
- ◯ harmful impacts to the environment, the economy, our health and the way we live
- ◯ I don't know

* 3. Please indicate how much you agree/disagree with the statements below

	Disagree strongly	Disagree a little	I don't know	Agree a little	Agree strongly
Native amphibians are an important part of pond ecosystems	◯	◯	◯	◯	◯
Invasive non-native species can be a threat to native flora and fauna	◯	◯	◯	◯	◯
Invasive non-native amphibians can spread disease to native amphibians	◯	◯	◯	◯	◯
Management of invasive non-native species is important to protect our environment	◯	◯	◯	◯	◯
Invasive non-native plants should be controlled	◯	◯	◯	◯	◯
Invasive non-native animals should be controlled	◯	◯	◯	◯	◯

* 4. The total annual cost of invasive non-native species to the British economy is estimated at: -

- ◯ £0
- ◯ £1.7K
- ◯ £1.7 Billion

Information about ponds in South East Cornwall

We would like to understand more about the ponds in the South East Cornwall area. By answering these questions you will help us build a good picture of this type of habitat.

* 5. Do you have a pond in your garden?

- ◯ Yes (Please continue to question 6)
- ◯ No (Please click NEXT at the bottom of this page and you will be directed to the next relevant part of this survey)

6. How would you describe your pond? Managed indicates regular maintenance such as cleaning and using filters. Unmanaged indicates no maintenance or very occasional such as yearly clearance of leaves.

- ◯ Managed fish pond
- ◯ Unmanaged fish pond
- ◯ Managed wildlife pond
- ◯ Unmanaged wildlife pond

7. Please indicate the way you are most likely to get aquatic plants for your pond or have done in the past.

- ◯ Garden centre
- ◯ Online
- ◯ Friends or neighbours
- ◯ I have not planted aquatic plants in my pond

Information about ponds in South East Cornwall cont.

8. If you have never planted aquatic plants in your pond please indicate how you think plants have arrived.

- ◯ Planted by previous owner
- ◯ Natural colonisation
- ◯ There are no plants in my pond
- ◯ I don't know

Amphibians living in your pond or garden

Please help us to identify the amphibians which you have in your pond or garden. The link below will help you with identification if you are not sure. The scale will help us get a clearer idea of how confident you are in your identification. Remember all information will be very helpful to us.

http://www.arc-trust.org/amphibians.html **This link will open in a new window. Just click to download the amphibian identification guide.**

9. Please indicate which of the following amphibians you see in your pond or in your garden(Images courtesy of http://www.froglife.org/)

	Have you seen this amphibian in your pond?	How confident are you that you are able to identify this amphibian correctly?
Common frog		
Common toad		
Palmate newt		
Smooth newt		
Alpine newt		

Other (please specify species and how confident you are that you can identify it correctly as with your previous answers)

10. Did using the identification guide (on the link to the ARC Trust website) give you more confidence identifying which amphibians you have in your pond or garden?

- ◯ Yes
- ◯ No
- ◯ I didn't use the identification guide

11. In order to get a good idea of the amphibian population it would help us to know where your pond or garden is. If you are happy to provide this information please use the following link to get the grid reference of your pond or garden. http://gridreferencefinder.com/

Please remember that your details will not be shared with any third parties without your permission and you are not obliged to provide this information but by doing so it will help us with our conservation work.

Information about you

In order to help us put your responses in context it would be very helpful to have a little information about you. Your identity will not be connected with any published data and all information will be treated with confidence.

* 12. How often do you use use the following forms of media to keep up to date with news and current affairs?

	Daily	Two or three times per week	Weekly	Monthly	Rarely or never
Social media e.g. Twitter, Facebook	○	○	○	○	○
TV	○	○	○	○	○
Radio	○	○	○	○	○
Online newspapers	○	○	○	○	○
Print newspapers	○	○	○	○	○

Other (please specify)

* 13. How many wildlife, conservation or gardening groups/organisations are you involved with or a member of?

- ○ None
- ○ One
- ○ Two
- ○ Three or more

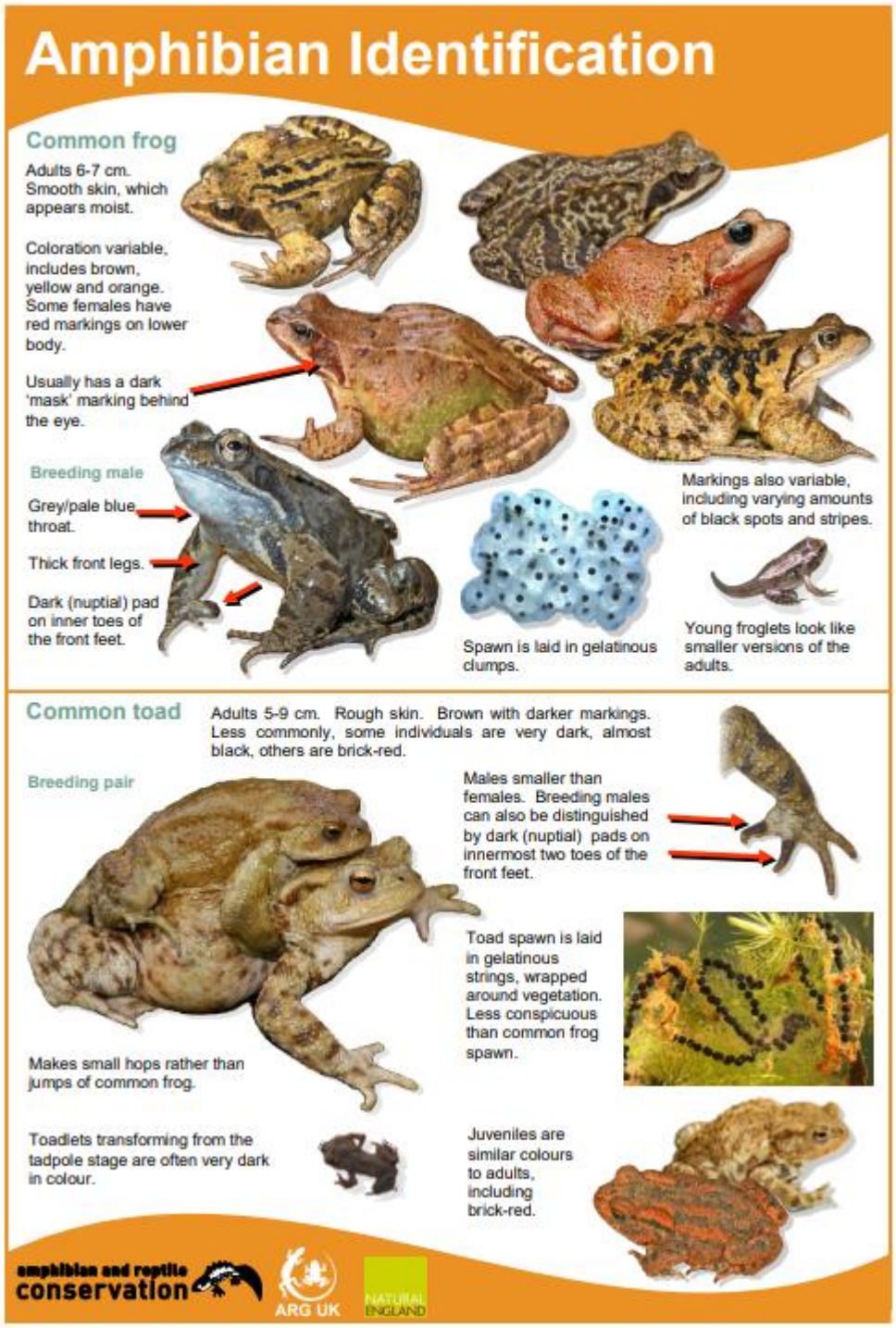
14. Please let us know your age

18 100

15. Finally, thank you very much for your help with this research. It would be very much appreciated if you could share this survey with anyone else in the South East Cornwall area.

If you would like to help us further with our conservation work or ask questions about this project please provide us with an email address. Please note that you are under no obligation to provide contact details and any details supplied will not be shared or distributed to any third parties.

Appendix 2 – ARG UK Amphibian ID Guide



Natterjack toad

Similar in size and appearance to common toad, but with a pale stripe running along the back.

Strictly protected species, requiring a licence to handle or disturb.

This is a rare species, unlikely to be found outside specific dune and heathland habitats.

Tadpoles

On hatching common frog and toad tadpoles are black. As they develop, common frog tadpoles become mottled with bronze, whereas toad tadpoles remain uniformly dark until the last stages of development.

Common frog and toad tadpoles generally complete development in the summer, but development rates are variable; some tadpoles may not transform until later in the year, or they may even remain as tadpoles over winter, becoming much larger than normal.

Tadpoles of water/green frogs grow larger than native frog and toad tadpoles. There are usually mottled markings on the base of the tail and the belly is usually white.

Frog

Toad

Water frog

Water/green frogs

This is a group of non-native frogs, including pool, edible and marsh frogs (although there is one population of pool frogs which is native). There is considerable variation in colour and markings within each species, so identification by eye can be difficult. Water frogs breed in late spring/early summer. Males call loudly at this time and sporadically later in the summer. The calls are a useful way of distinguishing the species and can be heard on the *Alien Encounters* website (www.alienencounters.org.uk).

Calling marsh frog Calling pool frog

Calling male water frogs inflate a pair of balloon-like vocal sacs, one either side of the head. These sacs are dark grey in marsh frogs, white in pool frogs and pale grey in edible frogs.

Pool frog

Pool frogs are similar in size to the common frog.

Edible frog

Grows to a little larger than the common frog.

Marsh frog

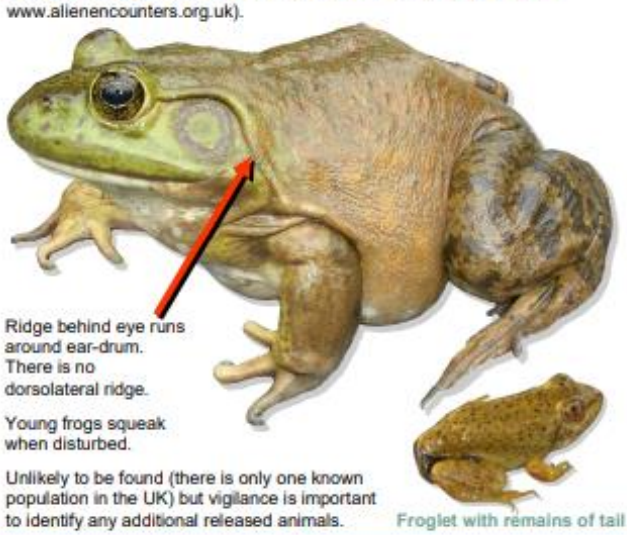
A large frog growing to 13 cm (much larger than the common frog). Variable coloration and markings. May, or may not, have pale dorsal stripe. Marsh frogs usually have some vivid green coloration, but some can be predominantly brown.

Sometimes mistaken for North American bullfrog, but marsh frogs have dorsolateral ridges and calling males have paired vocal sacs, either side of the head (both features absent in bullfrogs).

North American bullfrog

A very large, non-native frog growing to 15 cm. Calls loudly and breeds during the summer (call can be heard on the *Alien Encounters* website www.alienencounters.org.uk).

Black spots on body of tadpole. The tadpole stage can last several years and tadpoles grow to a large size, exceeding 10 cm.



Ridge behind eye runs around ear-drum. There is no dorsolateral ridge.

Young frogs squeak when disturbed.

Unlikely to be found (there is only one known population in the UK) but vigilance is important to identify any additional released animals.

Froglet with remains of tail

Midwife toad

A small non-native species, growing up to 5 cm. Rough skin, so potentially mistaken for a juvenile common toad. Midwife toads, however, have vertical pupils (horizontal in common toad) and males carry the eggs.

Few established populations, which are usually associated with gardens.

Secretive, but has a distinctive call, a single, repeated tone, like an electronic bleep, given on warm summer evenings (can be heard on www.alienencounters.org.uk).

Male carrying eggs

Smooth newt

A widespread species which breeds in a variety of water bodies. Often found in garden ponds.

Both sexes have an orange or yellow belly stripe and rounded spots, which are larger in the male.

Grows to about 10 cm. Breeding male has an undulating crest running from head to tail tip.

Non-breeding adults live mostly on land. Juveniles live entirely on land.

Palmate newt

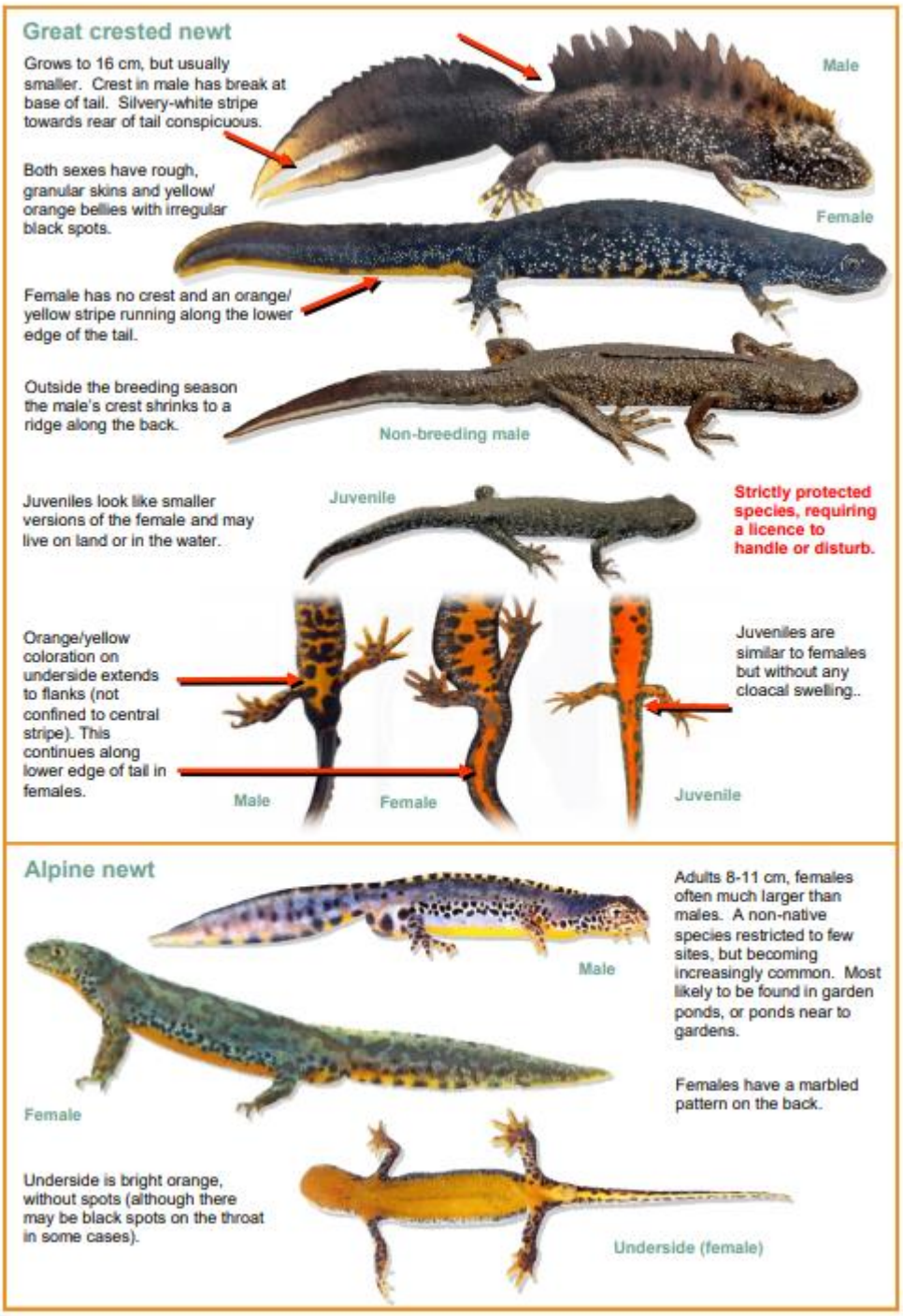
Grows to 9 cm. Breeding male has a ridge running along the back, rather than a crest. Dark, webbed hind feet, and tail ends in filament.

There are two pale coloured nodules on the underside of the hind feet of the female.

Throat of palmate newt has no pigment (looks pink). Throat of smooth newt is off-white and usually spotted.

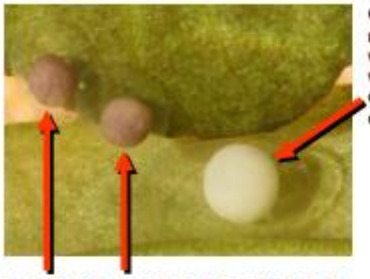
Female looks similar to smooth newt.

Juveniles live on land.

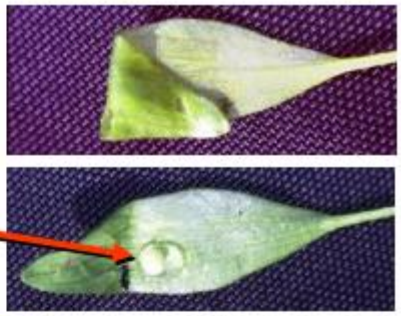

Great crested newt
Grows to 16 cm, but usually smaller. Crest in male has break at base of tail. Silvery-white stripe towards rear of tail conspicuous.
Male
Both sexes have rough, granular skins and yellow/ orange bellies with irregular black spots.
Female
Female has no crest and an orange/ yellow stripe running along the lower edge of the tail.
Outside the breeding season the male's crest shrinks to a ridge along the back.
Non-breeding male
Juveniles look like smaller versions of the female and may live on land or in the water.
Juvenile
Strictly protected species, requiring a licence to handle or disturb.
Orange/yellow coloration on underside extends to flanks (not confined to central stripe). This continues along lower edge of tail in females.
Juveniles are similar to females but without any cloacal swelling..
Male
Female
Juvenile
Alpine newt
Adults 8-11 cm, females often much larger than males. A non-native species restricted to few sites, but becoming increasingly common. Most likely to be found in garden ponds, or ponds near to gardens.
Male
Female
Females have a marbled pattern on the back.
Underside is bright orange, without spots (although there may be black spots on the throat in some cases).
Underside (female)

Newt eggs

Newt eggs are usually wrapped, singly, in vegetation. Leaves folded around great crested newt eggs are particularly conspicuous. To identify, unfold the leaf. Identification of undeveloped eggs is easiest.



Great crested newt eggs are white, sometimes with a tint of green or orange (jelly capsule 5 mm).

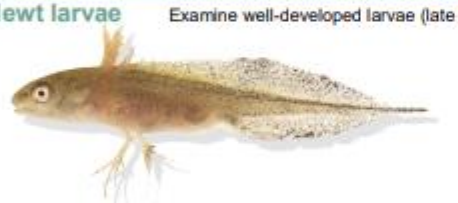


Eggs of smooth and palmate newts cannot be distinguished by eye, but they are smaller (jelly capsule 3 mm) than great crested newt eggs and are grey or beige when newly laid.

Several great crested newt eggs folded into a single blade of flote grass, giving a 'concertina' effect.

Newt larvae

Examine well-developed larvae (late May to July, or to August for great crested newts).



Palmate and smooth newt larvae (above) are indistinguishable in the field—but do not have the long toes or spotted tail fins of great crested newt larvae. Grow to approximately 3 cm.

Great crested newt larvae (above) have long toes and blotches of dark pigmentation on tail fins. Grow to approximately 5 cm.

Overwintering and neoteny

Young newts usually leave the water in late summer or autumn, although sometimes they remain as larvae over the winter (e.g. smooth newt, right).

Neotenous smooth newt

Exceptionally newt larvae grow to adult size, able to breed, but retaining their gills.

Further information Howard Inns (2009, reprinted 2011). *Britain's Reptiles and Amphibians*. WILDGuides.

Amphibian and Reptile Conservation & Fred Holmes (2014)

Additional photographs courtesy of Jon Cranfield, Ray Cranfield, Chris Gleed-Owen, Howard Inns, Mark Jones, Phyl King, Liam Russell, Duncan Sweeting and Rose Tichiner.

Revised with financial assistance from Natural England.

Amphibian and Reptile Conservation www.arc-trust.org

amphibian and reptile conservation

ARG UK

NATURAL ENGLAND

Appendix 3. Level of confidence in amphibian identification by respondents who reported the species as either present or absent from their pond or garden.

Species		Very Confident	A little confident	I don't know	Not very confident	Not at all confident
Common frog	Present	24	4	0	0	0
	Absent	2	0	0	1	0
Common toad	Present	19	5	0	0	0
	Absent	3	2	0	0	0
Palmate newt	Present	8	2	0	1	0
	Absent	7	1	4	1	1
Alpine newt	Present	4	0	0	0	0
	Absent	10	2	6	0	1
Smooth newt	Present	4	3	2	2	0
	Absent	10	2	2	1	1

Abbreviations

ARC – Amphibian and Reptile Conservation

DEFRA – Department for Environment, Food & Rural Affairs

EU – European Union

GB NNSIP – Great Britain Non-Native Species Information Portal

GB NNSS – Great Britain Non-Native Species Secretariat

INNS – Invasive Non-Native Species

INNS Amphibians –Invasive Non-Native Amphibian Species

NR – Nature Relatedness

NR-21 – Nature Relatedness 21 point questionnaire

NR-6 – Nature Relatedness 6 point questionnaire

UK – United Kingdom of Great Britain

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