Understanding public perceptions toward invasive species in different parts of Europe

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Abstract

Understanding public attitudes towards invasive species is crucial to curtail the reasons for their introduction and to increase the effectiveness of control measures. A questionnaire was distributed in three European countries (Italy, Spain and United Kingdom) to evaluate public attitudes on the problems posed by invasive species, their perception of the impacts and their willingness to introduce and support management actions. People whose occupations are not nature related or who practice gardening as a main outdoor activity, represent the highest risk groups relating to the introduction of invasive species. Ecosystem damage and species extinctions were the main concerns for people, and signal crayfish and zebra mussel were the species of most concern. People firstly supported control and eradication followed by increasing public ´awareness index´ as management measures. This information can feed into educational, prevention and eradication campaigns promoting the necessary socio-cultural changes to prevent negative impacts of invasive species.

Keywords: non-native species, conservation, education, management, public opinion

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1. INTRODUCTION

Invasive species represent a growing threat to biodiversity, but their socio-economic impacts are often underestimated (Vilà et al. 2010; Bradshaw et al. 2016). The general public is an important driver of biological invasions and can deliberately or accidentally introduce and spread many invasive species (Sharp et al. 2011; Connelly et al. 2016). At the same time, the most successful management approaches towards invasive species tend to be those that gain social support (Stokes et al. 2006; Gozlan et al. 2013). Therefore, taking into account public perceptions towards biological invasions is key for policy and management (Decker, Chase 1997; Shackleton et al. 2019). Understanding public attitudes towards invasive species might provide insights into the reasons for their introduction and dispersal (Kemp et al. 2017), which can be used for prevention and early detection and increase the effectiveness of eradication and control measures (Hulme 2006; Kapitza et al. 2019).

Public opposition can hinder eradication and control programs (Bremner, Park 2007; McNeely 2011), especially when invasive species are considered as aesthetically pleasing or charismatic (Jarić et al. 2020), as in the case of many mammals (Bertolino, Genovesi 2003), or when they derive economic benefits (Parrondo et al. 2018). To ease opposition, it has been suggested that educational campaigns should explicitly acknowledge variation in social values (Genovesi 2008; García-Llorente et al. 2011). Education campaigns can facilitate citizen engagement in prevention and eradication activities with regards to invasive species (Andreu et al. 2009). For example, informing the public about the negative impacts of invasive species can increase public support for their control, independently of taxa and landscape (Novoa et al. 2017; Cordeiro et al. 2020). Yet, public understanding about

86 invasive species appears to be limited, as shown by the rare allusion to biological
87 invasions in studies about drivers of biodiversity change (e.g., Selge et al. 2011), and
88 the low general appreciation of the concept of 'nativeness' in the natural environment
89 (Fischer et al. 2011).

90 Public opinion studies have proved useful for understanding the reasons of
91 human-mediated introductions (Kowarik 2003, 2011), to gauge the level of support
92 for different management approaches (Estévez et al. 2015; Crowley et al. 2017), and
93 to design more effective outreach programs that engage the public in control
94 initiatives (Schultz 2011; Fischer et al. 2014). For instance, focusing on a few iconic
95 invasive species might strengthen the need for action, and make the problem global,
96 rather than of local importance (Courchamp et al. 2017). In this sense, the use of
97 social media help identify iconic invasive species and canvass support for more
98 effective management actions (Gozlan et al. 2013).

99 After more than a decade of flagging the problems posed by invasive species
100 in Europe (Scalera 2010; Bradshaw et al. 2016; Courtois et al. 2018) and six years
101 after the implementation of European Union Regulation No 1143/2014 (EU 2014), it
102 is important to evaluate public opinion towards invasive species, as this may have a
103 direct effect on further introductions and drive support for management measures
104 (Tollington et al. 2017). The number of social studies addressing the impacts of
105 invasive species has increased much in recent years (Binimelis et al. 2007;
106 Vanderhoeven et al. 2011; Kapitza et al. 2019), but knowledge on differences
107 between stakeholders across countries and contexts is still limited and the social
108 perspectives on invasion biology is underrepresented (Verbrugge et al. 2013;
109 Abrahams et al. 2019). Accounting for social differences in attitudes to invasive
110 species might help find more effective solutions (Courchamp et al. 2017).

With this in mind, we conducted a survey on public perceptions (i.e., thought, belief, or opinion) of invasive species in three European countries (Italy, Spain and United Kingdom) to accomplish four main aims: ***i)*** To investigate the general perception towards invasive species and the differences among three European countries. ***ii)*** To study the relationship between public awareness on biological invasions and educational level, occupation and main outdoor activity. ***iii***) To investigate the level of awareness and the opinions regarding the reason for the arrival of the species, the worst impacts and best management practices. ***iv***) To identify potential iconic species that can be used to make campaigns more successful and to investigate if the perceived impact of the species depends on the internet media.

2. MATERIAL AND METHODS

The study was conducted in Italy, Spain and the UK as part of an EU project (Aquainvad-ed). countries have a similar number of invasive species per capita (Tsiamis et al. 2017) and also similar legal instruments for their control (Turbelin et al. 2017). The survey was conducted from May 2016 to August 2017 and targeted citizen over 18 years. The questionnaire was approved by Swansea University Ethics Committee. It did not include any information that could identify the respondent and was the same in the three countries, having been translated by native speakers. We used simple sentences that were understood in the same way in the three countries. We used 15 questions (Fig. S1) organized into three main sections: (1) information about outdoor activities, providing an overview of the environmental interest of the respondent and level of knowledge about invasive species, (2) perceptions of pathways of introduction and impacts of invasive species, and (3) attitudes towards different management approaches with different type of questions (Table S1). We collected responses online (n=1,000) with the survey hosted in surverymonkey platform (www.surverymonkey.com). The link to the survey was posted on two social media platforms (Facebook and WhatsApp) and was widely shared to maximize the reach in each country (Gbedomon et al. 2020). We also randomly distributed 300 leaflets with QR codes linking to the online questionnaire at bus and train stations in the UK, Spain and Italy. We also conducted face to face interviews in the UK on a voluntary basis (n=85) by asking participants randomly at the entrance of a public centre in Wales. Our sampling strategy was therefore a combination of random sampling since the online survey was available for any type of respondent, snowball sampling as respondents were encouraged to

161 share the survey link, and quota sampling as we specified quotas for age groups
162 (Fricker Jr 2016). Besides, due to the voluntary basis of the survey and the online
163 responses, our survey compilation was based on self-selection or convenience
164 samples because each individual chose to participate by filling the survey. We tested
165 for possible differences in responses between online and face to face interviews
166 through an ANOVA for each item and also for the overall ´awareness index´ index
167 (index and items are explained in the following paragraph).
168
169 2.1 **Awareness index by country and between countries**
170 To assess the level of awareness about the posed by invasive species, we
171 combined four questions collected on a Likert scale into an 'awareness index'.
172 Combining items into scales (i.e., index) is common in quantitative research in the
173 social sciences as it provides a more meaningful estimate of variance (Liu 2003;
174 Manfra, Bolick 2017). To develop the awareness index, we used the Motivated
175 Strategies for Learning Questionnaire (MSLQ) approach where items that are
176 expected to measure a similar motivation (motivational items) are grouped together
177 in constructs (Duncan & McKeachie 2005). This is a common procedure in social
178 studies, especially in educational psychology (Chin, Barber 2010; Jackson 2018).
179 The ´awareness index´ was composed by questions Q4, Q6, Q10 and Q13 in
180 the questionnaire (Figure 1 and Figure S1) (hereafter called 'items') and referred to
181 the sensibility and knowledge of the invasive species and the impacts they cause.
182 Item 1 was measured on a scale from 1 to 6, in order of increasing importance, but it
183 was changed to 1-5 to make it comparable to the rest of the items by pooling scores
184 5 and 6 together. Item 2scores ranged from 1 to 5, meaning very positive effect and
185 very negative effect, respectively. Item 3 with a score of 1 meant a strong agreement

and a score of 5 indicated strong disagreement to introduce a new species. Item 4 score of 1 meant no desire to contribute and 5 meant a strong willingness to contribute. Therefore, the four items ('*importance*', '*alertness*', *'commitment'*, and **'***support*') composed the **'***´awareness index´'*. invasive

The ´awareness index´ ranged from 1 (lowest awareness of invasive species and least motivation to tackle the problem) to 5 (highest awareness and motivation). Question 4 had the opposite scale, so it was inverted by using $Pi=(Pm+1) - Po$, where *Pi* was the transformed scores, *Pm* was the maximum value and *Po* was the observed score for that item (Borrell et al. 2016). We summed all the items scores to calculate the index, which was standardized to range between 1 and 5.

We investigated differences in 'importance', 'alertness', 'commitment' and 'support' among and within countries by means of a Welch's ANOVA (Welch 1951) followed by Games-Howell posthoc test. Welch's ANOVA does not assume equal variance and it is an appropriate approach for groups with unequal sample sizes (Zar 2013). We checked for normality of residuals using the Shapiro-Wilk test. In case residuals were not normally distributed we employed Kruskal–Wallis H test. We used R 3.3.1 software (R-project 2018) for all statistical analyses.

2.2 Awareness and characteristics of the respondents

Respondents were grouped according to their level of education and occupation, as indicators of socioeconomic status, and by their main practice of outdoor activities in the natural environment to classify respondents into different recreational user groups. Educational level was standardised for the three countries according to Table S2. Occupation was assigned to seven different groups (Table S3). The first three categories were based on the three-sectors theory or Petty's Law

211 (Murata 2008) classifying occupation in relation to the link with natural resources
212 (e.g., the first sector is fully related to nature) which is expected to affect the
213 responses (Table S2). We analysed the relationship between the ´awareness index´
214 index and the characteristics of the respondents (educational level, occupation,
215 outdoor activity) by Welch's ANOVA (Welch 1951) followed by Games-Howell
216 posthoc test (**aim ii**).
217
218 **2.3 Awareness and reason of arrival, worst impacts and best management of**
219 **invasive species**
220 To understand the type of activities that would be more supported by people
221 and to extract potential initiatives to improve ´awareness index´, we compared
222 differences between the levels of ´awareness index´ and their assumption about the
223 arrival of invasive species (Question 9), the worst impact species might generate
224 (Q11) and the preferred management approach for the respondents (Q12) (**aim iii**).
225 Welch's ANOVA followed by Games-Howell posthoc test was used as statistics. We
226 also calculated differences within ´awareness index´ groups (i.e, index scores of 1, 2,
227 3, 4 and 5) regarding the opinion in the three previous questions (Q9, Q11 and Q12)
228 using χ^2 tests.
229
230 **2.4 Species damage ranking**
231 Using question 8, we calculated how often a given species was chosen as
232 causing the worst ecological and economic damage **(aim iv)**. We carefully selected
233 species for question 8 by ensuring our selection represented different taxa of
234 invasive species (vertebrates, plants) being present and causing similar impacts in
235 the three study countries. The size, contrast and brightness of the photographs of

invasive species were adjusted to avoid bias (Luna et al. 2019). We used Google Trends (https://trends.google.com/) to obtain an index of popularity of each species based on the number of times that each species appeared in the search queries in each country. Google Trends can be used to assess media attention (Gozlan et al. 2013). We computed the popularity index by calculating the means of the popularity values given by Google Trends between 01/01/2004 and 11/03/2018. We used in the search engine the scientific and common name of the species in the language of each country. We tested the relationship between the number of times a species was considered to be causing the worst impact (dependent variable) in relation to the popularity index, the species (twelve species in question 8) and country (i.e., Spain, Italy and the United Kingdom) as independent variables. We used a regression model and, applying the different variable combination, we selected the most parsimonious model based on Akaike's Information Criterion (AIC) (Bozdogan 1987). Sum contrast was used to compare the coefficients of the resulting model to the mean.

2.5 Quality check

To evaluate the psychometric properties of any test, the internal consistency, reliability and content validity are important characteristics to evaluate (Nunnally 1975). To assess internal consistency, we examined the correlation between items and the ´awareness index´ (Likert 1932) by using the Corrected Index of Homogeneity (IHC) following Petere, Van (1940). This index has been widely used (Hernández-Díaz et al. 2016; Harari et al. 2017; Skukan et al. 2020) with 0.20 as the threshold value to consider an item as valid. All items with IHC values lower than 0.20 were obviated (Petere, Van 1940; Borrell et al. 2016). Besides, we used the

Wilcoxon test to compute pseudo-medians and 95% confidence interval on the Likert scale to estimate the perceived value of each item (Mangiafico 2016).To assess the degree of consensus among participants responding to similar questions we used a cumulative link mixed model with the clmm2 function in the R package *ordinal* (Christensen 2015). To test reliability and content validity, an independent panel consisting of three experts with knowledge in social science research on invasive species (one for each surveyed country) rated the questions and the items, from which we calculated percentage reliability and validity values (Olson 2010). The reliability refers to the degree to which the questions of a survey ask the same information each time they are asked and the degree of personal information. We asked the expert panel if the survey questions were sensitive, i.e. whether they revealed personal information, informative and meaningful, i.e. whether they addressed what we wanted to ask. The content validity included only the four questions included in the ´awareness index´ and was based on how meaningful those items were in explaining the index. We piloted the questionnaire with 23 participants to explore the wording and ambiguity of the questions used.

3. RESULTS

3.1 Effects of the method of data collection

We collected 1,085 responses to our questionnaire, distributed among Italy (n=241), Spain (n=336) and the United Kingdom (n=508). We found no difference between face to face or online interviews but for 'commitment' ($F_{(1,169)}$=4.189, p=0.04). The aggregated ´awareness index´ index was also unaffected by the method used to collect the answers ($F_{(1,140)}$=0.11, p= 0.741). Most respondents (i.e., 53%) were in the age between 26 and 45 years old. Around 25% of the respondents´ age ranged between 46 and 65. The number of respondents per age were similar between all countries (Figure S2) and as many men as women responded to the survey in each country. Demographics of the respondent group by country regarding age and gender were similar in all the countries data, so we ruled out any effect on the results.

3.2 Items and ´awareness index´ by country and between countries

Our results revealed that all items and in all countries were scored above the intermediate score (i.e. above 3) in 'awareness index' about invasive species except for 'support' (i.e., willingness to pay) where Spanish and British people scored below 2.5 (Fig. 2). For 'awareness index', all countries scored above the intermediate value but far from the maximum value of 5. Overall, and for the three countries together, 40% of the surveyed people achieved scores of 'awareness index' between 4 and 5, another 40% achieved moderate ´awareness index´(i.e., scores between 2 and 3),

311 and 20% had very low and low ´awareness index´ (i.e., scores between 1 and 2).
312 Italy was the only country where more than 50% of people achieved scores of
313 ´awareness index´ above moderate (i.e., scoring 3 or more) compared to 37% and
314 33% for people in Spain and the UK, respectively (Fig. 2). We found significant
315 differences between countries ($F_{2,528.44}$= 45.023, p<0.001) showing that Italian
316 people were more aware of invasive species and their potential impacts than
317 Spanish, and the latter more aware than the British (Fig. 2).
318 We also found differences between countries for each individual item (Fig. 2).
319 Regarding 'importance', 'alertness' and 'support', Italian people gave higher
320 relevance to the invasive species problem ($F_{2,511.55}$=6.697, p=0.001, Games-Howell
321 post-hoc p-value= 0.002 and 0.01, respectively), were more aware of the negative
322 impacts caused by invasive species ($F_{2,545.65}$=35.511, p<0.001) and were more
323 willing to contribute to the management of invasive species ($F_{2,485.7}$=15.237,
324 p<0.001; Games-Howell post-hoc t=5.5, adjusted p-value<0.001 and t=4.1, adjusted
325 p<0.001 respectively) than people in Spain and the UK with no differences between
326 the latter countries (p=0.63, p=0.17 and p=0.08, respectively for each item). Country
327 differences were also found for 'commitment' that expressed differences in
328 motivation to introduce invasive species if there was a benefit ($F_{2,527.58}$=75.073,
329 p<0.001). Spanish and Italian people were less likely than British people to introduce
330 invasive species (Games-Howell post-hoc t=10.87, adjusted p-value<0.001 and
331 t=9.95, adjusted p<0.001 respectively).
332
333 **3.3 ´Awareness index´ and characteristics of the respondents**
334 We compared the ´awareness index´ with the three groups of respondents
335 according to their educational level, occupation and type of activity the respondent's

practice the most. Considering the three countries together, there were no differences in the index regarding the educational level of the respondents (Post-hoc p-value >0.05). Regarding the occupation, there were only differences between experts and people working in the services sector or retired (Games-Howell post-hoc t=3.653, p= 0.009 and t=3.70, p= 0.009 respectively). People that practice fishing as their main outdoor activity were more aware of invasive species than people practising gardening (Games-Howell post-hoc t=3.16, df=184, p= 0.02).

3.4 ´Awareness index´ and reason of arrival, worst impacts and best management of invasive species

Regarding the reason of arrival, we found that as ´awareness index´ increased, answers pointing to deliberate introduction increased, whereas the least aware people tended to view introductions as accidental (although no significant difference between group scoring 1 and the rest) (Fig. 3a). We also found a significant relation between the levels of ´awareness index´ and the perceived worst effect ($F_{5,88.038}$=15.507, p<0.001) and the pathway of introduction ($F_{5,322.46}$=11.328, p<0.001) of invasive species. People with lower ´awareness index´ (scoring 1 and 2) were more concerned with disease transmission (18% of them) than people with higher ´awareness index´ (index = 4 and 5) (average of only 4.5% of the times considered as the worst effect). For most groups, the extinction of native species was the worst effect caused by invasive species ($\bar{x}$=47%). Increases in the people´s ´awareness index´ also increased their perception of the biodiversity loss as the worst effect (10% of importance to 29%), whereas the ecosystem damage was equally important for all groups ($\bar{x}$=25, SD=5) (Fig. 3b). Rivers were the ecosystems

where people thought the worst impacts would occur with the onset of invasive species (Figure S3). In both previous answers, regarding the reason of arrival and the perceived worst effect, people least aware of the problem answered 'don't know' in a greater number of answers. Regarding the respondent´s preference of management, 'surveillance, control and eradication' was preferred ($\bar{x}$=47%) over 'early detection' (t=3.23, p=0.008) and over 'more regulations' (t=2.81, p=0.03) increasing as ´awareness index´ increased. Eradication measures were accepted for a high percentage of respondents (Figure S4). 'Public awareness' was the second most preferred ($\bar{x}$=27%) management option but did not differ between groups (p>0.05).

3.5 Species damage ranking

The best model to explain the ranking of the species included the popularity index and the species (AIC=198.58). The signal crayfish and the zebra mussel were the species considered to cause the worst damage (estimate=11.08, SE=1.8, p<0.001 and estimate=5.83, SE=1.8, p=0.003, respectively) (Fig. 4). The public was least concerned with the sika deer (*Cervus nippon*) and pheasants (*Phasianus colchicus*) (estimate=-12.69, SE=2.2, p<0.001 and estimate=-9.24, SE=1.84, p<0.001, respectively) (Fig. 4). People in the UK considered the two invasive weeds (i.e., giant hogweed and himalayan balsam) as having the worst damage than people in the other countries. In Italy, the catfish was considered the worst species in terms of ecological and economic damage (Fig. 4). We found that the species damage ranking was positively correlated with the popularity index (estimate=0.249, SE=0.05, p<0.001) but did not differ among countries (Table S3).

3.6 Quality check

According to the expert panel, the questionnaire was reliable. Only 4.4% of the survey was considered sensitive and the average rate of failure for the questions was 15.6%. Regarding the validity of the index, the experts' average rate for the meaningfulness of the index was 72.2% with the lowest values for the 'support' item (55.6% meaningful) and the highest values for 'commitment' (rated as 88.9% meaningful) (Appendix S1). All items obtained IHC values over the 0.20 threshold, ranging from 0.31 to 0.48, which supports the compilation of items used to generate the index. The consensus among respondents was high and 85% of the respondents did not deviate significantly from the responses of the average rater (Figure S5).

411

412 ## 4. DISCUSSION

413 Insights of the differential level of ´awareness index´, attitudes and
414 commitment of European people about the problem of biological invasions can be
415 extremely useful when planning common policies or educational actions. Voluntary
416 surveys usually do not capture all the opinions from society. Although we targeted all
417 types of people, we noticed that people unfamiliar with the topic of the survey were
418 less likely to participate. Therefore, the sampling might bias the results towards
419 people more concerned with environmental issues as reported in other similar
420 studies (Bremner, Park 2007; Lindemann-Matthies 2016; Cordeiro et al. 2020).
421 Although this might be a limitation of our study, it can also be valuable because the
422 results represent that part of the society that is more critical and active in terms of
423 management of invasive species and therefore, will more likely react to any
424 proposed management.

425 Our study of public perceptions of invasive species indicates that the
426 European people from the three countries that participated in this study on a
427 voluntary basis have only a modest level of ´awareness index´ of invasive species
428 (average = 3.2) and that this differs significantly among countries. Italian
429 respondents were the most aware, while British people were the least, with those in
430 Spain scoring intermediate values. The low level of awareness found in the UK could
431 be due to the long tradition in Britain to introduce exotic species. For instance, the
432 Victorian Acclimatisation Societies from Britain intended to introduce animals and
433 plants to improve their economies, landscapes or gastronomies (Lever 1977;
434 Rotherham 2017). This fact might be reflected in the willingness of the British
435 respondents to introduce invasive species if there was an economic or recreational

benefit to be justified (Dyer et al. 2017; Shackleton et al. 2019). The low degree of ´awareness index´ in the UK might result surprising, given that, among the three countries, the UK has the strongest regulations in terms of prevention, early warning and management of invasive species (Tollington et al. 2017). However, having strong regulations could make feel British people less worried about invasive species.

Italian respondents obtained the highest score in three items related to the importance of the problem posed by invasive species, the potential impact of invasive species and the willingness to pay for management. Of the three study countries, Italy is the country with the highest number of species included in the list of worst invasive species (NOBANIS), which might explain the greater degree of public awareness. Also, communication, information and training campaigns have increased in the last decade (Ross-Hellauer et al. 2020) and they have been recently developed throughout Italy by LIFE ASAP project (www.lifeasap.eu/en/) which might have also helped to increase awareness in Italy. Spain and Italy have more LIFE projects related to invasive species than the United Kingdom, and these projects have an important part focused on education and communication, which might also explain their higher awareness in (Silva et al. 2014).

Globally, our results indicated that experts were more aware than people within the services sector, as found previously (Selge et al. 2011; Touza et al. 2014; Lindemann-Matthies 2016). However, the lack of differences in public perception between experts and people working within the first sector or teachers indicated that the latter groups might have more knowledge than expected, stressing the need to focus invasive species education and prevention campaigns on people whose work is less environmentally orientated. Public campaigns have proved useful for the

461 society to become aware of the impacts, in particular, if they include norms or the
462 way to proceed, such as disposal techniques of fish (Kemp et al. 2017) or the
463 consequences of inaction (Stern et al. 1999). People are more likely to defend
464 management actions if they are able to recognize the invasive species and, in
465 special, their impacts (Somaweera et al. 2010; Lindemann-Matthies 2016; Novoa et
466 al. 2017; Cordeiro et al. 2020) but also just a general knowledge of invasive species
467 has proved useful to increase the management support (García-Llorente et al. 2011).
468 Anglers were more aware than people practising gardening. People practising
469 aquatic sports spread, often unintentionally, aquatic invasive species, and for this
470 reason, many campaigns have focused on raising awareness among this group
471 (Seekamp et al. 2016). It is possible that the reason for their greater awareness
472 might be because anglers are the ones who can most readily see the negative
473 impacts caused by invasive species (Eiswerth et al. 2011). Yet, according to our
474 results, people practising aquatic sports thought that the main reason for the arrival
475 of invasive species was shipping and free trade, thus ignoring the relevance of
476 accidental introduction and the risk posed by boating and sport (Kelly et al. 2013).
477 We found that the least aware people were those who practice mainly
478 gardening and are retired. Gardening is a main pathway for the introduction of
479 invasive species (Mack, Lonsdale 2001; van Kleunen et al. 2018), as well as a
480 commercially important economic activity (Keller et al. 2007). Although import
481 restrictions of risky species can be an effective approach to reduce the spread of
482 invasive species and have been already adopted by some European countries
483 (Champion et al. 2010), sometimes economic incentives of importing invasive
484 species outweigh the environmental risks. Under this situation, our results highlight
485 the importance of implementing codes of good practices in gardening or educational

campaigns focused on gardeners to prevent people from introducing invasive plants as well as promoting local specimens for gardening (Hulme et al. 2018).

The least aware people thought that accidental introductions were more important than deliberate introductions, suggesting that their lack of awareness may impede them to identify deliberate releases. On the other hand, the most aware people considered that deliberate introductions were the main reason for the arrival of invasive species. Such contrasting attitudes might be indicative of the gap between experts and the general public, where the former consider people responsible for intentional introductions, whereas the less aware people consider that if there is an introduction it is because someone is not aware of the risk (i.e., accidental release). Also, it means that experts are aware of deliberate introductions carried out in the past for biological control, angling or forestry (Manchester, Bullock 2000; Hall 2019; Oficialdegui et al. 2019). Although the management options presented in the survey were not mutually exclusive, respondents were asked to choose the more effective or preferred option according to their opinion. The most preferred action was the 'surveillance, control and eradication', which increased as the level of awareness increased, indicating that management will get more support from people with higher awareness of the problem. Public awareness was the second preferred management action indicating that people will be receptive to get trained or receive information to deal with invasive species. Educational activities range from the delivery of brochures or specific websites (White, Shine 2009), events like science weeks to workshops dedicated to invasive species which have been considered highly effective (Schreck Reis et al. 2013). Assessing the success of the educational activities in changing the perception has proved useful to detect

510 additional target groups that are less receptive to those campaigns and may require
511 alternative approaches (Cole et al. 2016).
512 Previous studies (Fischer et al. 2014; Lindemann-Matthies 2016) have shown
513 that even when the knowledge differed, the type of reasoning when evaluating
514 management actions or aesthetic feelings was similar between lay-public and
515 experts, which argues against a polarised point of view between professionals and
516 general public. In this case, if the reasoning is similar, raising awareness might lead
517 to common solutions accounting for the whole society for more widely accepted
518 management actions, reducing public opposition to species control (Perry, Perry
519 2008) and making people more receptive to educational options.
520 Conservationists can promote social changes that facilitate understanding of
521 potential socioecological threats (Manfredo et al. 2017). One proposed approach is
522 to improve the way researchers disseminate results to the public to increase
523 consensus between experts and the public (Courchamp et al. 2017). Although
524 disseminating to the public is not yet the rule (Gozlan et al. 2013), there is increasing
525 pressure to ensure that research provides social, cultural and economic impacts so
526 invasive species risk perception will benefit from this approach (HEFCE ; European
527 Comission 2014). Social media increase the perception of the risk posed by invasive
528 species (Touza et al. 2014) and political debate has been shown to trigger political
529 changes to a greater degree than scientific evidence (Gozlan et al. 2013). Our
530 results are in agreement with this finding, as the popularity index of invasive species
531 was consistent with the public perception on their ecological and economic damage.
532 Our study indicates that focusing on a few iconic species such as the signal crayfish
533 or the zebra mussel might help to show that threats posed by invasive species have
534 international scope (Courchamp et al. 2017). Also, it shows that our results are

reliable in terms of consistency which allows us to make general solutions for the three countries together which is also beneficial for such international scope. Our results are applicable for more efficient education and management but additional countries need to be surveyed to build a broader picture of the differences in public awareness. Future research should focus on how the results from different social studies can be optimally included in educational campaings and management. People are receptive to education and social media is influencing their perceptions, so further research about the effectivity of different media communication would be highly valuable to prevent introduction and spread of invasive species.

5. CONCLUSION

Our study indicates that attitudes to invasive species differ. Identifying the characteristics of the public groups that can pose a risk to introduce species can be useful for implementing management and legal frameworks at different scales (Gaertner et al. 2016; Shackleton et al. 2019). According to our study, campaigns for prevention and support of invasive species management in Europe should stress the impacts on ecosystems and species extinctions and signal crayfish and zebra mussel can be useful as case studies to help flag the impacts caused by invasive species. People interviewed in this study, supported ‘surveillance, control, and eradication’, but also agreed that ‘raising public awareness’ will help to reduce the issue of invasive species indicating that the society is open to change.

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Author’s contribution

Ethics

This study received approval from xxxx xxxxx ethics committee and all respondents provided consent to take part in this study.

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Data availability

All data from this study in survey format is stored by xxxx xxxxx and is available on request from xxxx. Informed consent was obtained from all subjects.

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Figures

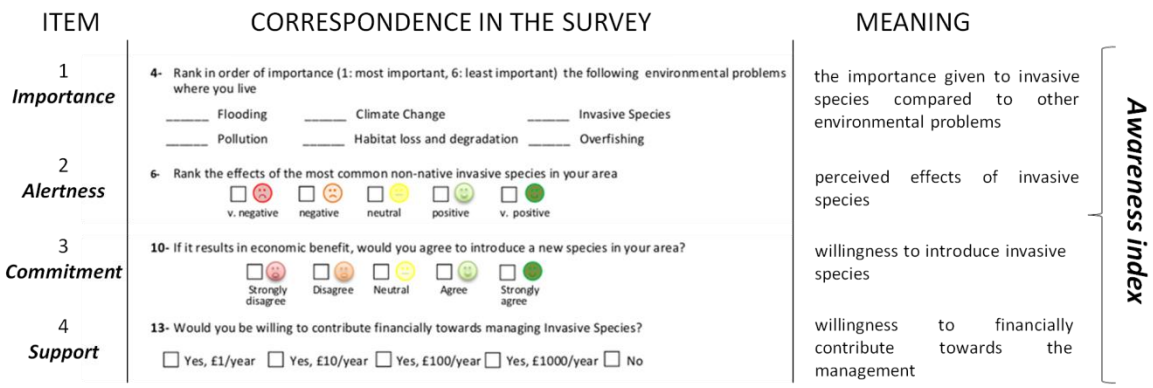
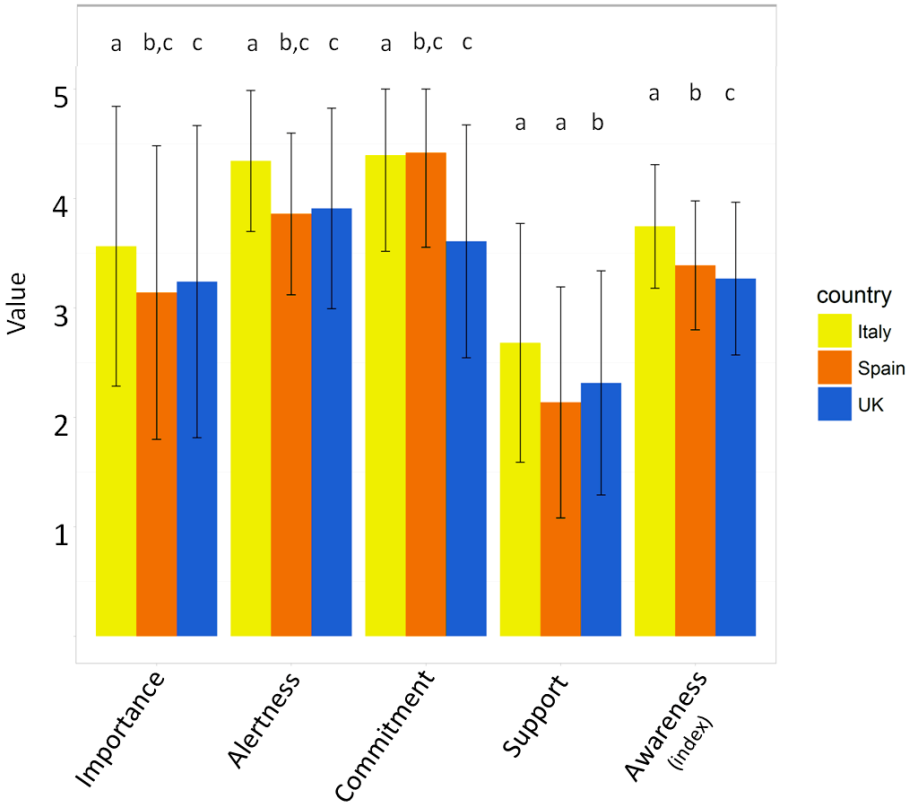


Figure 1. Number of items composing the ´awareness index´. their correspondence with the questions of the survey and their meaning.



877

878 **Figure 2.** Mean values in the Likert scale (±SD) of the different items (‘importance’
879 according to other environmental problems, ‘alertness' of the potential effect invasive
880 species may cause, 'commitment' to avoid the introduction and associated problems,
881 and 'support' contributing economically to manage invasive species) considered to
882 measure the level of ´awareness index´ and motivation/ implication towards invasive
883 species for the three countries surveyed: Italy (yellow), Spain (red) and United
884 Kingdom (blue).

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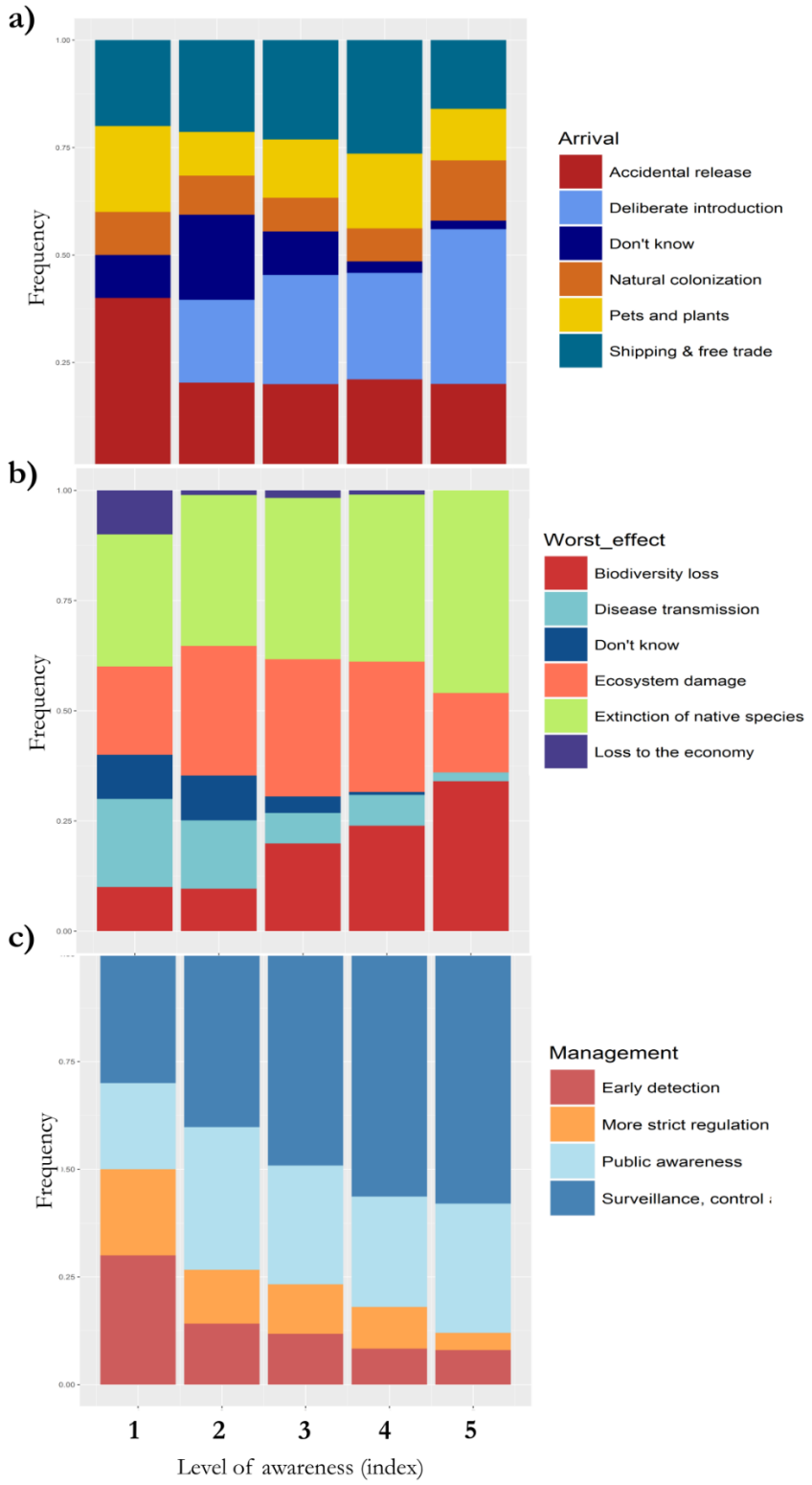
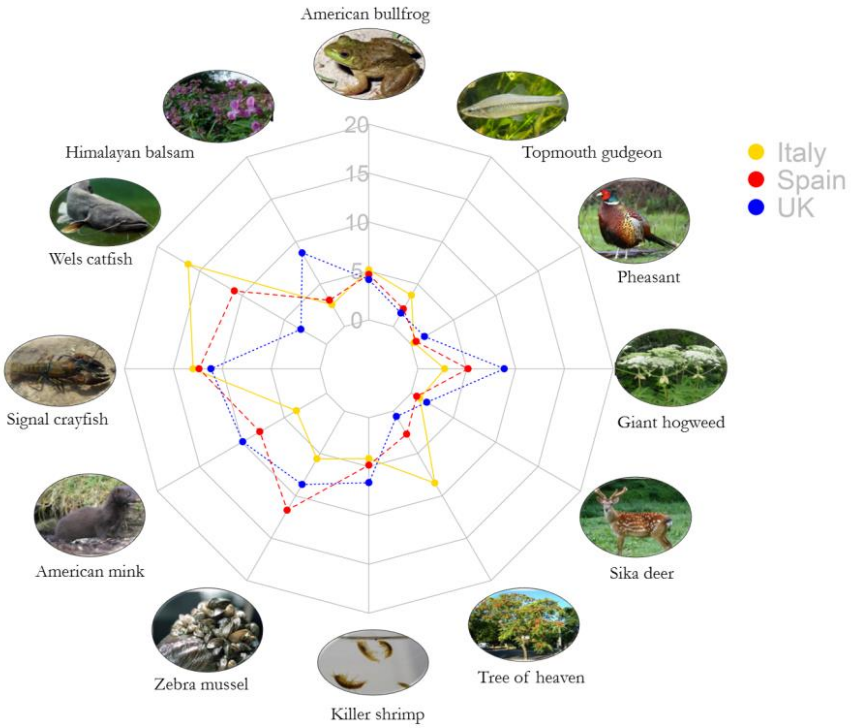


886

887 **Figure 3**. Number of responses (*Frequency*) regarding the causes of arrival (a),

888 worst effect of invasive species (b) and preferred management actions (c), according

889 to all respondents' level of ´awareness index´ (index), with 1 being the lowest and 5
890 being the highest.
891



892
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894 **Figure 4.** Spider chart representing the percentage of times the 12 different species
895 included in question 8 of the survey were considered to cause the worst damage by
896 respondents from Italy (yellow), Spain (red) and United Kingdom (blue).
897