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Ascertaining the Knowledge of the General Public and Stakeholders in the Forestry Sector to Invasive Alien Species—A Pan-European Study

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Abstract: Against the background of the phenomenon of globalisation, which has increasingly intensified in recent decades, invasive alien species (IAS) have led to biological invasions that have resulted in multiple negative effects on economies, human health, and especially on the environment. In order to control invasive alien species, preventive actions are considered the most effective methods. In this context, society can actively participate in the process of early detection and preventing the spread of these organisms, but there is a need to raise public awareness. In order for this process to take place in the most efficient way, it is necessary to initially evaluate the knowledge of the general public to IAS. Through a questionnaire that was circulated in ten European countries and had over two thousand respondents, this study aimed to investigate the level of knowledge of some stakeholders in the forestry sector regarding IAS. The results showed that a vast majority of respondents who participated in the study had heard about IAS and provided a correct definition of these organisms. Most of the respondents in this study heard for the first time about IAS from school, the Internet, or journal articles. Data analysis also showed that stakeholders in the forestry sector (foresters, forest owners, and members of environmental NGOs) were more likely than the other respondents to be aware of the impact of IAS. The results of this study offer an insight to researchers and decision makers assessing the differences of opinion regarding invasive alien species, and the necessary steps that could be adopted in the process of raising awareness in society.

Keywords: citizen science; online survey; biosecurity

1. Introduction

Through the transportation of goods and travelling, humans accidentally (and on occasion deliberately) transfer plants, animals, fungi, and microorganisms to new parts of the world, where they would not naturally have spread. Once these alien organisms,

that have overcome various biogeographical and ecological barriers, establish significant populations in the new territory, they may cause negative impacts to the ecosystem, i.e., they become invasive alien species (IAS) [1–6]. Due to globalisation, which has been intensifying in recent decades, alien species have resulted in multiple negative effects to economies, human health, but especially to the environment [5,7–14].

The results of the research project Delivering Alien Invasive Species Inventories for Europe [15] has found that about 15% of the more than 10,000 exotic species at the European level are potentially dangerous for European biodiversity and can be considered invasive. The dynamics of IAS records in Europe has shown that since 1950 more than one species has been established per year, and this trend shows no signs of decreasing [16,17].

In the context, in which IAS can easily pass between European countries without borders, the European Union (EU) adopted new regulations on the prevention and management of the introduction and spread of invasive alien species (Regulation EU No. 1143/2014) in order to address the problem in a coordinated and joint effort with all member states [3]. In addition, the EU's Biodiversity Strategy for 2030 proposes a commitment to significantly limit the introduction of IAS, and to decrease the number of Red List species they threaten by 50%.

Since the human factor is particularly important in the transfer of alien species, it is essential for individuals to be aware of the impact IAS have on the environment and society. In this context, the support of the general public may even be the key to the success or failure of IAS management measures [3,18–21]. Forest health monitoring can be performed by foresters and forest protection experts, but citizen scientists can also make major contributions to this process to the same extent [22]. Taking into account the cost/benefit ratio, both from an ecological and an economic point of view, preventive actions are recognised as being much more effective than control actions [23]. In this context, for society to actively participate in actions that could help prevent the spread of IAS, it is necessary to raise awareness among the general public regarding the threats of these organisms [3]. Yet, societies' perception of alien species and understanding of their impacts has to be thoroughly assessed in order to identify needs for awareness raising.

Because the "general public" is a very diverse category, for which awareness varies a lot, through this pan-European study we aimed to investigate the level of knowledge regarding IAS as well as the perception of several interested parties in the forestry sector (foresters, forest owners, and members of environmental NGOs) towards these organisms and the impact caused by them.

We hypothesised that respondents in this study perceive to a certain extent the impact of IAS, but there may be differences in knowledge and perception between the groups of stakeholders. In this context, we expected there to be a close relationship between the socio-demographic characteristics of the respondents and their perception, knowledge, and attitude regarding IAS.

Through a questionnaire focused on invasive pest species that circulated in ten European countries, this research studied the perception of citizens and stakeholders in the forestry sector regarding the IAS, following the socio-demographic characteristics to the answers provided in the survey.

2. Materials and Methods

2.1. Data Collection and Questionnaire Design

This study was carried out in 2020 in ten European countries (Austria, Belgium, Croatia, France, Hungary, Italy, Romania, Serbia, Slovenia, and United Kingdom). It addressed the perception of the public and several stakeholder groups in the forestry sector to the invasion and damage caused by oak lace bug (OLB) (*Corythucha arcuata* (Say, 1832) (Hemiptera, Tingidae)) to oak trees in Europe [24].

C. arcuata is an invasive insect that is predicted to cause major problems to oak tree and forest health in Europe, and which causes very distinctive and obvious signs of attack (damaged yellow leaves start appearing in July) that do not look normal even to people

with no ecological knowledge. This is very different from the invasion by plants or animals that may just look nice within the landscape and are only of concern to people with quite advanced ecological backgrounds (e.g., *Rhododendron* spp. and grey squirrels *Sciurus carolinensis* Gmelin 1788).

Thus, in addition to the questions about OLB in the questionnaire which was the basis of this research [24] was also added questions about IAS in general (Table 1).

Table 1. The questions related to the perception of invasive alien species (IAS).

Question	Possible Answers	
Q. 1 Have you ever heard about the term ‘invasive alien species’? Mark only one option.	A	Yes
	B	No
	A	TV
Q. 2 If yes, where have you heard about the term ‘invasive alien species’? Mark only one option.	B	Internet
	C	Newspaper or journal article
	D	School
	F	Other people
	G	I never heard of this term
Q. 3 What do you think the term invasive alien species means? Mark only one option.	A	Invasive alien species are native species that spread rapidly in their natural distribution
	B	Invasive alien species are foreign species
	C	Invasive alien species are species whose introduction and/or spread outside their natural past or present distribution does not threaten biological diversity
		Invasive alien species are species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity
	D	Other
	E	They revitalise degraded areas and/or enrich local biodiversity
	A	Causes damage to the economy
Q. 4 What are the effects of invasive alien species in general? Mark all applicable options.	B	Causes damage to the environment
	C	Causes the loss of biodiversity
	D	Affects people’s health
	E	I don’t think invasive alien species have any significant effects
	F	I do not know
	G	Other
	H	

Given that the term ‘invasive alien species’ is not really a formalised standard term across the entire field, the translation of the term in the questionnaire for each country is attached in Table 2.

Table 2. Translation of the term ‘invasive alien species’ in the languages of the countries where the questionnaire was distributed.

Country	Language	IAS Term Translation
Austria	German	invasive gebietsfremde Art
Belgium	Dutch	invasieve uitheemse soorten
Croatia	Croatian	invazivna strana vrsta
France	French	espèces exotiques envahissantes
Hungary	Hungarian	inváziv/inváziós idegenhonos faj
Italy	Italian	specie aliena invasiva
Romania	Romanian	specii alogene invazive
Serbia	Serbian	инвазивне стране врсте
Slovenia	Slovenian	invazivna tujerodna vrsta

As seen in Table 1, all questions were close ended, meaning with predefined answers. Question 1 had a binary answer (yes or no). Questions 2, 3, and 4 offered multiple possible answers. While Questions 1, 2, and 3 were single response questions, Question 4 was multiple response, which means that respondents had the opportunity to select more than one answer.

The questionnaire included some socio-demographic questions as well. We collected information on individuals’ country of origin, gender, age, and their affiliation to a cer-

tain target group (foresters, private forest owners, and members of environmental non-governmental organisations).

The questionnaire was originally designed in English and then translated into local languages of our target countries (Croatian, Dutch, French, German, Hungarian, Italian, Romanian, Serbian, and Slovenian). For each country, there was at least one contact person who was responsible for translation and distribution of the questionnaire.

The questionnaire was uploaded on the Google Forms platform and continued to be managed using the CAWI (computer-assisted web interview) method, an online questionnaire that respondents fill in by themselves [25,26]. The advantage of online questionnaires is that they are easily distributed via various channels to certain target groups [27]. The questionnaire was distributed between September and October 2020 by e-mail or through social media platforms such as Facebook, WhatsApp, and LinkedIn.

To reach several stakeholder groups in the forestry sector (foresters, private forest owners, environmental NGOs, etc.), a snowball method was used, and the questionnaire was distributed to relevant professionals and academic staff from the forestry sector. Thereby, the statements of the respondents regarding them belonging to a certain category of stakeholders were analysed and the questionnaire was distributed via various relevant channels to reach the under-represented groups.

The questionnaire was anonymous, and no personal data that would have made it possible to identify respondents were collected. Respondents were informed that the survey was conducted as part of a research project and that the results would be used in scientific publications.

2.2. Data Analysis

To investigate how socio-demographic characteristics of respondents were connected with their answers, the data were analysed using the same approach as that used in the initial study which was the foundation of this paper [24]. Since we received only 15 responses from the United Kingdom, the data from this country were not taken into account in the analysis process.

For Question 1, we used generalised linear mixed models (GLMM) with binomial error distribution and logit link, with country included as a random effect. For Question 4, the same model was chosen as for Question 1, but, because it is a binary model, we treated the answers as either 'Yes' or 'No' (For example, 'answer B—Causes damage to the economy' was analysed as 'Yes' or 'No'). For Questions 2 and 3, there was no need for data analysis, the data being presented in bar graphs to illustrate responses.

In the first step, a model was built that included the independent variables as fixed effects: regarding whether the respondent declared himself a forester (yes/no), forest owner (yes/no), environmental NGO member (yes, actively; yes, passively; no), forest visitor (once a day; several times a week; several times a month; several times a year; less often than that); gender (M/F); and age category (18–25; 26–35; 36–45; 46–55; 56–65; more than 65 years).

The next step consisted of comparing the completed model with each possible model through a model selection procedure based on Akaike's information criterion (AIC) [28]. In this way, the model with the lowest AIC value is considered the best, given the data and the set of candidate models.

The statistical analysis was performed using the R software [29] with the packages "MASS", lme4 [30,31], and ggalluvial [32].

3. Results

The questionnaire had a total number of 2084 respondents from all 10 European countries where the survey was distributed (Table 3). The majority of respondents were from Hungary (809) and the least number of responses came from the United Kingdom (15 respondents; hence, this was excluded from the analysis) followed by Italy (45).

Table 3. The number of respondents from each country participating in the study.

Country	Number of Respondents
Austria	51
Belgium	105
Croatia	142
France	102
Hungary	809
Italy	45
Romania	269
Serbia	363
Slovenia	198
United Kingdom	15
TOTAL (excluding UK respondents)	2084

The socio-demographic characteristics of the respondents highlighted that less than half were professional foresters, and that the majority of respondents, about two thirds, were male (Table 4). From the point of view of the socio-demographic characteristics of the respondents, there were also some overlaps. For example, 13% of respondents are both foresters and forest owners, and 10% are foresters and members of environmental NGOs at the same time. Additionally, only 6% of the respondents are female foresters.

Table 4. The socio-demographic characteristics of the respondents participating in the study.

Socio-Demographic Characteristics	Respondents' Self-Declaration	
Foresters	Yes	No
	37%	63%
Forest owner	Yes	No
	21%	79%
Environmental NGO member	Yes	No
	31%	69%
Gender	Female	Male
	37%	63%

A large majority of respondents (94%) declared that they had heard about IAS. Regarding socio-demographic characteristics, foresters ($z = 3.453$, $p < 0.001$), respondents who are connected to an environmental NGO, either actively ($z = 2.140$, $p = 0.032$) or passively ($z = 3.125$, $p = 0.002$), as well as frequent forest visitors (a once a day: $z = 3.218$, $p = 0.001$; several times a week: $z = 3.338$, $p < 0.001$; several times a month: $z = 3.393$, $p = 0.004$) were more likely to be familiar with the term.

The data analysis also showed that 39% of respondents knew the term ‘invasive alien species’ from school, 15% from the Internet, 14% from newspapers or journal articles, 11% heard about it from other people, 4% from the TV, and 12% from “other sources of information” (Figure 1). The remaining 5% of respondents were individuals who answered that they had never heard of this term.

Surprisingly, 90% of respondents were able to give the correct definition: ‘invasive alien species are species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity’. The remaining 10% of respondents selected one of the other provided definitions (Figure 2).

In order to analyse the extent to which the respondents were aware of the impact that IAS have on the environment, economy, and society, the questionnaire listed several options for the effects of these organisms, with the possibility of giving a multiple answer (several options). The answers provided by the respondents highlighted that in the public’s opinion, invasive alien species can have an impact on the economy, environment, biodiversity, and people’s health (Figure 3).

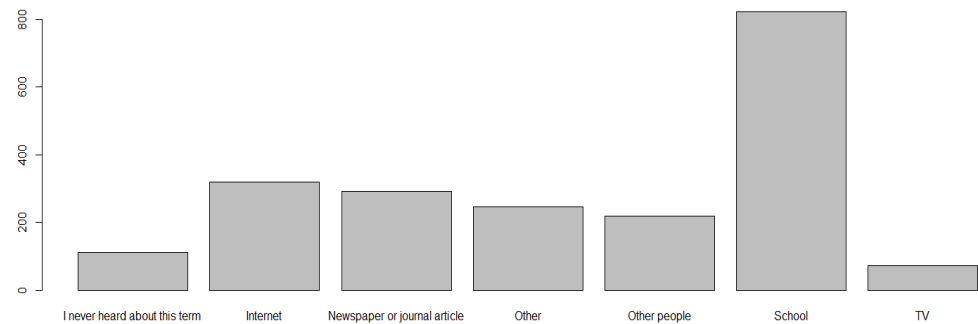


Figure 1. Respondents' answer to Question 2, "Where have you heard about the term 'invasive alien species'?" (n = 2084).

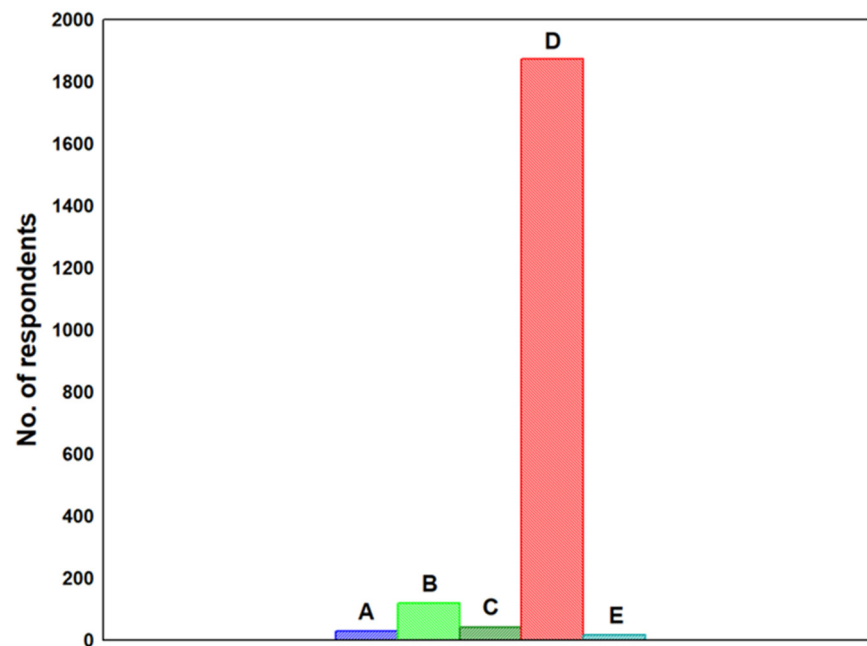


Figure 2. Respondents' answer to Question 3, "What do you think the term 'invasive alien species' means?". The letters above the columns represent the answer options in the questionnaire (see Table 1).

The data analysis showed that 59% of respondents felt that invasive alien species caused damage to the economy, and being a forest manager ($z = 4.435$, $p < 0.001$), forest owner ($z = -2.101$, $p = 0.036$), or connected to an environmental NGO (actively: $z = 2.874$, $p = 0.004$; passively: $z = 3.100$, $p = 0.002$) increased the likelihood that the individual had this viewpoint of IAS.

Almost three quarters of the respondents (73%) considered that invasive alien species were harmful to the environment and respondents who were connected to environmental NGOs ($z = 2.412$, $p = 0.02$) were more likely to have this opinion. Additionally, in the register of environmental protection, more than three quarters of respondents (76%) considered that invasive alien species caused a loss of biodiversity. Forest managers ($z = 2.840$, $p = 0.016$), respondents who were actively connected to environmental NGOs ($z = 4.694$, $p < 0.001$), and those who visited the forest several times a month ($z = 2.363$, $p = 0.018$) were more likely to hold this opinion.

Regarding the effects on society, only a quarter of respondents believed that invasive alien species affected people's health. Respondents who were connected to an environmental NGO (active: $z = 5.360$, $p < 0.001$; passive: $z = 3.132$, $p = 0.002$) were more likely to be of this opinion.

Only 9% of respondents believed that IAS revitalised degraded areas and/or enriched local biodiversity, and less than 1% of respondents believed that invasive alien species do not have significant effects on the environment, economy, and society.

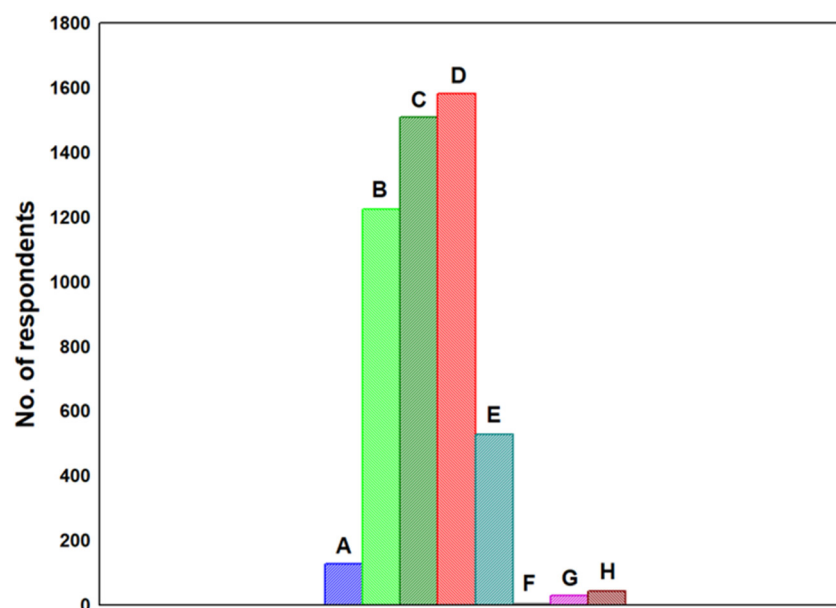


Figure 3. Respondents' answer to Question 4, "What are the effects of invasive alien species?". The letters above the columns represent the answer options in the questionnaire (see Table 1).

4. Discussion

Our survey highlighted that the majority of respondents have heard about, and gave a correct definition of, what invasive alien species are. Given that IAS are considered a serious threat to the environment, this finding suggests that there is a general public interest in the health of the environment as well as the integrity of biodiversity. A similar study evaluating the public perception of invasive species in Slovenia showed that 76% of respondents had heard about the term 'invasive alien species', while 62% also gave a correct definition of the term [33]. The difference between the studies can probably be explained by the fact that a significant part of the respondents in the current study were stakeholders from the forestry sector, which could have positively influenced the proportion of respondents who knew the term or at least who partially knew or could anticipate the definition and the effects caused by IAS. Additionally, the scope of our study (damage produced by OLB) could have contributed to increasing this percentage.

As expected, addressing stakeholders in the forestry sector, the proportion of respondents in this survey that were women was relatively low, approximately one third. This may be due to the fact that men are more likely than women to have activities in the forest [34], forest management being traditionally associated with men [35–38].

Predictably, stakeholders from the forestry sector were more likely to be familiar with the term 'invasive alien species'. Similar conclusions were reached by Höbart et al. [39] who found that there is a tendency for nature experts to emphasise more than the general public the importance of native species for the functioning of ecosystems at the expense of invasive species. Moreover, studies show that members of environmental organisations are prone to provide more support for nature protection [23,40], especially in invasive species control activities [41]. This result can be explained by the fact that stakeholders in the forestry sector and from environmental organisations know from their own experiences both a number of IAS and the related damage caused in forest ecosystems. Of these, it is worth mentioning (i) *Anoplophora glabripennis* (Motschulsky) (Coleoptera, Cerambycidae) which is considered to be one of the 100 most dangerous IAS [42] and which has a complex invasion history in Europe [43], and (ii) *Agrilus planipennis* Fairmaire (Coleoptera, Buprestidae) which has spreading rates of tens of km per year [44]. Moreover, the answers of the respondents

could have been orientated in this way by the starting point of this survey, which had an initial question focused on the invasion of oak lace bug, with the results being reported in another publication [24]. This hypothesis is all the more supported as Bălăcenoiu et al. (2021) showed that stakeholders in the forestry sector were more likely to have heard about oak lace bug (*C. arcuata*) than members of the public.

Regarding the main sources of information where individuals learnt about IAS, less than half of respondents learned about invasive species as part of their formal education. So, the results were likely influenced by the fact that a significant proportion of respondents in our study were foresters or members of environmental NGOs, many of them receiving specialised education in the field of natural resources (e.g., finished degrees/qualifications of forestry or biology). In the implementation of possible complex IAS control programs in the future, these results should be taken into account, especially since it has been shown that teachers and students who have been informed about the effects of IAS are more likely to accept and support the control of invasive species than those who are not previously informed in this regard [3].

Our results showed that the respondents were aware that IAS have a negative impact on the environment, economy, and society, which may indicate that there is a certain level of awareness of stakeholders in the forestry sector to the threat that these organisms constitute/pose. This result could be influenced by the context in which the questions were asked (against the invasion by *C. arcuata* in Europe). Citizens' perception of the impact of IAS is very important because it has been shown that respondents' acceptance for certain control methods is closely related to the impact these approaches have [41]. Thus, there are studies that show that the general public will also consider the fact that IAS can have positive impacts on the environment, e.g., on erosion control through soil fixation, ecosystem functioning, and landscape aesthetics [45,46]. Citizens can also consider the fact that IAS can have benefits on society, such as wood for domestic use (in the case of invasive tree species) often used for heating homes [46].

Given the fact that people are an important factor in the transfer of invasive species, if the knowledge base of the general public within Europe is in line with the results of this current study, then this will be advantageous in the fight against the negative effects of invasive species. In this sense, citizens could be integrated into projects aimed at controlling invasive species, especially since it is considered that citizen scientists can significantly contribute to the knowledge of biological invasions and their management [47]. However, the general public should initially be informed about the impact caused by IAS at all levels (economic, social and environmental) by implementing a complex program to raise awareness of the general public about IAS. Such a program is all the more necessary as citizens could represent an impediment to the control of invasive species [18,48,49]. For example, eradication actions can have ethical dilemmas. In the case of an attack by a quarantine species on a monumental old oak in an urban area, the cutting of this tree can cause a lot of protests. Thus, it would not be without interest to implement a pan-European project aimed at integrating citizens in the fight against the effects of biological invasions using citizen science. A great advantage of using citizen science is the fact that for such a pan-European project, the costs would be much lower compared to traditional scientific methods [47,50–54].

The results presented in this paper have certain limitations, strictly expressing the knowledge of the respondents, and not the attitude of all stakeholders targeted, because the sample selection did not take into account strict pre-established criteria so as to cover all target groups. There were big differences between the number of respondents in each country and the sample was not strictly representative, but the results may be indicative for educators and decision makers.

5. Conclusions

Stakeholders in the forestry sector were more likely than the other respondents to have heard about invasive alien species, to know the definition of the term, and be aware of the impact of these organisms.

Our results could form a foundation basis for further research investigating the public's perception of invasive alien species, and how to increase public awareness to the issues surrounding them.

The findings from this survey may provide a guide to help decision makers and environmental agencies in trying to change or influence certain attitudes by formulating appropriate communication messages.

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