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Unprepared to Deal with Invasion: Pre-Service Teachers' Perception, Knowledge and Attitudes toward Invasive Species

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Abstract: The serious and growing impacts of invasive alien species (IAS) on the planet make it necessary to include this issue with greater determination in educational programs, with the aim of generating citizens capable of dealing with this environmental problem in a sustainable way. Likewise, the management of IAS represents a clear socio-scientific issue (SSI), which gives greater interest to its inclusion in school. At this point, future teachers play a key role, so that their knowledge, perceptions and attitudes on the subject must be evaluated. In order to deal with this objective, a questionnaire was filled out by 400 students of the degrees in early childhood education and primary education of the Universities of La Rioja (UR) and the Basque Country (UPV/EHU), Spain. Our results show that pre-service teachers do not perceive impacts of different types generated by IAS, and they show a clear lack of knowledge about transmission vectors. Likewise, they do not support various control measures, especially slaughter of invasive vertebrates, related to affective dimensions. These results highlight the need to work toward an appropriate integration of this issue at different educational levels, training students and educators, fostering favorable attitudes toward a sustainable management of IAS.

Keywords: invasive alien species; socio-scientific issues; pre-service teachers; impacts perception; vector knowledge; control attitudes

1. Introduction

Invasive alien species (IAS) represent one of the main concerns about the planet's biodiversity [1–3]. The IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) includes IAS among the five main causes of the deep global change that has been occurring in nature during the last 50 years [4]. Likewise, this problem has been intensifying in recent decades [5], so that accumulated IAS records have increased by 40% since 1980 [4]. The effects on biodiversity caused by these species are so intense that they are leading to a process of biotic homogenization of the Earth's surface [6,7]. In the north of the Iberian Peninsula, where the present study was carried out, there are many examples of IAS outcompeting local endangered species, highlighting the American mink (*Neovison vison*) severely affecting the European mink (*Mustela lutreola*) [8], or the signal crab (*Pacifastacus leniusculus*) partly responsible for the recent extirpation of the white-clawed crab (*Austropotamobius pallipes*) in

many streams [9]. However, the generated impacts go further, with important human well-being and socioeconomic effects [10], fundamentally concerning agriculture, forestry, energy and health sectors, generating associated costs for their control and eradication, and reducing ecosystem services [2,11].

Taking into account that IAS entail an intense and growing problem, it is urgent to work from different approaches and disciplines with the aim of reducing their impacts and avoiding new processes of biological invasions throughout the planet. However, public perception of invasive species and attitudes toward their control are controversial [12–15]. In this sense, IAS represent one of the clear and well-documented examples of socio-scientific issues (SSI) [16], a theme that emerges from the nexus of science and society, involves moral, ethical and financial aspects, and generates social conflicts [17,18]. Conflicts around IAS are mainly related to necessary measures for the correct IAS management, such as the slaughter of charismatic animals [19,20] or biosecurity measures for the multiple users of especially vulnerable ecosystems such as rivers [21,22].

These conflicts seem to be related to the scarce knowledge of citizens, highlighting aspects such as the impacts caused by these species or the benefits that their correct management and eradication would imply [23–25]. In this sense, numerous authors have considered that citizenship literacy is the key factor in the development of safe and positive attitudes toward invasive species management programs [26–29]. In accordance with the concept of Education for Environmental Citizenship (EEC; [30,31]), it is necessary to guarantee an adequate level of knowledge around this topic to generate skills, values, attitudes, and competences in students that favor the sustainable management of this problem.

Education about IAS is especially relevant for students during their early educational stages, since childhood represents a key period for the introduction of knowledge related to biodiversity [32,33]. Moreover, children's and adolescents' attitudes about nature are still influenced mainly by television and Internet content, based on a few iconic and charismatic species, generally exotic, that enhance the so-called "cuddle factor" [34]. These aspects, joined together with others such as poor contact with nature [35,36], explain the limited knowledge of students about local biodiversity [33]. It has even been observed that children show greater interest in the protection of these charismatic and exotic species than in the biodiversity of the place where they live [34]. In Spain, the educational curricula for primary school [37], secondary school, and baccalaureate degree [38] deal at different times with the main problems associated with the loss of biodiversity. However, these curricula do not specifically mention invasive species until the first year of baccalaureate in the optional subjects of biology and geology (stage after compulsory education). This scarce training of students regarding IAS has also been observed in other countries [25]. Undoubtedly, it contributes to the limited knowledge around the management of IAS, generalized to all ages and countries [39].

Taking into account the interest in these early educational stages and the potential of teachers to greatly influence students' environmental citizenry, particularly their knowledge, values, beliefs, and actions toward the environment [40], IAS scientific literacy among pre-service teachers is really determinant [41]. Teachers seem to be the key to restructure educational processes and institutions toward sustainable development; therefore, teachers' knowledge and competences are crucial [42]. Remmele and Lindemann-Matthies [39] underlined the importance of pre-service teachers in making their students understand the reasons for certain IAS management programs. However, teaching about biodiversity conservation issues as IAS, which involve ecological, economic, and social aspects, presents difficulties for teachers [43]. The controversial nature of environmental issues and the intrinsically complex and abstract construct of biodiversity [44] might hinder teachers [45].

In order to work toward IAS scientific literacy, it is essential to determine students' knowledge and attitudes about IAS at different educational levels to identify elements that can be introduced in educational programs [25]. However, despite the enormous interest, few studies have dealt with this issue, and they have been barely explored in relation to students' knowledge, perceptions, and attitudes about IAS. In the specific case of student teachers, only in Germany has this matter been recently studied [39]. In Spain, where IAS represent a problem of special relevance [46], García-Llorente et al. [6]

and Bardsley and Edwards-Jones [47] evaluated social perceptions and attitudes among stakeholders and laypeople (over 18 age) in the surroundings of Doñana National Park and Mallorca island, respectively. However, there is no research of this type aimed at students of any educational stage, including pre-service teachers.

Based on these antecedents, the general objective of this study was to determine the perceptions, knowledge, and attitudes of pre-service teachers of early childhood and primary education about IAS. The specific objectives of this research were: (i) to investigate whether pre-service teachers perceive and are aware of the different types of impacts that IAS cause nowadays; (ii) to determine their ability to identify the main types of IAS transmission vectors; (iii) to assess their attitudes toward different invasive animal control methods; and (iv) to determine if a more realistic perception of impacts and knowledge of transmission vectors translate into positive attitudes toward control measures.

It should be noted that this study is part of a wider research aimed at characterizing how pre-service teachers understand the subject of IAS and the problems associated with it as a starting point in order to design novel teaching and learning sequences around SSI related to IAS.

2. Methodology

2.1. Sample

The sample consisted of 400 students (71% female, average age 20) of the bachelor's degree in early childhood education and the bachelor's degree in primary education of the Universities of La Rioja (UR; n = 132) and Basque Country (UPV/EHU; n = 268), all being students enrolled in a science education subject. The universities where this research was carried out are located in bordering regions, and they receive students from a wide geographical area in the north of the Iberian Peninsula, with diverse climatic characteristics but the same environmental problems, such as IAS matter.

Each member of the research team collected the data between April and May 2019 and oversaw the process of completing the online questionnaires with portable devices. Prior to participation, students were informed about the goals of the research, duration, procedure, and anonymity of their data. Participation was voluntary, and it was possible to withdraw participation at any time.

2.2. Research Instrument

As previously commented, this research is part of a broader investigation, for which a questionnaire was designed to evaluate different aspects related to IAS. In this study, the following aspects were developed: (i) perception of the impacts generated by IAS; (ii) knowledge of IAS transmission vectors; and (iii) attitudes toward IAS control. The questionnaire was developed based on various questionnaires previously used by other authors [23,25,48,49]. Several questions were adapted to the specific problems of the study area related to IAS, based on the authors' extensive experience in this subject.

In order to assure the content validity and viability of this research instrument, multiple meetings between the authors were conducted on its design, and it was also previously tested through a pilot implementation with a group of 20 students enrolled in a bachelor's degree in early childhood education at the University of La Rioja. Only a few minor changes were included to improve the final version.

Questions in the final form considered in the present study, after its validation and modification, are shown in Figure 1. The questionnaire included descriptors of different demographic variables (Q1–Q3); questions referring to previously cited topics: (i) perception on the impacts generated by IAS (Q4); (ii) knowledge of IAS transmission vectors (Q5); and (iii) attitudes toward IAS control (Q6–Q9). Q4 (4 items) included the four main types of impacts generated by invasive species, using a Likert scale to indicate the degree of agreement (from "strongly disagree" to "strongly agree"). Q5 included the six main transmission vectors for IAS, all of them described in the study area, with the aim of identifying whether the students recognized them as vectors. Finally, the block of questions related to attitudes

toward the control of these species (Q6–Q9) included general aspects (Q6 and Q9), and other specific aspects about two species widely distributed in the study area, such as the American mink (Q7) and signal crab (Q8).

Descriptors

Q1. Currently you are studying:

- Bachelor's Degree in Childhood Education
- Bachelor's Degree in Primary Education

Q2. What did you study prior to University?

- Baccalaureate of Arts
- Baccalaureate of Humanities
- Baccalaureate of Social Sciences
- Baccalaureate of Health Sciences
- Baccalaureate of Science and Technology
- Upper Vocational Training in the field of nature
- Another Upper Vocational Training

Q3. Do you belong to any organization of the following type? (Check all the items that you consider)

- Ecologist o naturalist
- Hiking, climbing
- Hunting
- Fishing
- Another type of association related to nature
- None of the above items

Perceptions of IAS' impacts

Q4. Indicate the degree of agreement or disagreement in relationship with the following statements (1. Strongly disagree; 2. Disagree; 3. Indifferent; 4. Agree; 5. Strongly agree)

	1	2	3	4	5
IAS damage local biodiversity					
All IAS cause ecological impacts					
IAS have a high economic impact					
IAS have an impact on human health					

Knowledge of IAS' transmission vectors

Q5. What are the entry routes for IAS into a new territory? (Check all the items that you consider)

- Voluntary introduction by citizens
- Releasing of pets to the environment
- Involuntary transportation on objects imported from other territories
- Involuntary transportation on the soles of shoes or other personal items
- Farm escapes
- Introduction of species used in gardening

Attitudes towards IAS control

Q6. IAS should try to be eliminated when: (Check all the items that you consider)

- Causing significant economic impacts
- Causing significant ecological impacts
- Causing significant damage to health
- They must always be eliminated
- They must never be removed

Q7. What methods would you use to control the invasive alien mammal population like the one in the image? (Check all the items that you consider)

- Sterilization
- Trapping and subsequent slaughter
- Capture and return to their natural territory
- None, once they have been introduced, I would leave them in the place where they were found.

Q8. What methods would you use to control the invasive exotic crab population? (Check all the items that you consider)

- Allowing their capture and slaughter by the forest rangers
- Allowing their capture and slaughter by all citizens
- Using of pesticides in the river sections where they are located
- None, once they have been brought in, I would leave them in the place where they were found.

Q9. Indicate the degree of agreement or disagreement with the following statements. (1. Strongly disagree; 2. Disagree; 3. Indifferent; 4. Agree; 5. Strongly agree)

	1	2	3	4	5
Forcing disinfection of all fishing materials each time they are used to avoid the dispersal of IAS					
When a person who is fishing catches an invasive fish, he or she must kill it, without being able to return it alive to the river					

Figure 1. Online form used in this research. Descriptors (Q1–Q3); Perception of impacts generated by invasive alien species (IAS) (Q4); Knowledge about IAS transmission vectors (Q5); Attitudes toward IAS control (Q6–Q9). * IAS shown in the images are the following: Q7, American mink (*Neovison vison*); Q8, signal crab (*Pacifastacus leniusculus*), both widely distributed in the study area.

2.3. Data Analysis

Percentages of the chosen answers given to each question were calculated and bar graphs were created by the SigmaPlot program (v10.0; Systat Software Corporation: SanJose, CA, USA). Likewise, according to the methodology proposed by other authors [23,25,49], a series of scores was calculated for questions Q4 and Q5.

Q4 contained four items and the response possibilities had values from 1 to 5 on a Likert scale, from "strongly disagree" to "strongly agree". The mean value of the four items was calculated for each student, which ranged between 1 and 5, and it was called "Impact Perception Score" (IPS). Likewise, for the same question, the mean value of each of the four items was calculated for all the students. These mean values were plotted, ± standard error, using column graphs made by the SigmaPlot v10.0 program.

In Q5, the number of correct answers was calculated for each student corresponding to the number of vectors identified by each one, and this value was called the "Vector Knowledge Score" (VKS).

Using the IBM SPSS Statistics program (v26.0; IBM Corporation: Chicago, IL, USA), Spearman's correlation analysis was carried out between the two scores (i.e., IPS and VKS) calculated for each student and between each of them with the other responses of the survey. Specifically, correlation was calculated between the IPS and VKS and the following items related to attitudes toward IAS: IAS must be always eliminated (fourth option of Q6); the four answers referring to the American mink control measures (answers to Q7); the four responses referring to signal crab control measures (in Q8); and the two items of Q9. In the case of the answers to Q6, Q7 and Q8, a value of 0 or 1 was assigned to each student, depending on his or her choice: correct (1) or not (0) for each answer. Values of Q9 sections, according to a Likert response scale, were calculated in the same way that was described for Q4, conferring values from 1 to 5, from "strongly disagree" to "strongly agree".

Finally, in order to determine the possible influence of certain demographic aspects, a non-parametric Mann–Whitney U test was carried out between groups using the IBM SPSS Statistics 26.0 program. This test detects whether a median observation in one group is significantly greater/smaller than that of the other group. Comparisons were developed for all the variables mentioned in the previous paragraph (i.e., IPS, KVS, the fourth option of Q6, the four answers to Q7 and Q8, and the two items of Q9) and between the following groups: (i) respondents who studied, prior to university, baccalaureate in natural and health sciences compared to others; (ii) respondents from the bachelor's degree in early childhood education and the bachelor's degree in primary education; (iii) respondents who belonged to any of the natural organization shown in Q3 compared to others.

3. Results

Among the 400 students who filled in the form, 299 were students of the bachelor's degree in early childhood education and 101 of the bachelor's degree in primary education. Prior to university, 81 students had completed a baccalaureate in earth and health sciences, the only one that contains the subject of biology, which included content related to IAS. Only 26 students among the respondents belonged to different environmental organizations, which were included in Q3 of the questionnaire.

3.1. Perception of IAS Impacts (Q4)

Most of the students believed ("agree" or "strongly agree") that IAS cause damage to local biodiversity (82%; Figure 2A). However, their perception of ecological, economic and human health impacts was lower (54%, 48%, and 63%, respectively; Figure 2A). In the perception section, it stood out that 26% of the respondents "disagree" or "strongly disagree" with the fact that IAS cause ecological impacts, despite their close relationship with local biodiversity (Figure 2A). Likewise, 52% and 37% of the students did not recognize the economic damages produced and the damages to human health, respectively, because they did not mark the options "agree" or "strongly disagree" (Figure 2A).

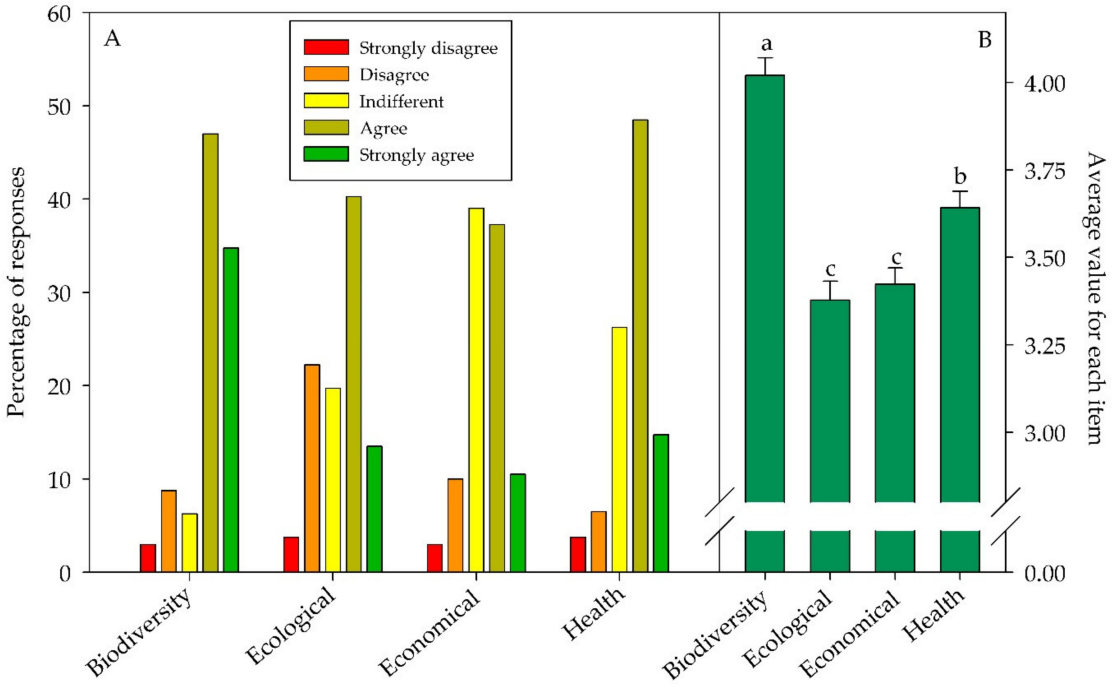

Figure 2. Pre-service teachers' responses about the perception of IAS impacts (Q4). (**A**) frequency (%) of each answer for each item. (**B**) mean value ± standard error of all the responses for each item; different letters (a, b, c) in Figure B indicate significant differences between the mean values of the items ($p < 0.05$).

By calculating the mean value of all the responses related to each of the four items of Q4, the previous observations were statistically confirmed ($p < 0.05$; Figure 2B). Students perceived IAS impacts on local biodiversity with an average value slightly higher than 4 (out of 5), which was statistically higher than the rest of the impacts (Figure 2B). In turn, ecological and economic impacts were the least clearly perceived, with values significantly lower than the impacts on human health (Figure 2B).

3.2. Knowledge of IAS Transmission Vectors (Q5)

Figure 3 shows percentages of choice of the different elements/activities proposed as transmission vectors (Q5). Voluntary release by citizens and involuntary transport of imported objects were the options selected by a high percentage of students, 72% and 77%, respectively (Figure 3). The introduction of gardening species or the release of pets remained in values between 60% and 70% (Figure 3). Finally, fewer than half of the students knew that IAS may be transferred on personal objects such as shoe soles or introduced through the escape of certain exotic species from farms (Figure 3).

3.3. Attitudes about Control Methods (Q6–Q9)

About 80% of the students considered that IAS should be eliminated when causing ecological damage or damage to human health (Q6, Figure 4). This percentage decreased to 42% in the event that IAS generate economic damage, and only 13.5% of the students considered that IAS should always be eliminated. On the contrary, 9% of students considered that IAS should never be eliminated (Figure 4).

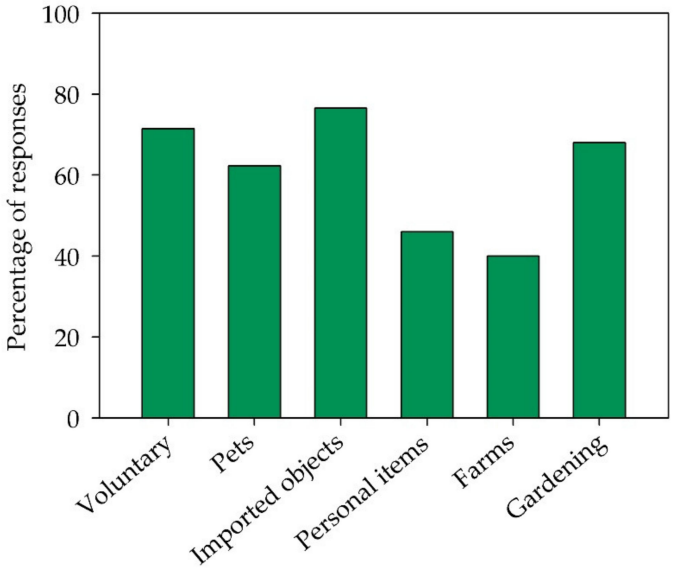

Figure 3. Pre-service teachers' responses (%) about IAS transmission vectors (Q5).

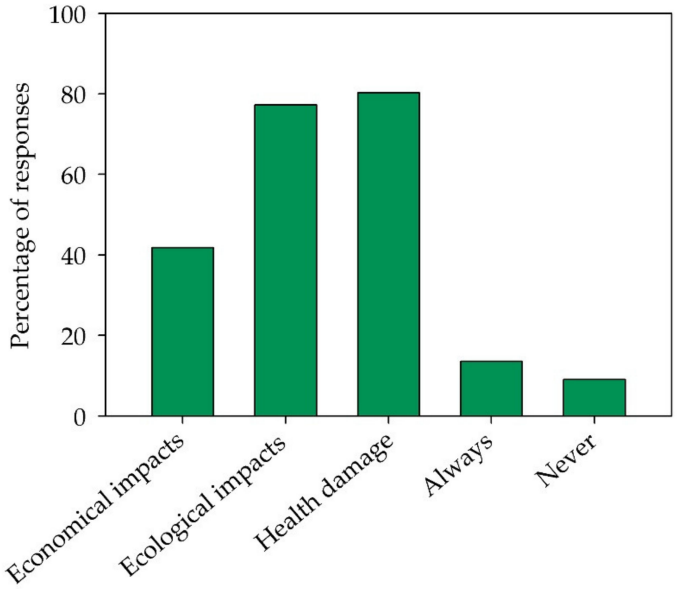

Figure 4. Pre-service teachers' responses (%) relative to IAS control (Q6).

Attitudes toward the control of invasive species were assessed using two widely spread species in the study area, a vertebrate (American mink, Q7) and an invertebrate (signal crab, Q8). Figure 5 shows pre-service teachers´ responses obtained in relation to the control of these two invasive species. Among the three measures proposed for American mink, 75% of pre-service teachers considered that it should be captured and returned to its natural environment, while sterilization (22%) or its capture and subsequent slaughter (3%, the current measure used to control the populations of this species in the study area) were hardly supported by the students (Figure 5A). Sixteen percent of the students considered that no control method should be carried out and minks should be left in the environment where they were found (Figure 5A).

In relation to the signal crab (Q8), the percentage of students in favor of its slaughter was much higher, although it was not the majority (Figure 5B). Almost half of the students (49%) supported its killing by the forest rangers, falling to 11% supporting the killing by the citizens. Eight percent supported the use of pesticides to control this species, while 40% were in agreement with not carrying out any control method (Figure 5B).

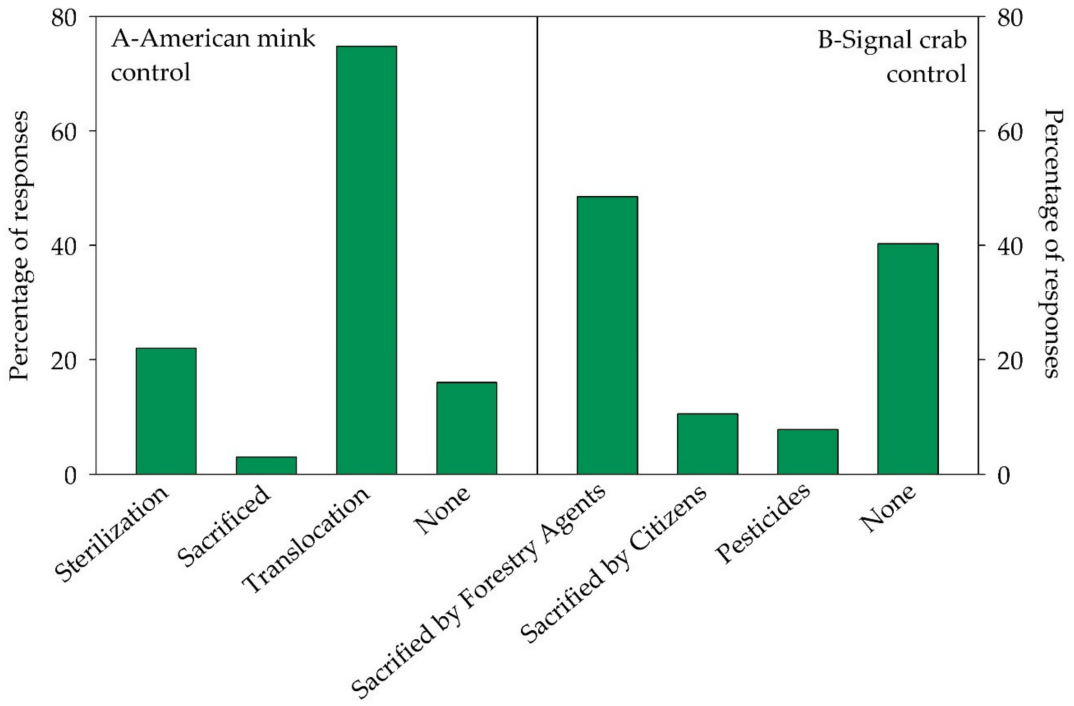

Figure 5. Pre-service teachers' responses (%) relative to the control of IAS American mink (**A**) Q7 and signal crab (**B**) Q8.

Pre-service teachers' attitudes toward the control of invasive species were also assessed by means of Q9. Figure 6 shows the results of the two items of Q9 related to IAS control during fishing activities, which showed very different responses. Sixty-eight percent of the students marked "agree" or "strongly agree" in preferring to disinfect all fishing materials each time they are used to avoid IAS dispersion, and only 11% were against it ("disagree" or "strongly disagree"; Figure 6A). However, the majority of students once again rejected measures related to the slaughter of animals. Only 15% of the students were in favor ("agree" or "strongly agree") of slaughtering an invasive fish when it is caught by an individual without being able to return it alive to the river (Figure 6B).

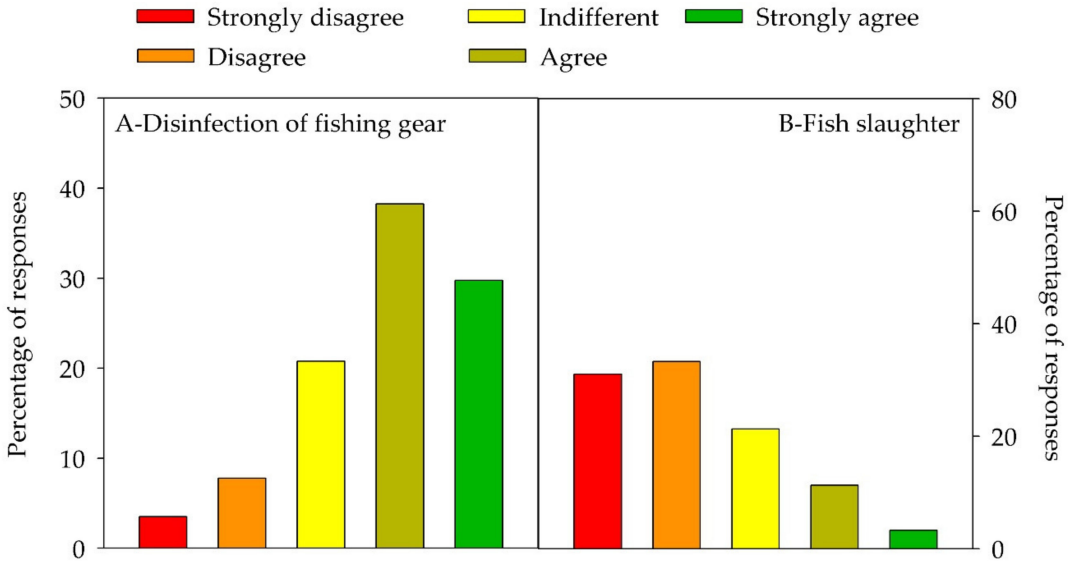

Figure 6. Pre-service teachers' responses (%) related to disinfection of fishing materials and to fishing and slaughtering invasive fish (Q9).

3.4. Correlations between the Different Items of the Survey

Table 1 shows a significant correlation between IPS and VKS scores ($p < 0.05$), although Spearman correlation index (0.307) indicates a weak correlation between them. The rest of the correlations between variables, analyzed pairwise, always showed a coefficient lower than 0.3, although they were significant in some cases, probably favored by the large size of the sample (Table 1). In any case, it was not a strong correlation, but it indicated that those pre-service teachers who had higher IPS and VKS tended to be more prone to always eliminate IAS; they were opposed to maintaining invasive American minks and signal crabs in the ecosystems where they are found, and they were favorable to sterilization and translocation of American mink. Likewise, they were more prone to the killing of signal crab by the forest rangers, to the disinfection of fishing materials, and to the killing of invasive fishes by fishermen (Table 1). However, under no circumstances was a higher value in IAS perception or knowledge scores correlated with support for the killing of American mink or signal crab by citizens.

Table 1. Spearman correlation coefficients between the Impact Perception Score-IPS (based on Q4) and the Vector Knowledge Score-VKS (based on Q5), and the different elements related to attitudes toward IAS control (Q6–Q9). Asterisk * indicates that the correlation was significant ($p < 0.05$).

Item	IPS	VKS
VKS	0.307 *	
Always eliminate IAS	0.197 *	0.089
Mink sterilization	0.117 *	0.136 *
Mink slaughter	0.055	0.093
Mink translocation	0.157 *	0.186 *
Mink none	−0.160 *	−0.205 *
Crab slaughtered by forestry agents	0.150 *	0.229 *
Crab slaughtered by citizens	0.020	−0.023
Crab pesticides	−0.067	−0.086
Crab none	−0.134 *	−0.161 *
Obligating to disinfect	0.298 *	0.242 *
Invasive fish must be killed	0.183 *	0.171 *

3.5. Groups Comparison

Table 2 shows the items of the questionnaire that presented significant differences between some of the groups studied, according to the Mann–Whitney U test. It should be noted that the pre-service teachers who previously studied baccalaureate in natural and health sciences presented higher IPS values compared to the rest (Table 2). Likewise, the student teachers who belonged to different environmental organizations knew how to differentiate among the transmission vectors better. Pre-service teachers who belonged to any of the previous groups were more favorable to American mink sterilization and signal crab slaughtering by citizens, although there were no significant differences compared to the rest among the majority of management measures. Finally, there were no significant differences in any of the items between the students of the bachelor's degree in early childhood education and the bachelor's degree in primary education (Table 2).

Table 2. Results of means comparison using the Mann–Whitney U test for different aspects of the form and different descriptors evaluated. When there are significant differences ($p < 0.05$), it is indicated with a number (0 or 1) associated with the element that had a higher value between the two compared. When significant differences do not exist, it is indicated with a script (-).

Item	Baccalaureate Natural-Health Sciences (0)–Other Baccalaureates (1)	Early Childhood (0)–Primary (1)	Nature Association (0)–No (1)
IPS	0	-	-
VKS	-	-	0
Always eliminate IAS	-	-	-

Table 2. *Cont.*

Item	Baccalaureate Natural-Health Sciences (0)–Other Baccalaureates (1)	Early Childhood (0)–Primary (1)	Nature Association (0)–No (1)
Mink sterilization	-	-	0
Mink slaughter	-	-	-
Mink translocation	-	-	-
Crab slaughtered by forestry agents	-	-	-
Crab slaughtered by citizens	0	-	0
Crab pesticides	-	-	-
Crab none	-	-	-
Obligating to disinfect	-	-	-
Invasive fish must be killed	-	-	-
Score perception of impacts	-	-	-

4. Discussion

Taking into account the intense environmental degradation that ecosystems are currently subjected to, more sustainable environmental behavior and management are necessary to sustain human well-being [50]. With this objective, EEC promotes pro-environmental behavior by means of active participation of citizens in moving toward sustainability [51,52], and therefore an adequate knowledge that favors the acquisition of the necessary skills and attitudes is required [31]. The different aspects that EEC promotes include the knowledge of ecological concepts and processes that provide the foundations for understanding the human impact on ecosystem functioning and ecosystem services [31], as is the case of IAS, which represents one of the main threats to biodiversity worldwide [2].

In the present work, we have determined that future early childhood and primary education teachers mostly perceived that IAS cause significant damage to local biodiversity, although they had limitations when identifying the impacts of another typology. A lower percentage of participants identified IAS as responsible for human health or economic damage, according to previous studies carried out among stakeholders [48] and university students in the US [25]. Pre-service teachers also perceived with less clarity other ecological conditions generated by IAS, which reflected an incomplete view of basic ecological processes and a poor understanding of concepts related to complex natural systems [53,54]. In general, these results showed a limited perception of IAS impacts by the students of the bachelor's degrees in early childhood and primary education, in agreement with previous studies carried out in Spain among the adult population around the Doñana National Park [6] and stakeholders in Mallorca [47].

Pre-service teachers of early childhood and primary education also had difficulties recognizing different IAS transmission vectors, especially the involuntary transport on the soles of shoes and other personal objects, or the escape from farms. It is worth mentioning that the escape from farms has represented the focus of the entry of American mink into Spain since the 1960s [55]. Regarding the lack of awareness of the involuntary transport on personal objects, pre-service teachers seemed not to be aware of their own role as potential IAS vectors. This unawareness was especially relevant in the case of the fluvial ecosystems of the study area, where there are many microscopic IAS or species with microscopic phases in their life cycle that generate important ecological and economic impacts, such as the IAS used as examples in this study (i.e., the signal crab [9]) or other relevant species like the zebra mussel [56] or *Didymosphenia geminata* [57]. Dispersal of these species and others is involuntarily carried out by citizens in their various forms of contact with rivers [58].

Several public administrations in the study area have designed numerous educational campaigns on invasive species since the end of the 20th century. These campaigns have usually focused on species such as the American mink or the zebra mussel, highlighting the educational material of the

project LIFE Lutreola Spain, recently developed in the communities of the Basque Country and La Rioja (http://lifelutreolaspain.com/en). However, the results obtained in the present study indicate that students are still not perceiving the seriousness of the problem. This could be related to the scant and/or sporadic treatment of this topic, almost exclusively in the field of non-formal education or even due to the design behind the educational materials. In this sense, Waliczek et al. [25] indicated the need to include this topic in educational curricula, with the aim of improving students' training. The same authors considered that this topic should pay special attention to IAS impacts and their control [59]. The present results, together with previous evidence (e.g., [39]), highlight the relevance of an appropriate education, either formal or informal, about IAS. This education should lead students and pre-service teachers to understand IAS potential threat to biodiversity and the negative impact on the appropriate functioning of the whole socio-ecological system, including economic and also human health threats. Future teachers, as multipliers of tomorrow, might be better equipped to deal with teaching and learning challenges related to complex biodiversity issues such as biological invasions. In the same way, according to pre-service teachers´ limited knowledge about their own role as potential vectors for involuntary IAS transmission, when treating this issue it is especially relevant to promote the preventive measures related to biosafety, which should always be carried out by all citizens to mitigate IAS spreading [60,61].

These limited perceptions about IAS impacts and the scarce knowledge about transmission vectors also represent obstacles to the development of management programs. In this sense, the European Network for Environmental Citizenship (ENEC, 2018) itself recalls that it is necessary to have an adequate body of knowledge to be able to act and participate in society as a sustainable agent. Likewise, this lack of knowledge detected among pre-service teachers makes it difficult to introduce this topic into the lessons as SSI, despite the fact that its treatment represents a good opportunity to work on scientific education [62]. The inclusion of SSI favors informed decision-making among students, participation in debates, and their own understanding of science as determining elements in their lives [63]. To achieve this goal, teachers require the scientific knowledge necessary for its treatment and reasoning [64], in order to avoid further confusion among students on a complex topic with multiple components to consider.

In line with this scarce knowledge of pre-service teachers, in the present research only 14% of the respondents considered that IAS should always be eliminated. When asked about their possible elimination if they cause a specific impact, this percentage increased significantly, especially if ecological or human health impacts were considered. These results indicate that pre-service teachers are not aware that all IAS, by definition, cause impacts of a different nature and, therefore, their elimination implies benefits of different types. Therefore, these results, together with other recent evidences from Germany [39], highlight the need for pre-service teachers to understand the reasons for carrying out certain IAS management strategies. The scant support for generalized IAS control was different, depending on the species in question. The surveyed students were especially against the American mink's slaughter, despite the fact that this is the measure used to control the populations of this species in the study area, with successful results in recovering European mink populations (e.g., MAGRAMA, 2013; LIFE Lutreola Spain, 2017).

The limited support for the slaughter of American mink is consistent with the greater rejection generated by the control of invasive mammals among society in relation to other taxa [65,66] associated with the "cuddle factor" and these organisms' aesthetics [49]. Likewise, human beings tend to empathize more with species similar to us, fundamentally mammals, for which greater care and conservation efforts are exercised [67]. In contrast, there is a greater social rejection of other types of organisms, mainly invertebrates [68], which could favor greater support for the sacrifice of invasive taxa of this type, according to the present study in relation to the signal crab. However, the percentage of students who would not carry out any action to eliminate this crab from the colonized ecosystems was very high (40%), despite the significant impacts that it generates in the study area [9,69], and unlike the 84% of the students who supported the American mink's control, although rejecting its sacrifice. The greater

resources devoted to conservation of mammals such as the European mink seem to encourage citizens to support the control of other invasive mammal species that reduce their populations. Interest in controlling these species seems logical, taking into account that students especially perceive IAS impact on biodiversity and they feel a greater affinity for mammals.

Rejection of the American mink's slaughter in this study was extended to other vertebrates, such as invasive fish, despite the fact that Iberian Peninsula rivers are ecosystems especially affected by the presence of invasive exotic fish species [70,71], which profoundly alter river functioning and their biodiversity [72,73]. It should be noted that rejection of invasive fish sacrifice occurred despite the existence of species in the area such as European catfish (*Silurus glanis*) in the Ebro River, which receives great attention in the media and whose negative effects on river biodiversity have been widely described [74]. However, the majority of the students agreed on implementing biosecurity measures that try to reduce IAS effects, such as disinfection of fishing materials. Therefore, rejection of control measures was especially related to the sacrifice of living beings, principally vertebrates.

Citizens' rejection of certain IAS control measures has been the subject of debate and study by many scientific researches. Thus, several authors have pointed out that greater knowledge about invasive species, or even about environmental issues, favors the development of positive attitudes toward their control [6,25,39,48]. In the present study, this premise was partially fulfilled. The surveyed respondents who had studied the baccalaureate in natural and health sciences before university showed a higher perception of IAS impacts, as a result of greater training in this matter [38]. In the same vein, the students who belonged to associations related to nature proved more knowledgeable about IAS transmission vectors. Although there are no general differences between the rest of the respondents, these two groups showed greater support for some measures to control invasive species. If we considered all respondents of the study together, a higher perception of IAS impacts and a greater knowledge about transmission vectors were significantly correlated, always proposing to eliminate them from the ecosystems where they were found. Likewise, this greater knowledge was correlated with the majority of control measures proposed in the form, although the Spearman correlation coefficient was always below 0.3, indicating a very weak correlation [75]. In the case of the American mink's slaughter, it did not show significant correlation.

Therefore, greater training in this area inside or outside the class can be, at least partially, translated into greater knowledge of the problem. Likewise, a higher perception of IAS impacts and a greater knowledge of transmission vectors can translate into attitudes more inclined toward IAS control. However, this correlation is not robust enough, so the inclusion of this topic in educational curricula should be directed toward a change in students' attitudes, based on their knowledge around the generated IAS impacts and benefits that their control provides. In this sense, Bremner and Park [23] observed that if the benefits of American mink eradication are explained in detail to the population in Scotland, these citizens tend to support the different control measures.

Final Remarks

Future early childhood and primary education teachers were not able to perceive clearly different types of IAS impacts, such as economic or health nature damages, nor did they know enough about their transmission vectors, such as the involuntary vectors associated with citizens. Different control measures were not supported either, especially those related to the slaughter of vertebrate species such as American mink, mainly related to affective dimensions. This lack of support can pose obstacles to the development of effective IAS management programs, as occurred in the well-known and widely cited case of the gray squirrel in Italy [12], or even appropriate educational interventions.

Therefore, it is urgent to educate students of different educational stages on this subject. It is essential to introduce educational content to promote attitudinal changes from the initial educational stages, which ultimately may allow mitigating the problems associated with IAS. Students must know their role as transmission vectors, the impacts that these species generate, and the benefits associated with their control, which will generate favorable attitudes toward the different management programs.

Taking into account the importance of implementing these attitudes from an early age, the role of future teachers is of special relevance in this matter. Finally, introducing this subject systematically in different educational stages can contribute to overcoming the sporadic treatment of the subject through extracurricular educational activities or specific didactic units designed by organizations and extracurricular programs.

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